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MINISTRY OF WATER AND ENVIRONMENT

WATER MANAGEMENT AND DEVELOPMENT PROJECT

Mechanisms for Monitoring the Ecology and community-ecosystem interactions in the Mabira Central Forest Reserves

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FOREWORD

The Mabira Forest Ecosystem is globally recognised for its importance in the conservation of biodiversity and protection of the watershed. Human and wildlife populations around the Lake Victoria basin derive their livelihoods from the Mabira Forest Ecosystem. It is therefore an area of high priority for the Ministry of Water and Environment in as far as livelihoods and ecosystem health are concerned. It is necessary for the National Forestry Authority (NFA), as management, as well as other stakeholders to ensure that the conservation integrity of the Mabira Ecosysmen is upheld. Given the natural and anthropogenic problems experienced, developing a Plan for Monitoring the Ecology and community-ecosystem interactions for the Mabira Forest Reserves is an important task that has been concluded.

The plan provides an overview of the global importance of Mabira Central Forest Reserves and highlights management challenges such as degradation, external pressures, illegal human activities and conflicts over resource use. The plan provides the goals and objectives of monitoring specific aspects such as vegetation change, fauna and flora, water quality and quantity, climatic parameters, human activities and their impacts. The following broad aspects are prioritized to be monitored: vertebrates; human impacts; water quality and quantity; climate; resource use; as well as vegetation and land cover. Aspects of data handling and general recommendations for implementing the monitoring plan are included.

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This Monitoring Plan was developed alongside the Forest Management Plan that has been updated and derived partly from the baseline reports: ecological as well as the socio-economic. We would like to acknowledge the support given by the team at the Ministry of Water and Environment in organizing the introductory letters and field visits.

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LIST OF ACRONYMS

CFR	Central Forest Reserve
CMG	Consultancy Management Group
CSC	Consultancy Steering Committee
EI	Exploratory Inventory
KOSMP	Kalagala Offset Sustainable Management Plan
NEMA	National Environment Management Authority
NFA	National Forestry Authority
PSP	Permanent Sampling Plots
QAAT	Quality Assurance and Advisory Team
TORs	Terms of Reference
UNCST	Uganda National Council of Science and Technology
UWA	Uganda Wildlife Authority
WIS	Water Information System
WMDP	Water Resources Management and Development Project

SUMMARY

The Mabira Forest ecosystem is globally recognised for its importance in the conservation of biodiversity and watershed management in the fragile Lake Victoria basin and the upper catchment of Lake Kyogga. Human and wildlife populations witin this area derive their livelihood from the Mabira ecosystem. It is necessary for the Mabiral Central Forest Reserve management to ensure that the conservation integrity of the forest is upheld. Given the natural and anthropogenic problems within the reserves, developing a plan for monitoring the Ecology and community-ecosystem interactions is inevitably a priority. With support from the World Bank, the Ministry of Water and Environment tasked a team of Consultants to work with stakeholders and develop a monitoring plan for the Mabira ecoststem. This is the outcome of the process carried out alongside the development of the management plan.

This plan provides an overview of the global importance of forest reserves within the Mabira ecosystem and highlights management challenges. These include forest degradation, external pressures for degazettment, illegal human activities in the forest reserve, and conflicts over use of forest reserve resources among others. Effects of climate change and Invasive Alien Species are also addressed. In addition, observations regarding the current monitoring needs for the reserves are discussed based on literature and additional research. This monitoring plan provides the goals and objectives of monitoring specific aspects of the reserves such as vegetation change, fauna and flora, water quality and quantity, climatic parameters, human activities and their impacts. The following aspects were, specifically, monitored: vertebrates; human impacts; water quality and quantity; climate, gravity flow schemes and glaciers; resource use; as well as vegetation and land cover. Aspects of data handling and general recommendations for the EMP are presented.

To guide the forest reserve management in monitoring the ecological and socio-economic aspects, this plan sets out approaches for conducting the monitoring. Aspects highlighted include key considerations in identifying and using indicators, baselines against which changes can be detected and the importance of involving the local communities in monitoring such changes. Detailed sampling designs, techniques and tools for gathering data (monitoring protocols and formats to be used by people of different levels of skills and at various times) are presented in this plan. These are aimed at ensuring quality, credibility and consistency in monitoring. The plan also discusses the procedures for recording, managing and analysing the data, interpretation as well as reporting. Management of Mabira Central Forest Reserves will however, prioritise the proposals and decide on what aspects to monitor, depending on available resources.

In order to implement this Ecological Monitoring Plan for Mabira, it is important for NFA and other stakeholders to decide on ‘what data are needed, and for what purpose’. This plan provides detailed methods that can be used to address monitoring needs for various purposes: from the management oriented to the academic. During preparation of this monitoring plan, the need to have various baselines was emphasised by various stakeholders. It would be ideal and desirable to include such baselines, but this has not been achieved in this plan because of two reasons: i) many of the data that exist, require verification and preliminary analyses to extract the baselines; and ii) various data are held by other stakeholders. Obtaining such data requires that proper mechanisms for the sharing of the data be put in place. Partners must, therefore, be invited to contribute to the monitoring programme. Moreover, there is a need to ascertain what data are available and what plans there are for utilising such data. The NFA should therefore take a lead in ensuring that this plan is implemented.

CHAPTER ONE

1.0. INTRODUCTION

1.1. General Overview

This plan is prepared to guide management in monitoring the ecology and community-ecosystem interactions in the Mabira Forest Reserves. The plan sets out approaches for carrying out the monitoring in line with the research and monitoring priorities of the National Forestry Authority (NFA). Indicators taxa and baselines are used as the basis for detecting changes in the ecology and community-ecosystem interactions. It is important to involve the local communities in monitoring the changes. This enables them to understand some of the seemingly unpopulat management decisions that may be taken based on findings of the monitoring process. Hence, the detailed sampling designs, techniques and tools for gathering data (monitoring protocols and formats) are designed to be usable by people of different levels of skills and at various times). These arrangements are aimed at ensuring quality, credibility and consistency in monitoring. The procedures for recording, managing and analysing the data are equally important. Ultimately, interpretations as well as reporting are important as well. Implementing the monitoring plan requires the involvement of partners beyond NFA such as the local communities, researchers, private sector and academicians, among others.

The following aspects are prioritized for monitoring within this plan:

- Vegetation changes
- Flora and Fauna
    - Various plant species
    - Large and medium sized mammals
    - Small mammals
    - Birds
    - Reptiles and Amphibians
    - Butterflies
- Water quality and quantity
- Climate
- Human activities and impacts

The ecological and socio-economic aspects was monitored against ecological and community-ecosystem interactions to guide management. The considerations in choice of methods and design include the following:

Indicators: Specific, measurable, actionable and sensitive ecological indicators were identified partly from previous NFA documents and inventory reports to enable determination of aspects of the ecology in relation to impacts of human activities as well as natural processes on ecosystem integrity of forest. These are presented as monitoring protocols in subsequent sections of this plan. The indicators enabled monitoring of ecosystem health, climate change, disturbance levels, vegetation changes, as well as available resources. Indicators also enabled monitoring selected species of conservation concern. Other aspects include changes in various environmental variables.

Baselines: Changes will be detected by comparing freshly collected observations against baselines, where they exist. Otherwise the required baselines will be generated through research and

implementation based on availability of funds. Taxa for which some baseline data exist formed the basis of monitoring are presented alongside the monitoring tools.

1.2. Monitoring Protocols, Tools and Formats

Proposed methods are selected for use by people with different educational, and skills levels. The protocols have been developed using guidelines recommended by the World Conservation Monitoring Centre (WCMC) (Tucker et al, 2005). The methods where required, allowed comparison of results over different monitoring periods to make the data useful in a broader context. The methods are summarised alongside the monitoring tools. The data provided insights, trends and thresholds for intervention. Each protocol has a title; justification statement; specific measurable, achievable and realistic objectives; approaches to be followed; and the frequency of data collection. The protocols describe the sampling techniques; equipment, and sample preservation. Aspects of data management and analysis as well as samples of field data forms are included.

Monitoring protocols are prepared to ensure quality and credibility, so that monitoring is carried out consistently, data are suitable for comparative analysis, and changes detected are real and not due for example, to differences in sampling. In summary, the following information is included in protocols:

a. Monitoring objectives
   - Reasons for monitoring
   - Conservation objectives on resources
   - Monitoring population / area and sub-units
   - Establishing the Frequency of occurrence

b. Monitoring methods and apects to monitor
   - Observation type
   - Data type/ Indicators
   - Complete census or sample survey
   - Sampling sites / time period
   - Data analysis

c. Monitoring Requirements
   - Personnel responsible and time required
   - Experience training necessary
   - Quality control
   - Equipment required
   - Data storage

d. Reporting procedures

These aspects are explained here in detail:

Monitoring objectives

The main objective of the monitoring programme or the reasons for the monitoring programme must be clearly defined. Monitoring species of conservation concern, for example, is aimed at assessing the impact of management strategies, especially law enforcement and community conservation on the integrity of the ecosystem in relation to utilization pressure. The monitoring data can then be used to

relate changes in abundance and distribution of taxa to the long-term changes in vegetation and type as well as level of human activities.

It is necessary to clarify, when and how often monitoring will be done. This depends on the taxa and size of the animal to be monitored. Large and medium sized mammals (e.g., elephants, chimpanzees and duikers) could be monitored once every five years. Changes in their populations are normally small and occur slowly over time. In case there is a good reason to suspect that there is a population decline (e.g., if there is heavy poaching), then the populations of these animals can be assessed at shorter time frames of two to three years. Small-sized animals (e.g. birds, rodents, reptiles and amphibians) can be monitored once every two years. These reproduce faster but more importantly, their populations respond rapidly to changes in their environment.

Monitoring methods and Aspects to monitor

It is impossible to monitor all species or even most of the animal species in an ecosystem. This plan recommends the monitoring of species of conservation concern, which contribute to the uniqueness of Mabira Forest. These range from amphibians, reptiles, birds, and small mammals to large mammals. These species are therefore, highly likely to be locally extinct in the face of global climatic change, disease, exotic species invasion and human activity. The monitoring results can help design mitigation and/or adaptation strategies for such species. In this way, elements of the ecosystem health may be inferred.

Monitoring abundance indices is recommended because forest reserve management should be more concerned with trends rather than measuring absolute values. Given the topographical and vegetation heterogeneity of Mabira, the forest reserve needs to be stratified for monitoring purposes.

A preliminary survey should be done before embarking on long-term monitoring. This has been done in the case of Mabira Forest Reserve in terms of the Ecological Baseline survey carried out within this work.

Monitoring requirements

Mabira management will need to cooperate with other specialist agencies/individuals to implement the monitoring programme. These expert agencies/individuals would provide rigorous training to field staff in monitoring methods.

The methods of data analysis presented in this plan are all possible using pencil and paper or a pocket calculator. It is better to use a spreadsheet, however. This allows one to check the data after one has entered them, it facilitates clear lay out and calculations. Monitoring data should be for further analysis of trends. Mainly basic analyses of trends are recommended (with some indication of the reliability of results e.g. confidence intervals). In addition, the effort involved and the coverage will be shown to enable comparison with other sites. Basic statistical tools will be used.

Data handling and reporting

Monitoring data can be used: to identify major patterns of abundance and distribution of key species, in relation to human presence and habitat characteristics; to evaluate effectiveness of protection measures; to identify areas of conservation concern (e.g. zones of high human impact or concentrations of fauna); and to provide a basis for monitoring ecological changes and patterns of human use. Ultimately, the data will be used to monitor ecosystem health and integrity of the Mabira Ecosystem.

The raw data collected through the various protocols must be carefully checked, entered into databases, checked, corrected and double-checked, before analysis and evaluations concerning management questions.

Table 1. Template for assigning roles regarding data management

Data collected	By whom?	Who enters data?	Who checks and corrects?	Who analyses data & presents results?	Analyses required
Water quality	Rangers	Ranger, assigned to database management	Sector Manager	GIS unit staff assigned to database management	?
Resource use	Rangers,	Ranger, assigned to database management	Sector Manager	GIS unit staff assigned to database management	?
Illegal human activities	Rangers	Ranger, assigned to database management	Sector Manager	GIS unit staff assigned to database management	?
Fauna and flora	Rangers	Ranger, assigned to database management	Sector Manager	GIS unit staff assigned to database management	?
Climate	Rangers	Ranger, assigned to database management	Sector Manager	GIS unit staff assigned to database management	?

Management (ideally NFA), must clearly define data-management systems and allocate responsibilities for each step in managing data from each monitoring protocol. Oversight by a staff member who is well trained and experienced in database management and GIS is needed to ensure quality control. The template (Table 1) is designed for completetion by the NFA to facilitate data managent.

Data from: in order to build an archive of data relevant for Uganda's Protected Areas, NFA should develop clear guidelines for visiting and collaborating researchers to leave behind their data and reports. The relevant data collection forms that are provided for various taxa should be used and data submitted to the warden in charge of research and monitoring.

1.3. Local Community involvement and Ranger/Guide based monitoring (RGBM)

Currently, participation of local communities in monitoring is limited. This is proposed with a view of enhancing or initiating further involvement. Community involvement is most appropriate in monitoring resource use and access, especially where resource use agreements and MoUs have been signed with Collaborative Forest Management (CFM) groups. Indicators are developed for monitoring some of the key socio-economic features to safeguard their integrity. The components include, for example, resource use (e.g. harvesting or access to cultural sites/sacred sites), and effectiveness of the collaborative management.

Monitoring by Rangers or Guides, takes advantage their presence in the forest to collect data in a systematic and organized way without increasing the workload. Basic observations that aim at detecting broad trends within habitats, key species, threats and values are made. This information is used for day-to-day management and conservation of forest. This is proposed for the Mabira ecosystem. The main

objective of RGBM will be to assess the effectiveness and impact of management strategies, especially law enforcement and community conservation and adapt accordingly.

RGBM data can be used to show:

i) patrol coverage - areas of the forest reserve patrolled and those that have not and help determine patrol deployments, hence staff management;

ii) ranger performance - distance covered, number of days and/or nights spent on patrol;

iii) illegal activities – their distribution to help determination of the "hot" spots to focus deployments, and in threat analysis (ranking of illegal activities that threaten the integrity of the forest reserve). The information also provides a measure to relate to human use and impact on the forest reserve resources;

iv) animal distribution – information can be directly correlated with changes in animal abundance and distribution over time and used in species and tourism management.

The Mabira Forest Reserves use a conventional law enforcement system of foot patrols that start from the camps as well as from NFA field offices. The Forest Guards and Patrol teams should have a standardized patrol form for monitoring. The following information is should be recorded:

- Number of NFA staff on patrol
- Duration of the patrol (including rest time)
- GPS location coordinates of routes taken (records every 250m or 15min)
- Types, quantities and GPS location coordinates of illegal human activity encountered (snares, poachers, poacher camps, camp fires, animal carcasses and cut stumps)
- Wildlife or their signs (nests, dung, hair, footprints) encountered by species and GPS location coordinates

It is undesirable for significant areas of the forest reserve to go unvisited for extensive periods. Since the data can be spatially analysed, for example using GIS, the patrol coverage can help direct efforts to areas that have not been covered.

CHAPTER TWO

2.0 GOALS, APPROACHES AND DATA REQUIREMENTS

2.1. Goals

2.1.1. Overview

This Monitoring Plan is aligned with the National Forestry Authority (NFA) research and monitoring priorities as well as the Mabira Management Plan. Based on the plan, as well as the research, management and monitoring requirements, the goal of this plan is to enable magement of the reserves to regularly and systematically generate information needed for the management of the reserves i.e. to assist the NFA and their collaborators to assure the effective conservation of the values that the Mabira Forest Reserves were gazetted for. The specific aspects to be monitored are the following:

2.1.2. Vegetation changes

The integrity of the ecosystem is to a large extent dependent on the health and status of the vegetation. Given that thid is the above ground foundation on which the rest of the components reliy, this plan will enable managers to:

- Compile information on the extent of current vegetation types
- Monitor threats against different habitats and vegetation types
- Monitor changes in vegetation cover, composition and structure, and the rate and causes of these changes

Vegetation change occurs sometimes as a normal process implying that the aim should not be to prevent any change or to view vegetation change as necessarily undesirable. The challenge for monitoring will be to identify undesirable change and what can be done about it. The NFA should make no specific efforts to monitor vegetation beyond the assessment of resource harvest and the impacts of fire, encroachment and Invasive Alien Species. Whenever more technical plant species inventories are needed, collection should be supervised and performed as far as possible by qualified individuals.

Alien Invasive Species are a worldwide phenomenon in natural as well as manmade environments. So far, the most serious issues of invasive species reported from Mabira Forests is the Paper Mulberry (Broussonetia papyrifera) and to a lesser extent Lantana camara. As invasive species are not Protected Area specific, and may threaten production forest, agricultural and grazing land as well. Ideally a national (or even regional) approach to this problem is to be preferred, as it will be more (cost) effective. Combined efforts by stakeholders are encouraged.

2.1.3. Fauna and flora

Fauna

The following groups of vertebrates should be monitored: i) large vertebrates (e.g. duikers, Mangabeys); ii) small mammals; iii) birds; iv) reptiles; and v) amphibians. The methods of monitoring these taxa are presented.

Animals being or to be monitored were selected because:

- Their signs (sightings, dung, nests, tracks, scats, rubbing posts etc.) are readily visible even in a dense forest;
- They are mainly charismatic species attracting interest of people locally, nationally and internationally;
- Some are hunted and/or of conservation concern;
- Though at low density, some are problem animals, destroying crops and/or livestock of people living around protected area

Before other species are added on the list of fauna to be monitored, it is important to note that the main aim of law enforcement patrols is to prevent illegal activity and to apprehend offenders. Hence, burdening patrols with more data requirements must be weighed against vigilance and effectiveness at law enforcement and ability of rangers to identify the fauna.

The fauna and flora interact in various ways to ensure the health and wellbeing of the ecosystem. Many of the species are also targeted for utilization and may be affected by other threats. This plan will enable managers to:

- Compile existing data on populations and species diversity.
- Identify key indicator taxa for ecosystem health and monitor their population trends.
- Monitor species that are endemic, rare, endangered and threatened.
- Monitor the status, trends and spread of alien invasive species and potential invasives.

2.1.4. Water quality and quantity

One of the critical roles of the Mabira ecosystem is that it is one of the most important water catchments for the Lake Victoria and Lake Kyoga regions. It is an important water catchment providing several ecosystem functions and services to aquatic biota and local communities. However, the human communities and industries within the surrounding areas are dependent on the water resource. They also influence the water quality and quantity. The integrity of these ecological functions is being compromised by the non-regulated use of the freshwater resources such as abstractions and by a threat of climate change. This plan will be used to:

- Monitor the water catchment function of the Mabira Ecosystem.
- Monitor pollution of water resources from activities inside and outside the reserves.
- Monitor impacts of industrial water utilisation schemes on the water catchment functions of the reserves.
- Monitor changes in the flow of rivers associated with the reesrves.

The objective of water quality monitoring is to justify the ecosystem functions and services in terms of water provisioning from the forest reserve; to track the extent of pollution of water resources from activities inside and outside the forest reserve; and to track changes in river flow.

The parameters selected for monitoring can be measured in the field, apart from the benthic macro-invertebrates. Rangers would require minimal training to use, calibrate and maintain the equipment.

A baseline has been set up by measuring the proposed parameters at the sites to be sampled monthly for one year. This will form a basis for monitoring future changes in the parameters. It is suggested that monitoring be carried biannually during the wet and dry seasons for all the environmental indicators. Benthic macro-invertebrates should be sampled annually preferably during the dry season. This would

give maximum abundance and diversity of aquatic insects as there is minimal disturbance of the assemblage compared to that caused by spates during wet seasons. By monitoring the abundance of aquatic insects, shifts in the range of these organisms will be ascertained and related to climate change.

Benthic macro-invertebrates have been used as bio-indicators of watershed condition and water quality in streams and rivers. This is because various taxa have varying tolerances to different types of disturbances. Various metrics such as number of taxa and their relative abundances can be used as indicators of water quality and are good indicators of water quality. The metrics will help management determine status of water resources, evaluate causes of degradation, determine effectiveness of management interventions such as catchment restoration and measure success of management programs. Aquatic insects are relatively easy to sample and identify. Benthic macro-invertebrates, in particular, are recognised as valuable organisms for bio-assessments, due largely to their visibility to the naked eye, ease of identification, rapid life cycle often based on the seasons and their largely sedentary habits. Numerous bio-assessment techniques have been developed over the last three decades, varying in complexity and region of implementation.

2.1.5. Climate

The climatic effects are becoming increasingly important for the integrity of different ecosystems. It is critical to keep track of these different patterns. This plan will be used to monitor weather patterns (temperature, rainfall, humidity and sunshine).

The objective of climate monitoring is to keep track of weather patterns. Various weather parameters should be monitored to ascertain how these influence animals and plant distribution. In addition, regular monitoring of weather parameters will give an insight into how global climate is changing. Standard weather parameters measured globally will be monitored and data on these parameters are available from other sites for comparison. These include:

- Air temperature: measured using mercury- or alcohol- filled thermometer or recorded electronically.
- Relative Humidity
- Precipitation
- Radiation (sunshine)

An automated weather station is proposed. The weather stations measure temperature, precipitation and humidity. The focus should be data storage, validation, analysis and dissemination for management use. In addition, manual weather stations can be placed at all rangers' outposts. The staff at the ranger posts will require training in handling and caring for the equipment and taking readings.

2.1.6. Human activities and impacts

Humans interact with the forest ecosystem in various ways and influence its integrity and health. The plan will enable forest managers to monitor:

- Population changes for the purpose of predicting the variation of pressure on forest reserve resources.
- Impact of resource use agreements and human activities inside the forest reserve on vegetation.
- Impact and sustainability of resource use arrangements
- Impact of cultural activities in the forest reserve.

- Effect of revenue sharing scheme on the communities and on the conservation of the forest reserve.
- Illegal activities and their impacts on the ecosystem e.g., poaching and logging.
- Forest fires
- Tourist impacts
- Human-Wildlife Conflict

Monitoring human activity will, thus, focus on signs of illegal activity (e.g. snares, poachers, poacher camps, fires, carcasses and cut stumps). The distribution and intensity of illegal activities will be correlated with wildlife abundance and distribution. In addition, the impacts of tourist activities will be monitored along the tourist routes.

Monitoring fire: Fire is considered one of the major long-term threats to tropical forest biodiversity. Although Mabira is usually too moist to burn, considerable areas can burn during exceptionally dry years. Nonetheless, most if not all, fires in Mabira are man-made. Forest fires create and increase the likelihood and severity of future fires in previously burnt areas. Opening of the canopy and destruction of large areas of understory promotes invasion by herbaceous and exotic vegetation. If this vegetation becomes established, it will slow forest recovery.

Wild forest fires are monitored to determine a fire hazard period. This is declared based on long-time monitoring of when and under what weather conditions fires are likely to erupt in the forest. This would assist forest reserve management to be prepared during that time and/or conditions to: i) prevent as many fires as possible occurring in the forest reserve; ii) extinguish fires that start while they are still small; iii) minimize the size and destructiveness of the fires that become big in spite of the control measures in place, and iv) assess the effectiveness of the fire control measures. Fires should be recorded whenever they are detected and/or reported.

Indicators to monitor are frequency of fires, area of forest reserve burnt, and distribution of the fires per month. Other information to be recorded are: cause of fire, time detected, time taken to put it off, source of fire, location, damage and severity and methods used to extinguish the fire.

Monitoring Tourist Impacts: The basic problem with tourism development is that the tourists and tourism facilities have adverse on the environment. Mabira is a fragile ecosystem and much of what is done within the forest reserve will ultimately affect the communities outside the forest reserve as the numerous streams and rivers carry much of the waste. Improper disposal of waste and off trail trampling could have adverse impacts on the habitat, wildlife, humans and reduction in aesthetic value.

Monitoring tourism impacts will help forest reserve management to assess whether regulations and actions for proper waste management are being adhered to so that the habitat integrity of the reserve is maintained. Tourism impacts should be recorded whenever they are encountered and/or reported.

Indicators to monitor tourist impacts in the forest reserve include: width of trails at selected points such as fragile habitats like wetlands, volume of non-biodegradable litter collected by rangers, frequency of toilet dirtiness, and number of complaints about litter and/or waste received, off trail trampling impacts like breakage and bruising of plant stems, reduced plant vigour, reduced plant regeneration, loss of ground cover, change in plant species composition and accelerated erosion. GPS coordinate locations of points with adverse tourism impacts also be recorded. Tourism impacts can also be detected from water quality results. Rangers and guides can be trained to collect and report this information. Also tourists can be interviewed for their views on waste management as part of the visitor satisfaction survey.

Monitoring Human-Wildlife Conflicts: Crop raiding is a cause of much conflict between local communities and wildlife throughout the world. In Africa the great dependence of a large proportion of the human population for their survival on the land, coupled with the presence of many species of large mammal leads to many sources of conflict between people and wildlife. This in turn creates increasing friction between protected area managers, and local communities living in the areas that are adjacent the protected areas.

Monitoring of wildlife-human conflict will help guide management identify the spatial-temporal distribution of human-wildlife conflict incidences, assess the damage and identify the animals involved. This information can be used in the development and designing of appropriate strategies and methods for reducing human-wildlife conflict. These will ultimately reduce amount of crop/animal/human losses to problem animals, help affected farmers improve agricultural production and improve local people's attitudes towards, and perceptions of, a forest reserve and its wildlife. Human-wildlife conflicts should be recorded whenever they encountered.

Proposed indicators to monitor: problem animal raids per village per month, problem animals raids per growing season, problem animal raids per km^2 of human settlement per year. Forest rangers, guides or community members can be trained to collect and report this information. Also farmers can be interviewed for their views on human-wildlife conflict as part of the socio-economic study.

The data can be analyzed and presented as graphical summaries, which are far more 'user friendly' than the tables and diagrams. If data is stored in electronic format such as an Excel spreadsheet, this is a rapid, simple process. In area reports, common graphical summaries produced are:

- Monthly distribution of problem animal incidents
- Selection of crops by problem animals
- Type of problem animals
- High, moderate and low levels of damage incidents.

If the same geo-referenced incident data are then transferred onto a GIS, detailed distribution maps can be produced. If these data are cross-referenced to a number of attributes, the possibility for numerical and spatial analyses increases considerably.

Monitoring in- forest reserve resource use: In the context of sustainable in- forest reserve resources use, monitoring will focus on observing what goes on in terms of harvesting patterns (e.g. the kind and amount of resources harvested, period of harvesting and who harvests). A Participatory Monitoring (PM) approach is proposed, with periodic crosschecking by more qualified researchers. This approach has some potential for facilitating sustainable in- forest resource use. Relevant resource users, rangers and researchers will primarily observe changes. Involving relevant resource users in monitoring will increase their motivation for ensuring that the program succeeds. The continued exchange of information (required in PM) will bring the resource users and forest reserve management close, which will strengthen their working relationships.

This process will involve keeping records of harvesting activities, and assessing the results and impacts in the field, to form the basis for evaluating the success of the interventions and learning from the experiences.

Sustainable in- forest resource use will be achieved through three key processes (a) controlled access of the community to the forest reserve; (b) community empowerment to manage the resources; and (c) a dialogue for forest management.

The rate at which agreed, forest reserve products are collected and the collection methods will be used to determine whether there is progress towards controlled access to the resources by comparing the data with previous harvest and data.

CHAPTER THREE

3.0 SITE DESCRIPTION

3.1 Mabira Forest Reserve

3.1.1. Introduction

The plan was developed for Mabira Central Forest Reserve and five other smaller reserves of the Mabira Ecosystem. Mabira forest islocated in Buikwe District, Uganda (0°24 0°35 N 32°52 33°07 E) and has an area of 306 km2 (Davenport et al.1996). Mabira is covered by medium altitude, moist semi-deciduous and moist evergreen tropical tropical forest communities (Lewis, 2001). The altitude ranges between 1070 and 1340 m above sea level, with gently undulating plains of numerous flat-topped hills and wide shallow valleys (Fungo et al, 2013). The mean annual precipitation of the forest is between 725-1474mm while the annual mean minimum and maximum temperatures range from 16 to 17°C and 27 to 29°C, respectively (Lamto et al, 2010).

The reserve supports a high diversity of biota including mammals (Dickinson & Kityo, 1996), birds (Baltzer, 1996; Posa and Sodhi, 2006), butterflies (Davenport, 1996; Kronstad, 2009), and plants (Lwanga, 1996; Nature Uganda, 2011) that is typical of all Afro-tropical forest ecosystems. Two main vegetation sub-types are represented in the forest reserve namely; young and colonizing forest covering 2.7% and mature mixed forest which is the largest covering 52% of the forest area (MWE, 2009).

The total number of plant species now known from Mabira Forest Reserve is 544 with the trees, shrubs and climbers contributing 358 species based on the Ecological Baseline Surveys carried out in 2016 within this work (312 were recorded in the previous Forest Department Biodiversity inventory; hence we recorded an additional 46 species of the combined group 'trees, shrubs and climbers'. The rest of the reserves had the following numbers of species: 42 (Namakupa), 63 (Namawanyi), 67 (Nandagi) and 68 (Kalagala), and 73 (Namanangai). In the case of Mabira Forest Reserve, the herbaceous species were previously not included. We therefore have 186 herbaceous species added to the list of species. Nine of the tree species are of restricted range and three Mahogany species listed as globally threatened (Davenport 1996; Nature Uganda, 2009).

Forest birds are over 150 species (Byaruhanga et al, 2001), two species of diurnal forest primates (Baranga, 2007) and 218 species of butterflies (Davenport, 1996; MWE, 2009). Up to 42 species of amphibians, 13 genera and 9 families have been recorded in the Mabira ecosystem. All of them belong to the Order Anura. The family Hyperoliidae has the highest number of genera (3) and species (11). The water-confined families of Dicroglossidae, Hemisotidae, Pyxicephalidae and Pipidae are represented by single species. A total of 32 reptile species belonging to 4 orders, 13 families and 23 genera were recorded. These are definitely sensitive to changes in ecosystem health. The forest has some species of global conservation importance for example Francolinus nahani (Nahan's Francolin), which is on the list of globally endangered species (BirdLife International, 2009).

Already by 1996, Davenport et al (1996), reported that "Mabira Forest Reserve was subject to extensive encroachment, pitsawing, charcoal burning and hunting formany years. And that in the 1970's and 80's politicians encouraged many people to leave their homes and re-establish inspecially cleared areas of the forest. These immigrants came from many parts of Uganda, in particular from eastof the Nile. This single act caused much disturbance to the forest and it is estimated that 25% of the reserve was cleared

to accommodate the settlers. The encroachers were evicted in 1988 after a much, publicized action by the Forest Department.

Despite steady recovery from disturbances caused by encroachment of the 1980's, the forest remains heavily degraded mainly at the edges (MWE, 2009). Enclaves exist in the forest reserve with 27 villages (Baranga, 2007) where subsistence farming is the primary economic activity for the 3,506 families within (BLI, 2009). The secondary economic activities mainly include; charcoal burning, pit sawing, collection of poles for construction, collecting medicinal and other non-timber forest products (MWE, 2009) which are needed to supplement the incomes of enclave residents (Baranga, 2007; Akite, 2006). Despite the worrying levels of degradation, the forest remains an important biodiversity reserve and an important tourist destination, receiving more than 62% of all tourists visiting forest reserves in Uganda (Nature Uganda, 2011).

3.1.2. History of Disturbance in Mabira Forest Reserve

A lot of habitat change has been recorded in many areas of the world and Uganda in particular. The extent and quality of forests, woodlands, wetlands and other terrestrial land cover types have been greatly impacted and changed through anthropogenic pressure in the search of resources and land for settlement and agriculture. Large sections of the forests of Mabira, Nandagi, Namananga, Namakupa, Namawanyi and Kalagala (Figure 2.1) over the years experienced massive but varying levels of human incursions on the forest estates and in some cases converting more than 80% (in the case of Nandagi, Namananga, Namakupa, Namawanyi and Kalagala) for cultivation. Large sections of the previously encroached forests have since been reclaimed and some restoration action taken place, although in some section natural regeneration is now observed. While the local sugar works (Sugar Corporation of Uganda Limited) is replanting areas of the forest for their own consumption, they are also responsible for releasing effluent waste into the River Musambya which appears to bepolluting this river that runs into the Reserve".

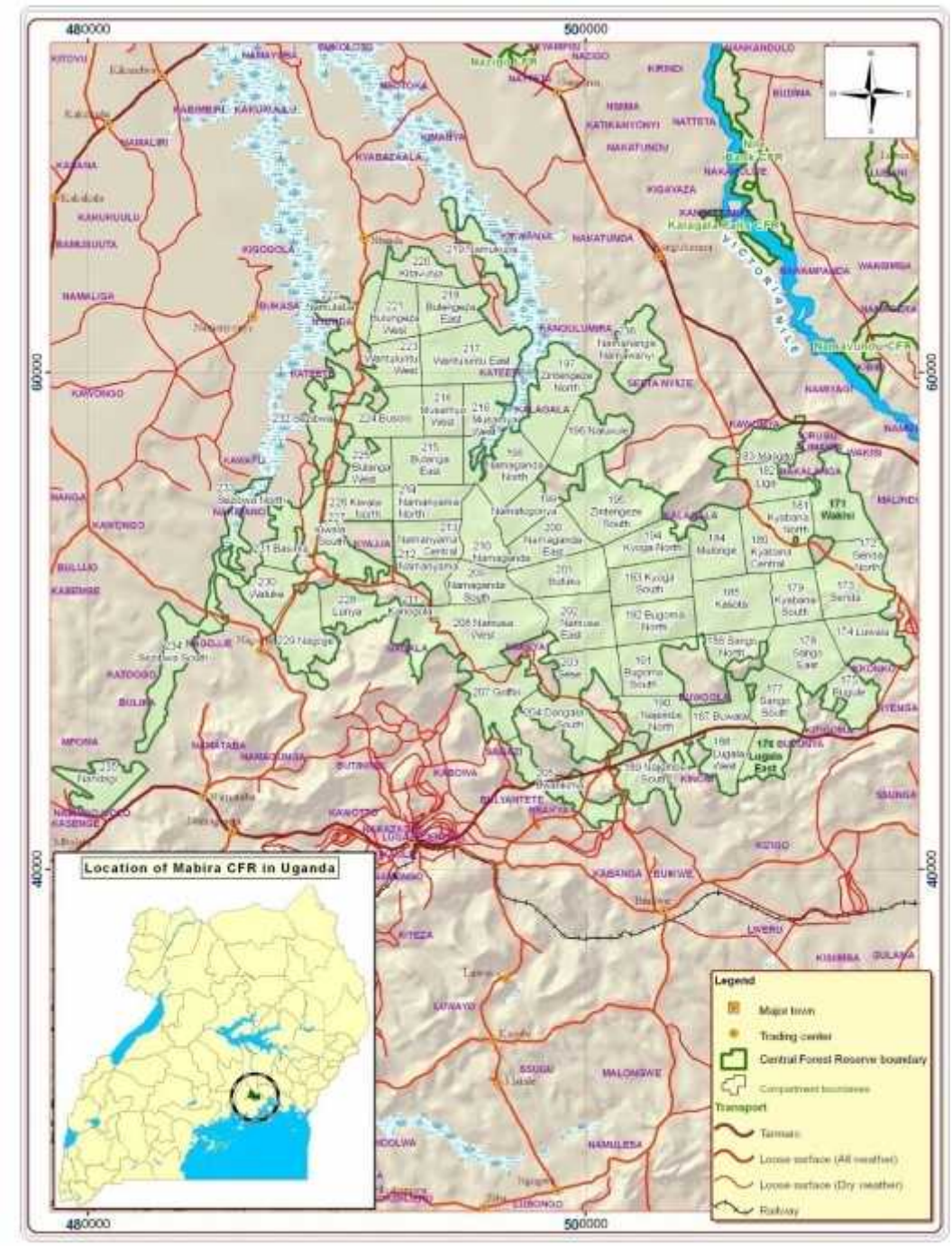

Figure .1. Mabira CFR with the other 5 CFRs surveyed for this report

3.1.3. The Management zones

The Mabira forest was in 1994-1997 divided into Management zones consisting of Strict Nature reserve, Recreation/eco-tourism zone, zone for low impact use and the production zone (Davenport, 1996; MWE, 2009) these are illustrated on the map in Figure 2.2).

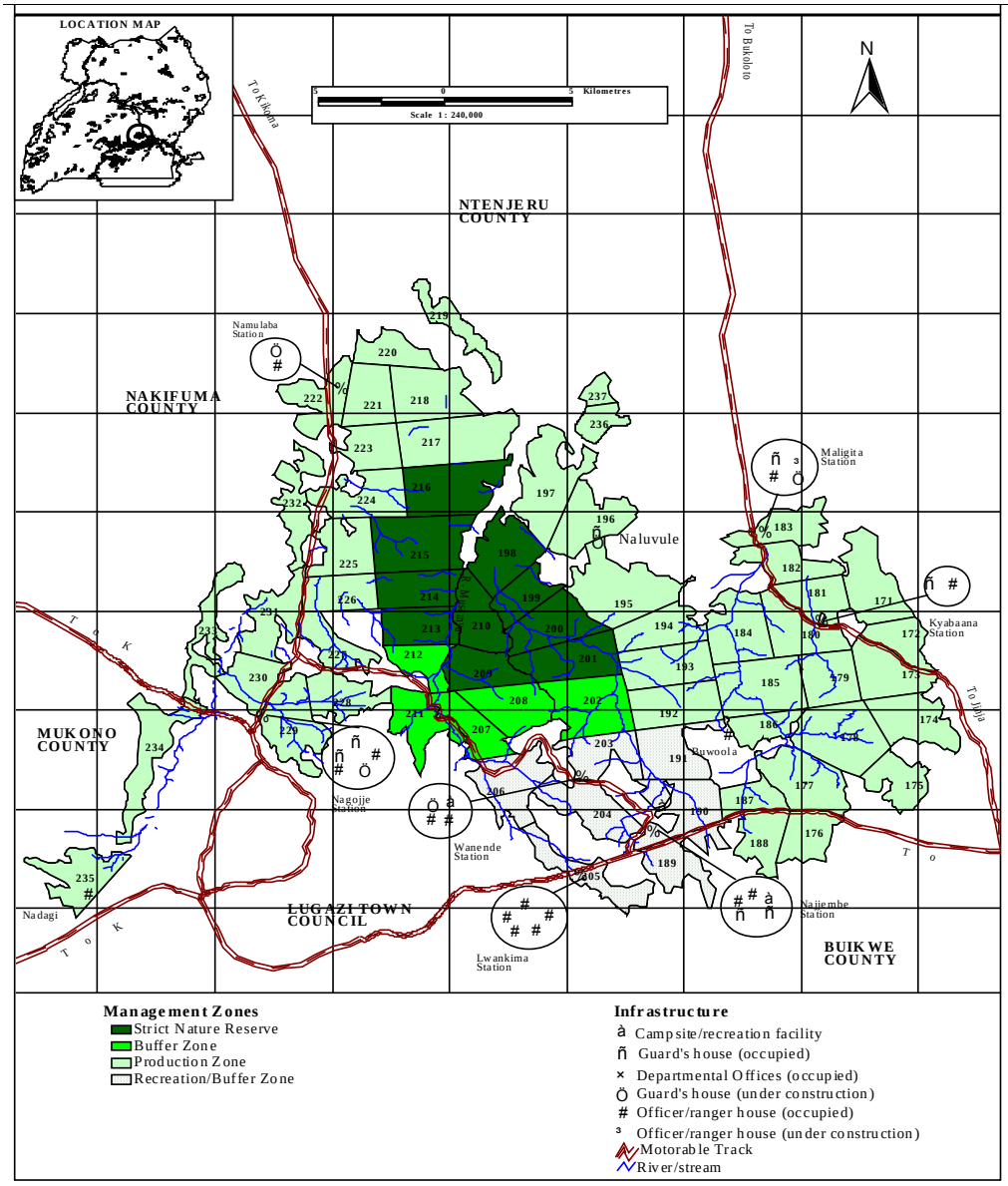

Figure 2. Map showing the management zoning of Mabira Central Forest Reserve

The Strict Nature Reserve: This is located almost in the centre of the forest and was set aside mainly for species and habitat protection. The only activities allowed in this management zone are education and research with extraction limited to only meet the requirements of these two activities. Studies in this zone were carried out from Wanende 'beat'.

The Recreational/Buffer Zone/eco-tourism: This Management zone surrounds the strict nature reserve and is meant to offer protection from undue human pressure from outside. Allowed in this zone are ecotourism and harvesting of local herbs by inhabitants from surrounding communities. This zone was established within the Forest department as a tourism development project. Studies in this zone were carried out from Najjembe 'beat'.

The low-impact use zone: This zone occurs outside the buffer and on average appears to be the largest. Local inhabitants are allowed to collect firewood and medicine from this zone. Studies in this zone were carried out from Lwankima 'beat'.

The production zone: This occurs within the zone of low impact use and is part of the overall forest management programme. Here silvicultural practices are used to enrich stands for extractive use by private companies while other activities include enrichment planting of trees and salvage operations (MWE, 2009; Kizza *et al*, 2013). Studies in this zone were carried out from Nagojje 'beat'.

3.2. Namukupa forest reserve

Namukupa forest reserve is located in Namukupa village. Fields of cultivation fringe the forested area with small-scale gardens on the larger side. The other side is fringed by *Learsia hexandra* and *Cyperus papyrus* dominated swamp. The forest still retains her natural vegetation in its centre although the boarders and some sections of the interior are dominated by the invasive *Brousonetia papyrifera*.

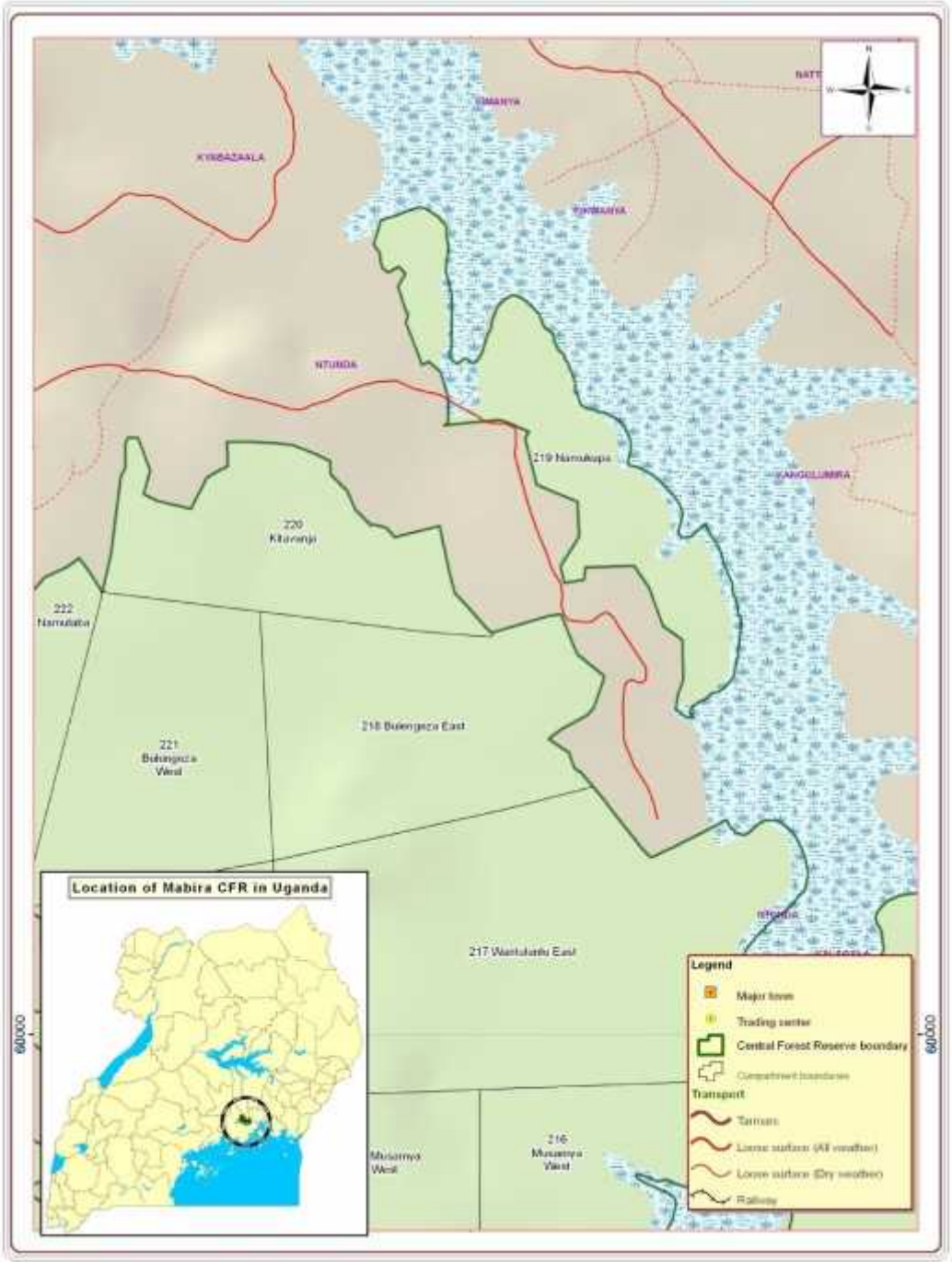

Figure 3. Namakupa Forest Reserve which is one of the study sites

3.3. Namananga Forest reserve: Namananga Forest reserve is located in Namananga Village. One section of the reserve is in a swamp dominated by *Learsia hexandra* and the forested expanse is dominated by *Brousonetia papyrifera*. Fields of cultivation and areas of human settlement fringe the reserve.

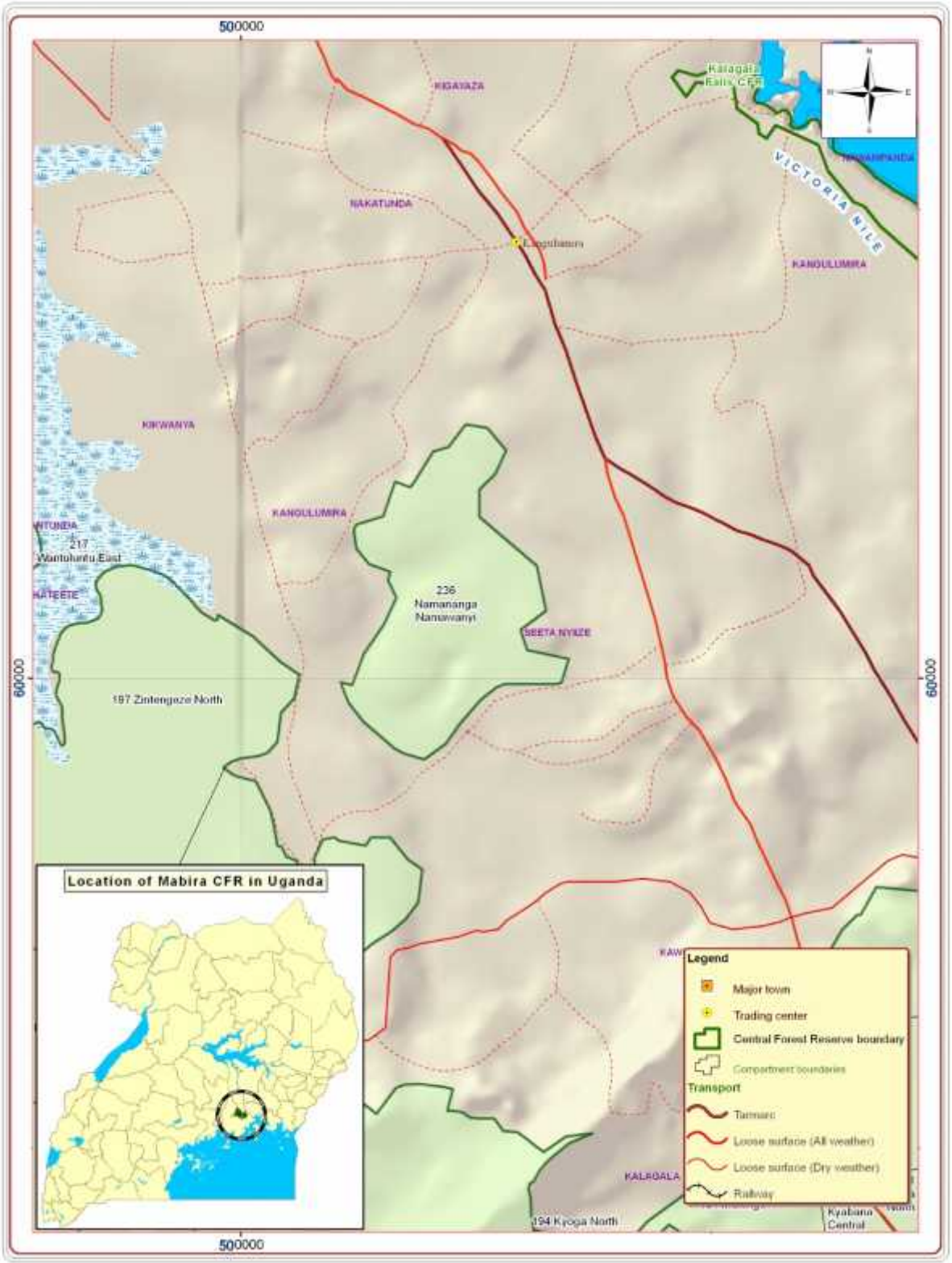

Figure 4. Namananga and Namawanyi Forest Reserves where assessed

3.4. Namawanyi Forest reserve: Namawanyi Forest reserve is located in Namawanyi Village. The reserve is dominated by *Brosonetia papyrifera* with very few indigenous trees and is fringed by fields of cultivation. The forest is contiguous with Namananga and both reserves are regenerating with average tree height below 15m.

3.5. Nandagi forest reserve: Nandagi forest reserve is composed of forested expanses, fields of cultivation and fallow lands. The sampling sites outside the Forested part of the reserve are located in Nama 2 village (Figure 2.5) and those inside the forest reserve are located in Nandagi village. Majority of the points in Nama 2 village were within fields of cultivation and fallow lands. Nandagi forest reserve is composed mainly of plantations from trees of *Terminalia* spp., *Eucalyptus sp* and *Pine sp*. The reserve is bordered by a long wetland stretch from one end of lower elevation, small-scale agriculture fields from the other and sugar cane plantation from the end of higher elevation.

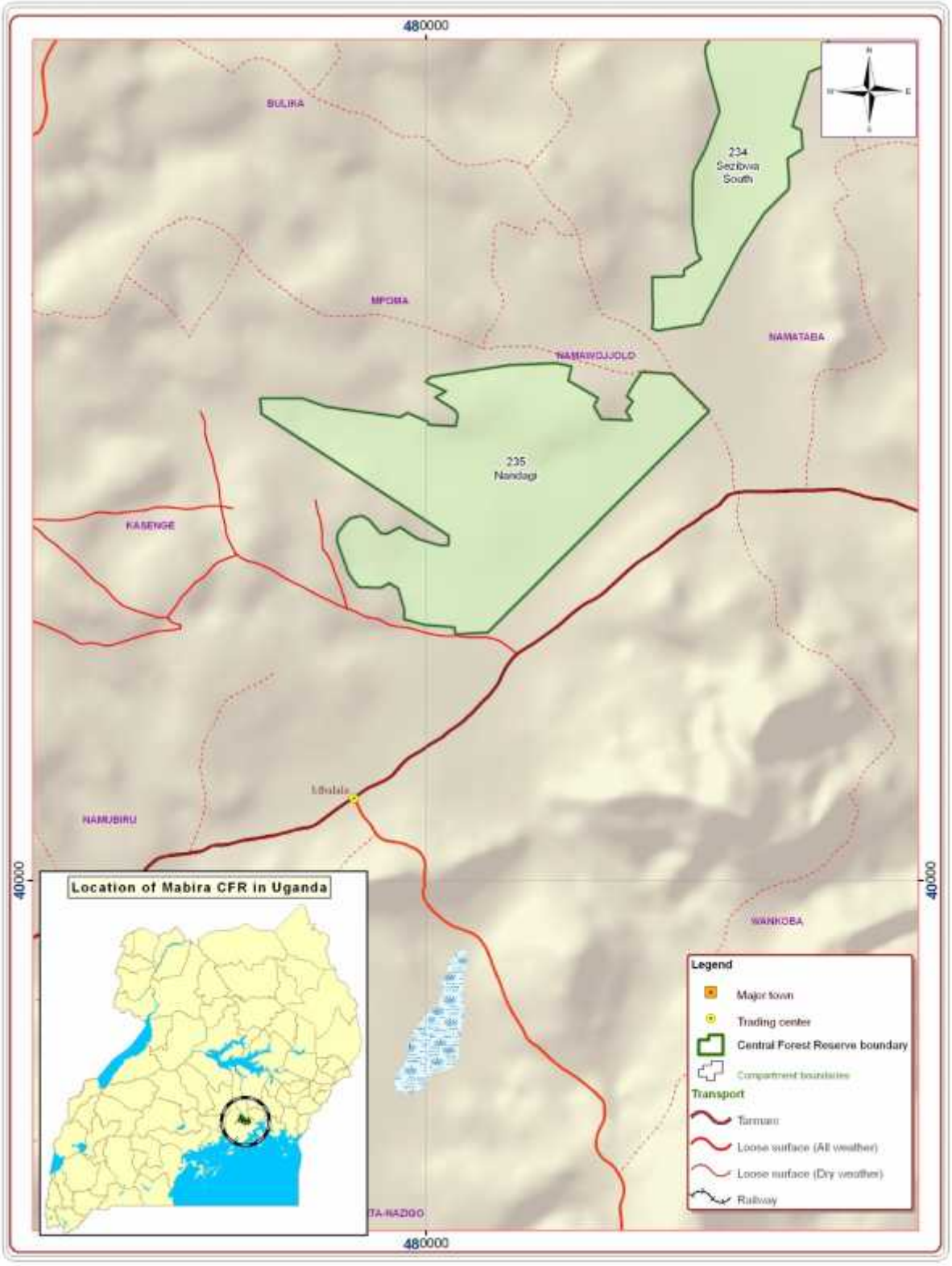

Figure 5. Nandagi Forest Reserve which is one of the study sites

3.6. Kalagala forest reserve: Kalagala forest reserve is along one section of river Nile in Kalagala village. Parts of the reserve are cultivated with small-scale gardens and tree plantations of *Terminalia sp* while the natural vegetation forms a stretch of about 3km. On this stretch is a mosaic of bushed thickets and forested patches.

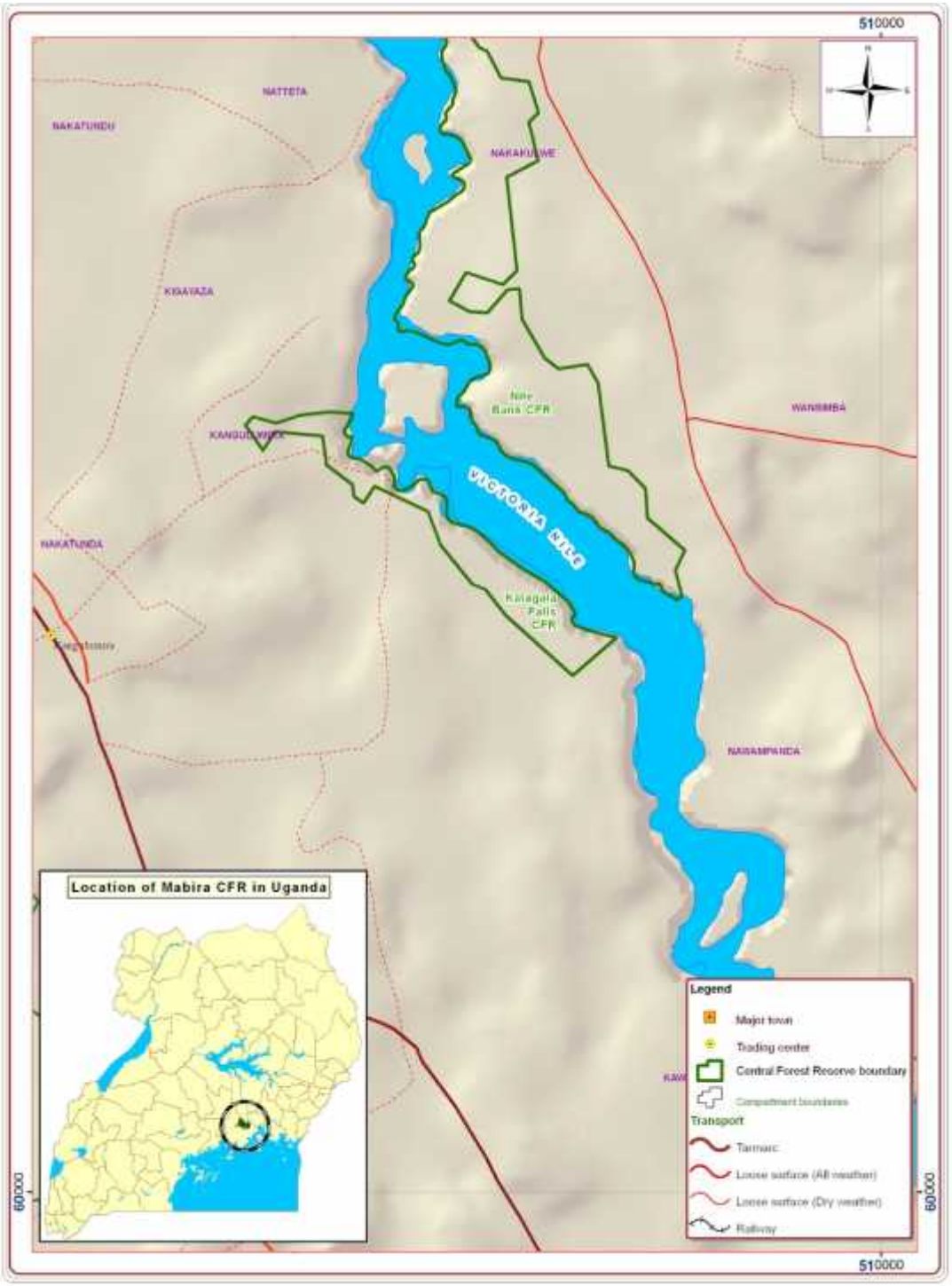

Figure 6. Kalagala Falls, one of the study sites within the Mabira Ecosystem

3.7. Threats to the Integrity of the Mabira Forest Reserves

The key threats to the Mabira Ecosystem as listed in the Forest Management Plan are the following:

i. Unsustainable forest harvesting
ii. Agricultural encroachment
iii. Population pressure
iv. Illegal acquisition of land titles in the forest/land grabbing
v. Infrastructural development e.g. Roads, power lines, dams, industries, etc.
vi. Political interference
vii. Inadequate funding
viii. Hostilities of some communities
ix. Invasive species - Broussonetia papyrifera (paper mulberry)
x. Uncontrolled brick making and sand mining
xi. Unclear forest boundaries
xii. Urbanization
xiii. Industrialization
xiv. Uprooting planted trees
xv. Forest fires
xvi. Diseases and pests
xvii. Vermin

Analyzing the threats to the integrity of the Mabira forest ecosystem. Potential sources of threats could be from overexploitation, encroachment, invasive alien species, and pollution; climate change etc.

A) Analyzing the threats to the integrity of the Mabira forest ecosystem

Threats to the integrity of Mabira forest reserves will be analysed. A detailed description of the surrounding areas will be undertaken; and potential threats evaluated; identification of disturbances and potential impacts arising from disturbances will be done. The threats could be from ove-exploitation, encroachment, invasive alien species, and pollution among others. Within the PSPs, signs of various threats e.g. over-exploitation (e.g. pit sawing stumps), encroachment (signs of cultivation), invasive alien species, and pollution etc will be recorded. We propose to undertake a seven step threat identification and analysis process as suggested by Salafsky and Margoluis, (1999). These steps are highlighted below:

i) Defining forest area: The forest reserve area will be defined (spatially and temporally), e.g. forest reserves interface over two years.

ii) Listing of threats: All direct threats to the biodiversity at the forest site will be listed.

iii) Ranking of threats: Each threat will be ranked based on 3 criteria: area, intensity and urgency. Area refers to the percentage of the habitats in the site that the threat will affect. Intensity refers to the impact of the threat within a micro-site - will the threat completely destroy the habitat in a small locality, or will it only cause minor changes? Urgency refers to the immediacy of the threat - will the threat occur tomorrow or in 15 years? If there are 4 threats, then the highest ranked threat for each criterion receives a score of 4, and the lowest ranked threat receives a score of 1. We will try not to exceed five or six threats!

iv) Total ranking: The scores across all three criteria will be added up to get a total ranking.

v) Extent to which threat has been met: Determine the degree to which each threat has been met (this will require to first agreeing what "100% threat met" means for each threat).

vi) Calculating the raw scores: The raw score for each threat will be calculated. The total ranking will be multiplied by the percentage calculated in step 5 to get the raw score for each threat.

vii) Threat reduction index: The final threat reduction index score will be calculated. The raw scores for all threats will be added, then divided by the sum of the total rankings, and multiplied by 100 to get the threat reduction assessment index. The raw scores will be totaled and then divided by the total ranking to get the final threat reduction assessment index, as a percentage. This will be undertaken using the tool shown in Appendix Tables 1a & 1b) to assess threats:

These steps will enable us assess drivers and their associated agents. They will also enable investigation of the existence of safeguards, as well as size and representativeness of the key habitats. Quality and quantity of key ecosystem services; pest and disease management; use of prohibited products; and procedures, control and monitoring measures of exotic species, forest conversion from natural forest to other land uses.

Table 2: Tool for assessing threats to the forest reserves [PART A]

SITE NAME											
SITE DESCRIPTION											
ASSESSMENT PERIOD								COMPLETED ON			
COMPLETED BY											
THREATS		CRITERIA RANKINGS				TOTAL RANKING		% THREAT REDUCED		RAW SCORE	
		AREA		INTENSITY	URGENCY						
A											
B											
C											
D											
E											
F											
G											
TOTAL											
THREAT INDEX FORMULA		TOTAL SCORE		TOTAL RANKING		CONVERT TO PERCENTAGE				THREAT INDEX	
THREAT INDEX CALCULATION			÷		=		×	100	=		

Table 1b: Proposed tool for assessing threats to the forest reserves [PART B]

EXPLANATION OF THREATS	
A	Threat
	100% Reduction =
B	Threat
	100% Reduction =
C	Threat
	100% Reduction =
D	Threat
	100% Reduction =
E	Threat
	100% Reduction =
G	Threat
	100% Reduction =

3.8. Sample design

The distribution of monitoring activities is designed to ensure that data are representative when this is achievable and desirable. Detailed sampling designs, techniques and tools for gathering data are proposed in this plan.

The approaches will promote integration of the various monitoring components in the long term and allow inferences to be made. The parameter(s) to be sampled at each site, sample frequencies, and the protocols are provided. The plan explains how the sampling design will ensure that the data are representative and is appropriate in helping answer various questions. The frequency of sampling for the various parameters is indicated. Different stakeholders including local communities and partner institutions can use the designs and tools developed.

Stratification is used to ensure sufficient coverage of different parts of the forest reserve. Various parameters are included to help monitor and understand trends of changes. Specific features, characteristics and requirements of each are given prominence in this plan.

The sampling design for the cological components is described as follows:
i) All Permanent Sample Plots (PSPs) located in Mabira Forest Reserve (and the smaller reserves, if any) will be included in monitoring. Data from those that have been assessed recently will be used as baseline.

ii) Where PSPs do not exist, for example in the smaller reserves of Namakupa, Nandagi, Namawanyi, Namananga, and Kalagala falls, additional PSPs may be established based on a stratified random approach dependent on the current management zones (related to disturbance/management category). The whole of the Mabira management plan area (composed of six central forest reserves covers a total area of 31, 293 hectares. The sites that have undergone different intensities of disturbance (particularly in the case of Mabira Forest Reserve) and it is important to monitor the recovery process. The zones with different disturbance histories are summarized in Table 3.

Table 3. Disturbance categories to be used as strata for sampling Mabira Forest Reserves

Main Vegetation Type	Description	Site Category (Years since abandonment of disturbance)
A: Encroached	Plots in site less than 3 years after the last encroachment	0-3 years
B: Encroached	Vegetation types in plots abandoned between 3 and 10 years	3-10 years
C: Encroached	Vegetation types in plots abandoned between 10 and 30 years ago	10-30 years
D: Logged	Plots in selectively harvested or mechanically logged (pre and post 1950)	>30 years ago
E: Essentially Undisturbed old growth	Plots that lie in areas that were never harvested or encroached (nature reserve)	Undisturbed

CHAPTER FOUR

4.0. MONITORING PROTOCOLS

4.1. Monitoring Protocol for Vegetation Change

Introduction

Monitoring vegetation change will be done in the PSPs where various plants related parameters would be monitored. The trees are measured for dbh and identified. Those plants that cannot be named in the field will be collected and identified at Makerere University Herbarium. Identification will be aided by the use of identification books such as the Forest Trees of Uganda (by Hamilton A.C.), Indigenous Trees of Uganda (By Eggeling, W.J.) and the Flora of Tropical East Africa (various authors). If a plant cannot be identified to species level during surveys, specimens will be preserved and identified at Makerere University herbarium. The classification system used is Angiosperm Phylogeny Group III (APG III).

Monitoring objectives

(i) Reasons for monitoring:
To establish causes of vegetation change in the Mabira Forest Reserves
To establish if the alien species are turning out to be invasive

(ii) Monitoring population / area and sub-units:
The entire Mabira Ecosystem (Main Forest Block and Smaller Reserves) covering zones of different disturbance regimes

(iii) Frequency of surveillance:
Every one-year.

(iv) Users of results
The Mabira management and different resource user groups
Different local communities adjacent to the boundary

Monitoring methods

(i) Observation / data types:
PSPs
Record incidences of fire and other illegal activities within the PSPs
Record incidences of invasives within one kilometre from the park boundary inside the park.

(ii) Data type:
Number of incidences, coverage (Size), location

(iii) Complete census or sample survey:
Sample survey

- Stratification of the area based on vegetation zones.
- Establishment of sample plots systematically for counts.
- Establishment of Permanent Sample Plots.

(iv) Sample area / method:
Need for more information
(v) Timing of observations: Every three months

4.2. Monitoring protocols for Fauna and Flora

4.2.1. Monitoring protocol for large and medium sized mammals

Monitoring objectives

(i) Reasons for monitoring:

- Some of the large mammals are indicator species
- Some mammals are taxa of conservation concern
- Populations of some mammals are probably declining over the years due to various reasons such as poaching and other human activities.

(ii) Conservation objectives for the resource:

To maintain the frequency of occurrence and distributional range of mammals in Mabira Forest

(iii) Monitoring population / area and sub-units:

Sampling of mammals should be carried out in vegetation zones where they are known to occur. The opportunistic samples should be taken in cases where mammals move outside their ranges for crop raids.

(iv) Determining the Frequency of occurrence:
Mammal counts should be made every six months (or on a yearly basis if resources are scarce). The monitoring methods to be used include:

Monitoring methods

The methods depend on the taxon, size of animal, terrain, and preferred habitat or vegetation zones. Dung piles, duiker droppings, and nests along transects should be used to calculate animal abundance/density indices. The signs are easier to find as compared to the respective individuals. Animal sign encounter rates can be determined and used as indices of abundance for monitoring trends. Transects should be walked during the same season every year or whenever monitoring is done in order to make the results comparable. Changes between the dry and wet seasons can have a strong effect on the number and quality of visible animal signs e.g. dung piles and nests disappear more rapidly in the wet season than in the dry season. However, falling leaves in the dry season may cover the animal signs making them difficult to see. One-off transects are recommended for monitoring the mammal species in Mabira Forest and the smaller reserves. The one-off transects are cut at the time of data collection. This reduces the cost of maintaining permanent transects even in the years the monitoring is not being done.

Locating transects in space: since the surveys are repeated as part of a monitoring process, it is necessary to locate sites where they were undertaken. Much of the environmental data taken has possible application in the ground-truthing of satellite images. This is important if the capacity to use satellite images to monitor large scale changes in forest cover is realised. The location of the start and end of each transect should be recorded using GPS (from the nearest convenient open area) and waypoints taken at regular intervals along the line as opportunities arise, particularly at points likely to feature on maps, photographs or satellite images, such as river confluences.

Human activity: Information on human activity observed on transects provides an index of the type and intensity of human use of an area. These indices may be directly correlated with changes in faunal

abundance over time. They also provide a measure to relate to people's perceptions of their use of and impact on forest resources. For each encounter of a human sign, the type of evidence, the estimated age and the distance along the-transect should be recorded.

Habitat description: Recording vegetation cover should be done based on the following scale: High closed forest (canopy >40%, >15 m high); High open forest (canopy <40%, >15m high); Low closed forest (canopy >40%, <15m high); Low open forest (canopy <40%, <15m high); swamp; herbaceous (clearing >30m diameter); grassland >30m diameter). Other environmental variables that can be recorded include: altitude; direction of slope/aspect (compass bearing facing down slope-use angles not symbols); angle of slope; position on slope/catenary position (Valley/Gully, Slope (Upper/Mid/Lower), Hill top/Ridge).

Line-transect counts: Line-transect sampling is based on the assumption that the probability of detecting an animal, nest or dung pile decreases with increased distance from the line of travel. Line-transect analyses calculate densities of signs using perpendicular distance measurements to estimate a function describing the probability of seeing animal signs, such as dung or nests at any given distance from the transect line. The analyses rely on the distribution of perpendicular distance measures along transects to calculate a detection probability. For each sign e.g. dung pile, or duiker dung pellets:

i) Record distance from the start of transect
ii) Perpendicular distance from the centre line of the, transect, to the middle of the sign (clearly distinguish in the notes those visible from the transect from those only seen once you left the line). For tree nests, estimate where a vertical projection from the centre of the nest would hit the ground and measure from this point to the transect (not from the base of the tree it is in). If the trail passes through the centre of a group of nests, find the nest group centre by measuring to the near edge of the nearest nest and the far edge of the furthest nest and divide by two.
iii) Estimate the age of nests or dung:

Nest

a. Fresh nest - odour, and usually dung, present;
b. Recent nest- vegetation still green for the most part but no odour, dung often still present;
c. Old nest- intact, but all vegetation dead and dung absent;
d. Very old- decomposition advanced;

Duiker dung pellets:

a. Fresh - odour and a sheen (fatty acids) still present;
b. Recent - pellets with dulled surface, but no mould;
c. Old - may have a patina of mould, pellets beginning to break down;
d. Very Old - pellets crumbling, dispersed and covered by leaf fall;

Aging of animal signs helps in determining whether the sign is of the same “sign event” (made by same animal, and/or at the same time but spread out) or a result of a different “sign event” but in the same area. Training in the use of these methods is required to make observer records consistent.

Monitoring Requirements

(i) Personnel responsible and time required: the Sector Manager will coordinate monitoring with sample locations identified by the team of Rangers. Trained Field Staff must carry out surveys.

(ii) Experience training necessary: Training must be given to all staff undertaking the surveys.

(iii) Equipment required: GPS, map of Mabira Forest, and marked transects photographs of key landmarks to aid relocation. Standard recording forms (with copies of code sheets) should be used. Binoculars, camera, tape measure for measuring tracks and Field safety kit are required.

(iv) Data storage: Original Data Recording Forms and maps should be safely stored within each Field Office and the data entered onto the standard Excel summary form before entry. Field monitoring reports must be submitted with the data. These should document the

(v) Data analysis: A decline in presence should be of concern and should trigger further investigations and appropriate management measures. Changes relative abundance measure and longer-term trends may be examined by relevant statistics if necessary.

Simple estimates of density from line-transect data: Assume the data to represent 94 detections along a 1-km transect (with observations being made on both sides).

Analysis based on exact distances: This analysis assumes a half-normal detectability function.

n = total number of animal signs detected; x_i = perpendicular distance of the ith animal sign detected from the transect line; L = length of transect

Density around the transect is estimated as: $D = n \sqrt{[2n / \pi \sum_i (x_i^2)]} / (2L)$

For example data, $\sum_i (x_i^2) = 109{,}146\ m^2$.

The estimate is thus: $D = 94 \sqrt{(188/109{,}146\pi)} / 2000$

$= 0.00110$ animals per $m^2 = 11.0$ per hectare

Analysis based on DISTANCE software: provides more estimates (confidence limits, goodness-of-fit tests, etc); allows various analyses; is easy to use.

A Data Explorer utility allows entry and manipulation of data and to specify the sampling distribution and intensity. The software is available in DOS- and Windows-based formats from http://www.ruwpa.st-and.ac.uk/distance/.

(vi) Reporting procedures:

Reporting could be done at least every two years to cater for seasonal trends.

(vii) Indicators: Usage depends on the taxa and sampling methods.

- Number of individuals of species/km;
- Number of snares/km
- Carcasses/species/km
- Number of suspects of hunting or poaching /month
- Number of animal killing incidents/month
- Number of animal shooting /month
- Number of poacher camps/month

Data Collection Form: Large Mammal Monitoring

Enumerator: ……

Title: ……

Other observers / trainees: ……

Forest reserve area: ……

Altitude - min (m): ……

GPS Coordinates: ……

Sampling start time: …… End time: ……

Transect number: ……

S. no.	Species	No. of Animals	Altitude	Slope	Habitat	Remarks

Other observations	Snares	Carcasses	Suspected hunters/ poachers and evidence			Remarks
			Guns	Bows/arrows	Camps	

4.2.2. Protocols for monitoring small mammals

Monitoring Objectives
Three types of live traps are most commonly used:

i). Longworth live trap: expensive but can be locked in the open position so that they can be prebaited. Have an optional shrew hole to permit small shrews to escape (most shrews die within a few hours in a live trap)
ii). Sherman live traps: lightweight aluminium traps. Are light in weight; the folding types are easy to store and carry in the field. Difficult to clean; may cause inadvertent trap mortality, among young animals; relatively, inexpensive.
iii). Wire-mesh traps: used for larger species of small mammals, such as squirrels.

A trapping design where a trapping grid is surveyed in a checkerboard configuration and traps are placed at the checkerboard intersections, which are 15-30 m apart. The typical trapping grid is 10 by 10 but a larger configuration would be better particularly for density estimation. This should be done in a stratified fashion based on the vegetation types and GPS locations of the grid taken.

To protect small mammals from cold and rain, boards should be used to cover live traps. Food is used to lure animals into the traps, but also to sustain them once they have been caught. Some experimentation is needed to determine the best bait for each species. Traps are usually visited twice a day in early morning and evening, but accumulating evidence suggests that four checks a day would be better, to reduce the stress of capture.

Analysis: CPUE (Catch Per Unit Effort analysis): the effort will be the number of traps laid, while catch is the number of individuals of the same species captured.

Capture-recapture – open populations: used when the small mammal captures are marked and returned into the population. Then numbers of recaptured individuals related to unmarked individuals are determined. Such data can be analyzed by software for implementing Jolly-Seber model – POPAN.

Bats
Bats are among the most difficult mammals to census because of their mobility. Bats roost by day and are active at night. Most census methods for bats are applied to these roost sites. Bats may be counted at the roost site or as they emerge from the site. They could also be trapped using mist nets.

Analysis – The method is assumed to be, a complete/total population count so there is no need for statistical analysis.

Human activity and habitat variables of sites where small mammals are traped/seen should be recorded as for large mammals.

4.2.3. Monitoring protocol for Selected Species of Birds

Monitoring objectives

(i) Reasons for monitoring:

- Forest birds are of conservation importance, some of them globally.
- Some forest birds are indicators of high forest quality or ecological value.

(ii) Conservation objectives

To maintain or increase the current levels of breeding bird species richness and population size in selected forest indicator species.

(iii) Monitoring population / area and sub-units:

(iv) Frequency of surveillance:

Every year

Monitoring methods

(i) Observation / data types

Direct visual observations and calls/songs of birds, mostly ascribed to species

Bird species richness

Relative bird abundance from Timed Species Count (TSC)

Frequency of species occurrences per 10-minute observation period

Sampling methods

(a)Temporary or permanent sample location:

Permanent primary and secondary routes.

Monitoring requirements

(i) Personnel responsible and time required:

Teams of at least two ornithologists

(ii) Experience/ training necessary:

At least one or two of the rangers need to acquire skills in ornithology and be fully experienced with forest bird identification

(iii) Equipment required:

Binoculars (8x or 10x magnification), map with marked sample areas and coordinates,

Compass, GPS, field notebook, standard recording forms, stopwatch, and field first aid / safety kit.

(iv)Data storage

Original Data Recording Forms should be safely stored within each Field Office and the data entered into the standard Excel summary form.

Theoretical perspective

Birds of conservation concern should be monitored by sight or sound along permanent transects (as opposed to one-off transects used for large mammals). Transects should be kept clear such that movement is discrete to avoid scaring off the birds.

Point counts (or point transects) undertaken from a fixed location for a fixed time are recommended. This can be done any time of the year, and not restricted to the breeding season. Birds are recorded along a predefined route within a predefined survey unit. Recording is done at regular intervals along the route and for a given duration at each point.

Point count stations (the position from which the count is made) should be laid out in a regular/systematic manner and stratified according to vegetation type. Count stations should be 200m apart. Too much time will be wasted moving between counting stations if the distance is too large. More than 20 point counts are needed from each stratum; point counting is not suitable technique for small sites. Twenty counts can readily be made in a morning starting soon at dawn.

Wait for a set time (a minute), to allow the birds to settle down following your arrival then count for 5 or 10 min at each station depending on habitat and bird communities present. Record each bird seen or heard counting each individual only once at each station. Most registrations will occur in the first few minutes.

In habitats with high densities of birds, it is easy to confuse different individuals or to be uncertain whether you have already recorded a particular individual or not. A simple way of resolving this is to record their approximate positions in a notebook. This can be divided into four quarters, and birds recorded in these quarters (e.g., left and to the front, right and behind, etc) marked accordingly by species code.

The method is suited for: (i) dense habitats such as forest and scrub; (ii) more cryptic, shy and skulking species; (iii) species-rich habitats; (iv) individual species or groups of species; (v) situations where access is restricted and the terrain is difficult; and (vi) bird-habitat studies. It is efficient in terms of the quantity of data collected per unit of effort expended. (v) Although time is lost moving between points, counts give time to spot and identify shy birds. Once counting has been done, it is advisable to repeat each transect one or more times to maximize the chance of recording all species since bird activity often varies across seasons (either because the species is absent, or because it becomes unobtrustive at certain times). Two counts per nesting season is usually the minimum for monitoring studies.

To obtain an index of abundance, count up to an unlimited distance or only within an arbitrary range such as 30 m from the observer, then calculate number of birds per unit length of transect. There are ways of incorporating distance estimation into point counts to enable detectability to be assessed and density calculated: Use two counting bands, and record birds up to a fixed distance (e.g. 30 m) and beyond that distance separately. Formulae (based on possible manner in which detectability falls off with distance) can then be used to calculate the density of each species. By recording birds in several distance bands, or to the exact distances, a range of more sophisticated methods can be tested and applied.

Use a GPS or mark the locations of counting stations in an obvious manner (e.g. using brightly coloured tape). A high level of observing experience is required of observers. Human activity and habitat variables of sites where bird species are seen or heard should be recorded.

Analysis

Point counts can be used to provide estimates of the relative abundance of each species or if coupled with distance estimation, from the point count stations to all birds seen or heard. This provides a useful measure of bird detectability and allows species-by-species density estimation.

Simple estimates of density from point-transect data: Assume the data representing 63 detections made on 40 points.

Analysis based on exact distances: this analysis assumes a half-normal detectability function.

n = total number of animals detected

x_i = distance of the ith animal detected from point

k = number of points

Density in the area in which the points fell is estimated as:

$$D = n^2 / [\pi k \sum_i (x_i^2)]$$

For the example data $\sum_i (x_i^2) = 91118 m^2$, so,

$$D = 63^2 / [\pi \times 40 \times 91118]$$

$$= 0.00035 \text{ animals per } m^2 = 3.5 \text{ per hectare}$$

Analysis based on two recording zones: this analysis assumes a negative-exponential detectability function.

The first zone is a circle of radius Z around the point; the second is outside that, to infinity.

n_1 = number of animals detected in the first zone

n_2 = number of animals detected in the second zone

Density in the area in which the points fell is estimated as

$$D = \{(n_1 + n_2) \log_e [(n_1 + n_2)/n_2]\}/(\pi k Z^2)$$

For the example data, $Z = 30$ m, $n_1 = 33$ and $n_2 = 30$.

The estimate is thus

$$D = \{63 \log_e (63/30)\}/(\pi \times 40 \times 900)$$

$$= 0.00041 \text{ animals per } m^2 = 4.1 \text{ per hectare}$$

Distance sampling: enables assessing the degree to which our ability to detect birds differs in various habitats and at various times. The software and further information to undertake these analyses are freely available at http://www.ruwpa.st-and.ac.uk/distance.

Datasheet for Birds

Date (day/month/year)……..…
Counter details……..
Name of lead counter……....
Other observers / trainees present……..
Forest reserve Area and Location……..……
Nearest town / village…….……...
Primary plot GPS coordinates: SE corner: NW corner …….
Altitude - min (m) ……...……..
Altitude - max: Aspect ……..……
Broad habitat types: % cover within survey plot…….……..
Start time……End time…….
Weather conditions……...…….

Time	Species	Number of Birds				Remarks
		Juveniles	Sub-Adults	Adults	Age Unknown	

4.2.4. Monitoring protocol for Reptiles and Amphibians

Monitoring objectives

(i) Reasons for monitoring

Reptiles and Amphibians are important species for monitoring because they are ecological indicators of the health of ecosystems.

(ii) Conservation objectives

To guide maintenance of the current levels of reptiles and Amphibians

Monitoring methods

Methods for monitoring reptiles

This involves capturing individuals to estimate the abundance. Reptiles are mobile and/or shy and cryptic, so not all members of a population will be counted by sight. Hand capturing is used for small terrestrial snakes, lizards and chameleons. The small terrestrial reptiles are captured by hand after searching for them in microhabitats they frequent. Small reptiles are found most easily by looking in potential shelter sites (under rocks, logs or bark of dead trees). Gardening gloves should always be used to guard against cuts and bites or stings from various anthropods. Care should routinely be taken to avoid being bitten by venomous snakes. A small hand-held torch is invaluable for looking into cracks or holes in search of reptiles.

Count or capture the reptiles during their activity periods. Mid-morning is a good time to search for many diurnal species, while the reptile is basking. Walk slowly with the sun at the back, pausing to scan suitable microhabitats. Nocturnal species can be found using torchlight. Some species are best detected by their dull eye shine when a dull white light is used to search for them; the flashlight should be held close to the observer's eyes.

Sampling should be done along the permanent transects used for birds. Get off transects when favoured microhabitats are spotted. Human activity and habitat variables should be recorded to accompany the records. Training of fieldworkers is necessary to develop skills for species identification, safe capture, and handling.

Data Analysis: Catch per unit effort – where effort is calculated as the number of fieldworkers involved x time spent searching and catch is the number of individuals captured. If effort varies from day to day, divide numbers caught by a measure of effort for the day to give the catch per unit effort.

Methods for monitoring amphibians

Transect sampling is recommended for the terrestrial amphibian species. Walk along transects searching for the animals. Logs, stones and other objects within a specified distance of the transect line (e.g. 2 m) should be turned over and checked. Transect sampling can be used to relate amphibian abundance to habitat variables. This method may yield low numbers except where a species is particularly abundant. Make at least 20 walks along a transect to detect species present. Human activity and habitat variables should be recorded as for large mammals. Training of fieldworkers is required.

Data storage and Analysis: Reptile and Amphibian Samples collected should be deposited at the Makerere University Museum for future reference. The basic information should allow the creation of a

species list for each site. The species list can be used to calculate basic diversity indices.The number of animals detected per unit of person-hours provides an approximate estimate of numbers as used in reptiles.

In general, the frequency of surveillance should be every tree months (quarterly): Other methods may involve the use of: Drift fences, Pitfall traps, Double-ended funnel traps, Visual encounter surveys (VES) and Audio Strip Transects.

Monitoring Requirements

Personnel responsible and time required

At least two rangers should be trained to acquire basic herpetology skills. At least two weeks of training are recommended to cover: Field guide use and identification.

Equipment

- Standard camping equipment, medical supplies and food
- Animal marking equipment: Nail polish, 3-edged file, and cuticle scissors.
- Assorted specimen bags and bottles;
- Binoculars; Clinometer; Compass; Coverboards; Digital camera
- Field guides and Anuran call tape for reference
- Flagging tape; Frye nets; GPS unit; Hand gloves; Hand lens; Hand spades or rake
- Hip chain and topofil thread; Kestrel temperature and wind gauge
- Light plant press; Longworth live traps; Maps of the area; Minnow traps
- Pair hip waders; Pair leather gloves (for large snake captures)
- Permanent marker pen; Plastic ziplock baggs & data sheets; Rangefinder
- Secateurs or machete; Sherman traps; Snake fork; Snake sticks
- Snake tubes for handling venomous snakes
- Standard field kit: notebook, check-sheets, Clipboard, pens, pencils, ruler, small scissors, Sharpie markers, hand sanitizer, erasers etc.
- Stop watches; tape measure; Torch; Water thermometer and pH meter; Wire mesh traps; Wrist watch;

Datasheet: Amphibians and Reptiles

DATE:_____ OBSERVER:_____ LOCATION:_____ pg___of___

Start temp (C):_____ End temp (C):_____ %clouds:_____ Rain:_____ Wind speed:_____ Start time:_____ End time:_____

Wind speed codes: 0=no movement; 1= calm, smoke drifts; 2=light, feel on face, leaves rustle;
3=gentle, leaves in constant motion, flags extend; 4=moderate, dust and paper rises; 5=fast, small trees sway, crested wavelets on water.

Det. Type=Detection type; v=visual; c=capture; a=auditory; s=sign. Sub.=Substrate type: R=rock; L=log; W=water; V=vegetation; X=litter. Age: A=adult; M=metamorph; L=tadpole; E=egg mass.

Sex: M/F/U.

Status: G=gravid; S=swollen testes; otherwise leave this column blank.

Area	Time	Species	Det. Type	Sub.	Mark	Total length				SVL				Age	Sex	Status	Other type

Data entered by:____ checked by:____

4.3. Monitoring Protocol for Human Impacts

Fire Monitoring Datasheet

Date and time fire detected
Who detected the fire
GPS coordinates of burnt site
Fire origin (inside/outside)
Cause of fire
Location of fire (Name of site if possible & GPS coordinates)
Type of fire (ground, surface, crown, ground/crown etc)
Date and time of arrival of various parties on the scene
Date and time fire extinguished
Direction of wind: blowing from
Strength of wind (nil, light, medium, strong)
Ground slope (nil, gentle, moderate, steep)
Fuel: type (grass, leaves, branches etc)
quantity (light, medium, heavy)
No. of forest reserve staff fighting fire
No. of volunteers fighting fire and names
Damage done:

i) Estimated area burned [measure or pace the length L (largest distance from the burnt edge to burnt edge) and width W (largest distance perpendicular to the length) then use the formula for an ellipse (most burnt areas are shaped at least roughly like an ellipse; $A=\pi LW/4$)]

ii) Fire intensity classified as:

0 = no burn;
1 = light ground fire that destroyed the litter (dead leaf) layer and lightly damaged the sapling layer but most saplings still with green leaves;
2 = sapling layer severely damaged up to 5 m and some damage to canopy trees; and
3 = sapling layer destroyed, mid-canopy severely damaged and canopy damaged

iii) Tree damage should be assessed as:

0 = fire did not touch tree;
1 = fire touched tree but no damage was incurred;
2 = fire touched tree and tree's bark was burned;
3 = fire touched tree and tree was burned into the cambium; and
4 = fire touched tree and tree incurred severe damage to its cambium (>50% of the bole burned) or fell as a result of burning

What suppression measures were taken (how was the fire fought, kind and quantity of tools, direction of attack)
How effective were the suppression measures
What post-suppression measures were taken?

TOURIST IMPACTS DATA SHEET

Monitoring objectives

(i) Reasons for monitoring:

- To minimise the negative impacts of tourism on the Mabira and environment and increase visitor /tourist satisfaction

(ii) Conservation objectives for the resource:

- To maintain the carrying capacity of the Mabira for tourism

(iii) Monitoring habitats and campsites

- Visitor and ecological surveys in habitats and campsites used by tourists.

(iv) Frequency of assessment

- Visitor and ecological surveys will be done quarterly.

Monitoring methods

(i) Observation type

- Ecological impacts
- Condition of the vegetation

(ii) Data type:

- Litter
- Inadequate disposal of waste
- Presence of wildlife
- Levels of noise
- Size of campsite

(iii) Complete census or sample survey:

- Sampling around tourist routes and campsites

(iv) Sample area / time period:

(v) Monitoring Requirements

- Personnel responsible and time required:
- Experience training necessary:
- Equipment required:
- Data storage
- Data analysis

(vi) Reporting procedures:

- Store data in the recently completed database.

(vii) Indicators

- Width of trails at selected points
- Volume litter collected by ranger visit
- Check toilets visually
- Number of complaints about litter/waste/6 months

Data Collection Forms: Tourism Impacts

Date……

Location ……..

GPS coordinates……..

Type of impact: ……..

Off trail trampling

Width of trail……..

Breakage and bruising of plant stems……

Reduced plant vigor……..

Reduced plant regeneration…….

loss of ground cover…….

change in plant species composition…….

accelerated erosion…….

others (please state) ……

Volume of non-biodegradable materials collected……

Toilet dirtiness…….

Complaints received……..

Human-wildlife Conflict Data Sheet

General information

- Date
- Location
- GPS coordinates

Animals

- Species causing damage
- Timing of raiding behavior, i.e. diurnal/ nocturnal?
- Frequency of raiding (do animals come daily, weekly, or occasionally etc?)
- Where do wildlife species come from, i.e. are they moving out specific areas such as the forest reserve to enter fields or are they living in and around fields?
- Farmer's ranking of raiding species, i.e. species ranked from 'most' to 'least' troublesome sp. (sometimes useful to know something about the reasons why individuals rank a particular species as 'most troublesome')

Crops and farming strategies

- Location of farm,
- Description of surrounding vegetation and habitat type(s)
- Distance from village/house to farm
- List of main crops grown by farmer(s)
- Types of crops damaged by wildlife/domestic animals
- Quality of crops damaged (i.e. quality prior to damage event)
- Other crops present but not damaged
- Plant part(s) damaged, e.g. root/tuber, stem, leaves, flowers, fruits etc.
- Spatial distribution of crops within fields/farm, with particular reference to their location with respect to forest reserve boundaries, boundaries with un-cleared/fallow land, riverine forest, etc., i.e. potential wildlife refuge areas
- Whether neighbouring fields/gardens were raided
- Brief outline of the agricultural calendar e.g. timing of planting, crop protection, harvesting etc.
- Farmer's ranking of crops i.e. crops ranked from 'most important' to 'least important' (may also be useful to know why particular crops are ranked as important e.g. household food crops/cash crops etc.)
- Farmer's ranking of crops with respect to their vulnerability to crop damage by animals

Impact on farming households

- measure of crop losses
- farmer's estimate of crop losses (either as area lost or kgs lost)
- independent measure of area of standing crop damaged
- independent measure of no. of plants damaged/total no. plants (giving the percentage damage incurred)
- Conversion of area of crops damaged to kg/ha crops damaged
- Economic losses

Other damage (provide details)

- loss of human life
- injury to human beings
- destruction of farm infrastructure
- creation of an environment of fear
-

4.4. Monitoring protocol for Plant resource use

The focus should be on monitoring the most widely used resources such as medicinal plant use, harvesting *Acalypha* sp. for meat roasting skewers and craft materials by establishing permanent sample plots (of 10 x 10 m) where various parameters will be monitored. However, the plan will put in consideration any other resource use that may be suspected to have likely negative impacts on some particular resources. The different questions that will be addressed during the monitoring will vary depending on specific resources and methods that will be used.

Monitoring objectives

(i) Reasons for monitoring:

To guide sustainable utilization of relevant plant resources and maintain the plant diversity in Mabira

(ii) Monitoring population / area and sub-units:

Sampling of the plants will be done according to vegetation zones and areas of major resource use.

(iii) Frequency of surveillance:

Every 6 months

(iv) Users of Results

The Mabira management and different resource user groups

Monitoring methods

(i) Observation / data types:

Data will be collected using the methods agreed upon by the Mabira management and different resource user groups. For instance firewood harvesting will be estimated by number of average head loads converted into kilogrammes outside the forest reserve while stumps will be counted along the plots in the forest reserve. Medicinal plant collection will be estimated by the quantities in kilogrammes of materials harvested (leaves, bark or roots) outside the forest reserve while the debarkings will be counted along the transect.

(ii) Data type:

Measurement- diameter at breast height (dbh), height and canopy cover for Tree and Pole category (life form); Canopy cover will be measured.
Count (sapling and seedling, later for regeneration purpose)
Count: shrubs, stumps and debarking.

(iii) Complete census or sample survey:

Sample survey

- firstly stratification of the area based on resource harvests and vegetation
- laying of sample plots systematically for counts along transects
- laying of Permanent Sample Plots.

(iv) Sample area / method:

The sample area for plant resource harvest will be as follows;

- 25x20 m^2 (0.05 ha)- tree category (<30 cm dbh, overbark)
- 10x10 m^2 (0.01ha) - pole category (10-29.9 cm dbh, overbark)
- 5x5 m^2 (0.0025 ha)- sapling (4-9.9 cm dbh, overbark) and regeneration (4 cm<)

(v) Timing of observations: Monthly

Monitoring requirements

(i) Personnel responsible and time required:

Monitoring to be coordinated by Warden Research and Monitoring with sample locations identified by Field staffs and different resource user groups. Trained Field Staff must carry out surveys.

(ii) Experience training necessary:

Training must be given to all staff undertaking the surveys

(iii) Equipment required:

GPS, map of Mabira Forest Reserves, marked transects, photographs of key landmarks to aid relocation. Standard recording forms must be used, with copies of code sheets. Binoculars, camera, small tape measure for measuring tracks and paint and brush for marking, 50 meter tape, 30 meter tape, diameter tape, dendrometer, plant sample collecting bags, plant presses and a field safety kit.

(iv) Data storage

The reports should include: large scale maps indicating boundaries of multiple use zone and strata. The reports should include the original data forms.

(v)Data analysis

Changes resource use levels and trends may be examined by relevant statistics if necessary.

(vi) Reporting frequency:

Every six months

(vii) Health and safety

Forest work involves some inherent risks and hazards because of the places we go to and the activities we undertake. Following safety precautions applying to all fieldwork may minimize the risk substantially;

- If at all possible, avoid going alone to the field/forest.
- Wear clothing and footwear suitable for the weather, the activity and terrain
- Never smoke in forests or grassland, and take care when lightening fires
- Show extra care on cliffs and steep slopes
- Don't incur additional risks by e.g. climbing cliffs, walking on slippery rocks, or wading alone rivers, unless these activities are an essential part of the work
- Familiarize yourself with the direction and location of the nearby village/settlement and available communication networks
- Make sure you carry the First Aid and Emergency Kit

(viii) Indicators

The following monitoring indicators will be used.

- Number of harvesting signs /km
- Number of trails leading out of forest reserve/km
- Number of suspects illegally harvesting/month
- Number of legal/illegal plant resource harvesters
- Recovery/ regeneration rates/ potential.
- Trials of alternative harvest regimes

- Life-cycle dynamics and identification of limiting life stages
- Productivity
- Levels of harvest, including quantities harvested
- Impacts of harvest on the species harvested
- Impacts on other species

Data Collection Form: Plant Resource Use

Recorded By: ..... Date: .....

Name and Location of forest reserve area: .....

Plot No: .....

GPS points (N/E): .....

Altitude (m): ..... Slope (degree): .....

Sign of human impacts

Cutting of trees and other vegetation Yes/No, If Yes (Species).....

Logging Yes/No, If Yes (Species (no of cut stumps) .....

Non Timber Forest Products and/or Medicinal and Aromatic Plants (MAPs) collection Yes/No,

If Yes (Species and extent): .....

Grass cutting Yes/No, If Yes (Species): .....

Other impacts

Grazing Yes/No, If Yes which animals

Forest fire Yes/No

Over all condition of the forest reserve: regeneration / Pole / Trees

S. No.	Species	Diameter or circumference at breast height 9over back) in cm					Remarks
		Regeneration Dbh< 4cm	Saplings Dbh 4 to 9.9 cm	Poles and trees Dbh 10 cm and above			
				Dbh	Tree top	Dist. of tree from observer	

Appendix 10. Mechanisms for sustainable resources use

Locality and Biodata

Date	Respondent Age::
Village (LC1):	Education level:
Parish (LC2):	Household size
Sub-county	Occupation
Name	
Respondent Sex:	

Resource use

Resources extracted	Who extracts	location	Where extracted	Group or individual	When extracted	Part extracted	How extracted	How much	Domestic or sale	Seasonal abundance	Value addition	Time required	Distance forest reserve boundary

PSP No.		Mabira Forest	Compartment No./GPS location	Data date---------- Recorded by----------					
Quadrant No.	Tree No	Tree species names (Local /common)	Pole s 5-9 (cm)	10-19 (cm)	20-29 (cm)	30-39 (cm)	40-49 (cm)	50+ (cm)	Remarks

4.5. Monitoring Protocol for water quality

Objective

The objective of monitoring water quality is to see if there is a change in the catchment s pollution) and potential climate change effects that would compromise the quality and qu water in streams and rivers.

The proposed monitoring considers physical, chemical and biological aspects of water qua intended to be simple and quick to apply. The main parameters to be monitored include: river d electrical conductivity, surface water temperature, dissolved oxygen, pH, water transpare benthic macro-invertebrates.

Electrical conductivity (µS/cm): This is a measure of the ability of water to conduct electricity with level of human activities in the watershed and the nature of the underlying geology. It a with season being lower in the wet season and higher during the dry seasons. It is a recommer a YSI 30 conductivity meter be used as it has proved to be robust in Bwindi and Kibale Nation reserve studies.

Surface water temperature (^oC): Water temperature is extremely important for all fr ecosystems. This should be measured onsite using digital equipment such as conductivity and oxygen meters. With the threat of global climate change, stream water temperature is predicte

Dissolved oxygen (mg/l): Is a crucial requirement of all life in water. It is normally saturate flowing rivers. It is however expected to drop with a reduction in river discharge and an in water temperature. Other human impacts such as pollution may alter the concentration of oxyg

pH: Is a standard measure of the hydrogen ion concentration of the water and is represente logarithmic scale. A digital pH meter is recommended for use in monitoring.

Water transparency /clarity (cm): This will be indexed from a transparency tube fitted with a secchi disc at the bottom.

Benthic Macroinvertebrates

Sampling Protocol

1. A sample consists of three (3) $1m^2$, 1-minute duration, and vigorous kicks into the screen. The person holding the kick screen times the sample and tells the kicker when t
2. Sampling is to be done within a 100-m stream reach, the same reach that the Assessment is conducted in. The kicks should be spread over over this reach.
3. The first kick is done at the downstream-most location. The second and third kicks upstream of the first kick.
4. Kicks are done in three separate habitat types (e.g. different rock-size areas) and one done to include a leaf pack if it is present.

Sorting Protocol

i. All organisms are removed from screen and placed in a container
ii. Vegetation is taken off screen and shaken in a water-filled container to remove all orga

iii. About 5 minutes should be spent searching the net for organisms. If organisms are still present continue sorting until all are removed.

Labelling Protocol

i. Each sample label should contain the date the sample was collected, the name of the stream and site location, and the names of the collectors. Label should be written in pencil.
ii. Record the type of substrate present at the location where each kick was collected. Also record any comments that could affect the sampling procedure or the organisms captured. For example, factors such as high rains over the past week, a recent landslide, an empty bottle of pesticide found at site should be noted and recorded on the data sheet.

Equipment and Reagents Needed

The equipment needed include the following: Dissolved oxygen meters, conductivity meters, pH meters, stop clocks, red end rule, measuring tapes, kick screen samplers, Surber samplers or kick-nets for sampling aquatic insects, sample bottles, 5% formalin, ethanol, microscopes (for use in the laboratory) and GPS units.

Additional items needed include: Copies of sampling protocols, habitat assessment sheets, , containers for rinsing samples, vials/containers for organisms, forceps, labels, pencils, notebooks, boots.

Data sheet for bio-monitoring of streams

NAMES OF COLLECTORS_____
DATE SAMPLE COLLECTED_____STREAM NAME_____
SITE LOCATION_____
STREAM WIDTH_____STREAM DEPTH_____LEAF PACKS PRESENT?___
SUBSTRATE TYPES kick 1_____, Kick 2_____, Kick3_____
COMMENTS ON SITE? (e.g. recent landslide)_____
TAXON NAME (NUMBER OF INDIVIDUALS)

Ephemeroptera (E)
Baetidae____
Caenidae____
Heptageneidae____
Leptophlebiidae____
Ephemerellidae____
Trichorythidae____
Prosopistomatidae____

Coleoptera (indicate # larvae/adults)
Elmidae____/____
Gyrinidae____/____
Dytiscidae____/____
Hydrophilidae____/____
Helodidae (or Scirtidae)____/____
Psephenidae____/____

Odonata
Anisoptera: Aeschnidae____
Anisoptera: Gomphidae____
Anisoptera: Libellulidae____
Zygoptera: Calopterygidae____
Zygoptera: Chlorocyphidae____
Zygoptera: Lestidae____
Zygoptera: Protoneuridae____
Zygoptera: Coenagrioniidae_____

Hemiptera
Nepidae_____
Corixidae_____
Hydrometridae____
Naucoridae____
Veliidae_____

Plecoptera (P)
Perlidae____

Diptera
Tipulidae____
Tabanidae____
Chironomidae____
Ceratopogonidae____
Simuliidae____
Athericidae____
Dixidae____
Psychodidae____
Stratiomyidae____

Trichoptera (T)
Hydropsychidae____
Leptoceridae_____
Lepidostomatidae____
Philopotamidae____
Polycentropodidae____
Psychomyiidae____
Calamoceratidae____

Other fauna (e.g. snails, worms) _____
Total number of Taxa Collected__
 # EPT / Total Individuals (%)___

HABITAT ASSESSMENT SCORES
1. Bottom Substrate_____
2. Embededdedness_____
3. Stream Flow____ Range of flow estimates (m/sec)_____
4. Canopy Cover_____

5. Channel Alteration
6. Pool/Riffle Ratio
7. Bank Stability
8. Bank Vegetation: left bank____right _____
9. Streamside cover_____
10. Riparian Zone Width_____
TOTAL SCORE (sum 1-10)_____

CHAPTER FIVE

5.0. PRIORITY SITES AND TAXA OR SELCTED PARAMETERS FOR MONITORING

5.1. Plants and Vegetation Change

The plants and vegetation change will be monitored within the Permanent Sample Plots (PSPs) that exist within the Mabira Forest Reserve. Locations of the 10 PSPs within Mabira are shown in Figure xx. Five of the PSPs are located in the eastern part of the forest: [MAB/186/1, MAB/188/1, MAB/192/1, MAB/195/1, MAB/197/1] while the other five are located in the western part: [MAB/219/1, MAB/224/1, MAB/228/1, MAB/230/1, and MAB/234/1]. Baseline dbh measurements have been carried out in 2001 and re-measurements done in 2010 for marked and identified trees. Re-measurement procedures are described in detail in Alder (2002). The datasheet is shown in Table xx. In the case of the smaller reserves, a decision should be made concerning the possibility of establishing new PSPs within those reserves.

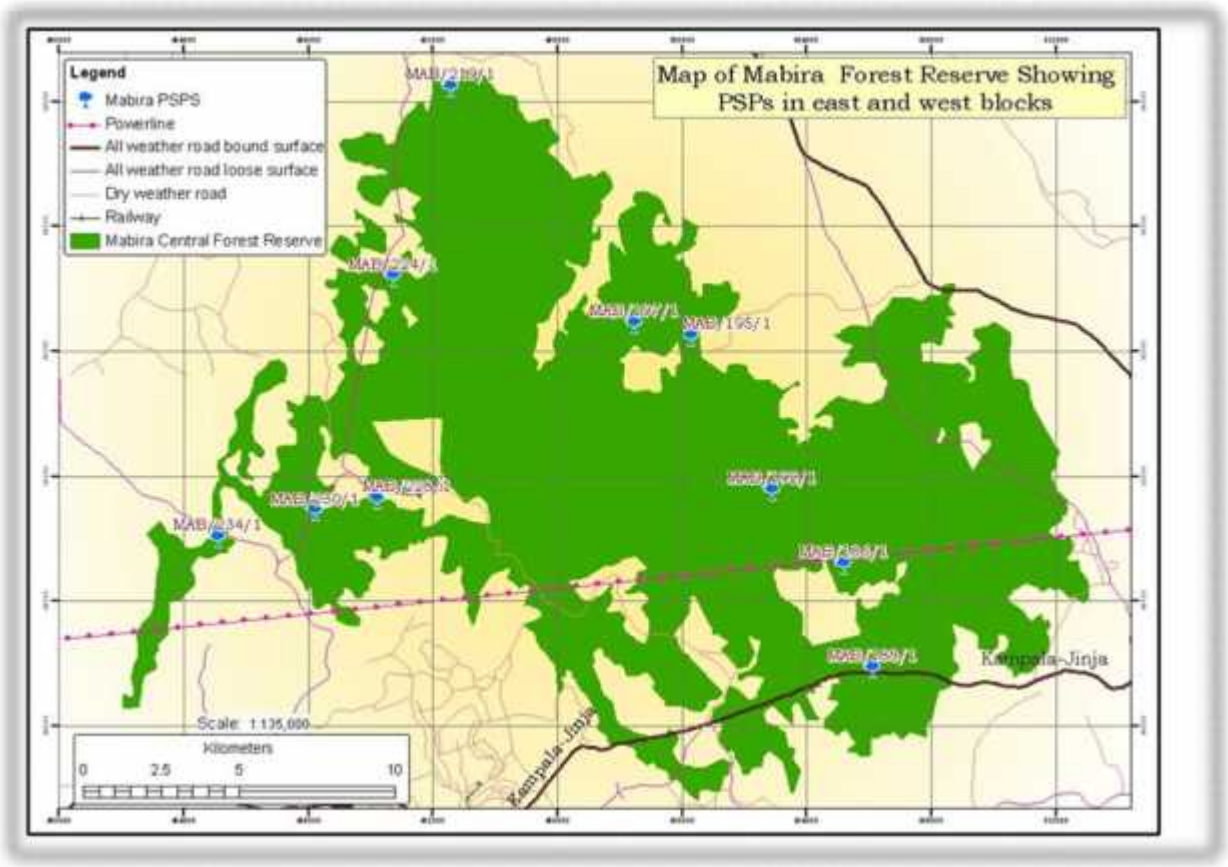

Figure 7. Map of Mabira of Mabira Forest Reserve showing the Locations of 10 Permanent Sample Plots

Table 8: Tree counts and diameter (dbh) measurement data collection sheet 2010

PSP No.		Mabira Forest	Compartment No./GPS location	Data date---------- Recorded by----------					
Quadrat No.	Tree No	Tree species names (Local /common)	Pole s 5-9 (cm)	10-19 (cm)	20-29 (cm)	30-39 (cm)	40-49 (cm)	50+ (cm)	Remarks

Within these plots, diameter at breast height (dbh) has been measured for the trees using calipers. Tree identification has been carried out using the Field Guide to Ugandan Forest Trees, by Allan Hamilton (1991). Where possible, both local and common names were used. The inventory was carried out in 2001 and 2010

Red listed species such as *Prunus africana, Warbugia ugandensis* and *Milicia excelsa* as well as the Mahoganies (*Entandrophragma angolense, Entandrophragma cylindricum,* and *Entandrophragma utile*) should be monitored.

Two of the grasses are uncommon species in Uganda; *Isachne mauritianum*, a species of forest clearings known only from four other forests namely, Kashyoha-Kitomi, Bwindi Impenetrable, Rwenzori and Mpanga. The wild species of rice, *Oryza eichingeri*, is also uncommon in Uganda and is known from four other forests namely, Zoka, Semuliki, Maramagambo and Budongo.

Two species of ground orchids were recorded; the fairly common *Corymborkis corymbis* and *Zeuxine elongata*. Orchids are a *CITES* protected group of plants. The invasive *Broussonetia papyrifera*, *Lantana camara* and *Mimosa pudica* have also been recorded for Mabira. These species need to be observed to monitor and limit spread if it spread into the forest. Factors like forest clearing can hasten the spread of invasive species, as they are usually heavy seeders that will quickly colonize disturbed areas. Other potentially invasive species found in Mabira are *Ricinus communis* and *Nicotiana tabaccum*.

These two species, are shade loving herbaceous species which can be used to monitor changes in the forest cover quality by observing changes in their relative cover values include *Setaria megaphylla*, *Whitfieldia elongata* and *Oplismenus hirtellus.* It would be expected that a reduction in forest cover would result in more light reaching the ground and hence a decline in the coverage of dominating shade loving species. We recommend the less frequent *Leptaspis zeylanica* to be used to monitor the state of Nandagi.

5.2. Large and Medium Sized Mammals

The forest dependent species to be monitored include *Deomys ferrugineus* and *Scutisorex somereni* both closed forest-dependent specialists that are highly sensitive indicators of forest disturbance. Of the five primate species they reported for Mabira, the Grey Cheeked Mangabey (*Cercocebus albigena*) was subsequently upgraded to an independent species, the Ugandan Crested Mangabey *Lophocebus*

ugandae which species we recognize for this report. *L. ugandae* is endemic to Uganda, which makes Mabira CFR and the four other locations it is known to occur in Uganda very critical for its long-term survival.

5.3. Small Mammals

Small mammals can be safely used to reflect changes in community composition by human habitat modification, due to the fact that they animals are very rarely directly poisoned or hunted by humans so disturbance tends to be through indirect sources. Three closed forest dependent species Deomys ferrugineus, Malacomys longipes and Scutisorex somereni were recorded albeit in small numbers.

5.4. Birds

The bird species to be monitored include three species listed as threatened in the IUCN Red List of Threatened Species. Version 2016-1 - i.e. the Blue swallow (*Hirundo atrocaerulea*), the papyrus Gonolek (*Laniarius mufumbiri*) and Nahan's Francolin (*Francolinus nahani*).

The majority of the bird species recorded during the surveys are classified as "Least Concern" according to the IUCN criteria. However, seven of the species recorded are classified as threatened either at global or regional level according to the IUCN criteria (Table 9). These should be monitored.

Table 9. List of threatened species of birds recorded in MFR and the five small CFRs

Name	habitat preference	Global/regional threat	Mabira	Kalagala	Nandagi	Namukupa	Namananga	Namwanyi
Nahan's Francolin *Francolinus nahani*	FF	G-EN, R-VU	1	1	0	1	1	1
Grey Parrot *Psittacus erithacus*	FF	R-NT	1	0	0	0	1	0
Cinnamon-chested Bee-eater *Merops oreobates*	F	R-RR	0	0	1	0	0	0
White headed saw-wing *Psalidoprocne albiceps*	F	R-RR	1	0	0	1	1	0
Toro Olive-Greenbul *Phyllastrephus hypochloris*	FF	R-VU/RR	0	1	0	0	0	0
White-browed Crombec *Sylvietta leucophrys*	FF	R-RR	0	0	1	0	0	0
Green tailed Bristlebill Bleda eximius		R-NT	1	0	0	0	0	0

The record of these species shows that there was a threatened/vulnerable species in each of the CFRs. Hence, the main forest block and even the small CFRs are of great ecological importance to some of these endangered species, which are normally sensitive to habitat modifications.

5.5. Reptiles and Amphibians

Amphibians are regarded as good ecological indicators. Amphibians are excellent bio-indicators of broader ecosystem health because of their intermediate position in food webs, their permeable skins, and their typically biphasic life (aquatic larvae and terrestrial adults). These will be monitored in within the PSPs alongside other fauna.

5.6. Butterflies

Butterflies are probably the best taxonomic group for assessing and monitoring patterns of terrestrial arthropods' diversity (Caldas & Robins, 2003). Butterflies have the most widely studied biology and taxonomy with an estimated 90% species already studied (Midgley, 2002). Butterflies derive almost all their nutritional and some non-nutritional resources from plants. Tropical butterflies occur in all habitats ranging from pristine to disturbed (Hammer at al, 2003). In the field butterflies are probably the most visually accessible and easily quantifiable representatives of the invertebrate world with an estimated 5,680 species worldwide (Foottit & Adler, 2009). They therefore have a prominent place in conservation programmes and biodiversity assessments.

5.7. Plant Resource Use

Monitoring will be carried out in a combination of permanent and temporary geo-referenced plots located close to the trails where resource use is most intense. The plots will be marked discreetly to avoid suspicion. This will include use of cryptic markers (e.g. metal that can be detected with a device), or use of very accurate GPS, or marked points with listed offset control plots in the remote areas not accessed for exploitation, to guide comparison of the ecological state with and without resource harvesting. Control plots will be selected to match the sample plots near trails. Matching will consider factors such as species diversity, soils, and topography to ensure 'representativeness'. The monitoring will be carried out in intervals of at least every month and this should be synthesised after six months.

5.8. Water Quality

The Mabira ecosystem is an important water catchment providing several ecosystem functions and services to aquatic biota and local communities living around the reserves. Water quality can change frequently over time (years and seasons), necessitating frequent, repeated measurements to adequately characterize variations in quality. For the Mabira catchment where water quality will be assessed after a fairly long period, a monitoring framework is required to be implemented at specific sites within and around reserves.

Physical-chemical parameters to be monitored include (TN, TP, PO3, NO3, and NH4, pH, DO, turbidity, temperature, electrical conductivity, total dissolve sediment and total suspended solids). These parameters were measured twice in the May 2016. Water samples are analysed at Makerere University. In addition water quality information can be collected from National Water and Sewage Corporation (NWSC).

Table 10. Sampling sites for water quallity

Location of Water Quality Monitoring points				
	X	Y	Elevetion	Remarks
1	486511	74618	1061	Sezibwa Kayunga Bridge (the point along River Sseziwa below the bridge along Mukono-Kayunga road.)
2	492789	69837	1071	Musamya Kyabazala (the point along River Musamya is approximately 1.8 km below the Griffin forest camp)
3	484920	50084	1083	Sezibwa Nagojje
4	483153	42983	1097	Sezibwa Namataba

THREATS IN THE MABIRA

The survival and relevance of Mabira forest ecosystem is facing increasing threats from unsustainable human activities. Some of the threats include: unsustainable forest harvesting; agricultural encroachment; population pressure; land grabbing; political interference; degradation of habitats through pollution and conversion; invasive alien species and inadequate funding to mention but a few.

S/N	Threats	Causes	Effects to the communities	Effects to the forests	Solutions
1	Unsustainable forest harvesting	▪ Illegal forest harvesting ▪ High demand for products (timber, firewood) ▪ High population ▪ Poor governance ▪ Corruption ▪ Unemployment ▪ Poverty ▪ Ignorance/lack of awareness ▪ Greed ▪ Search for land for farming ▪ Involvement of environmental police in illegal activities	Positive ▪ Improved livelihoods ▪ High income Negative ▪ Unreliable rainfall for agricultural production ▪ Population influx (migration) ▪ Reduced access to forest products and services ▪ Increase in resource use conflicts ▪ Creates negative perception/ attitude towards the forest as communities think that their role in forest protection has been taken over by EPPF	▪ Deforestation ▪ Biodiversity loss ▪ Extinction of certain species	▪ Sensitization ▪ Law enforcement ▪ Restoration planting ▪ Substitution of certain species ▪ Promotion of tree planting on farm land ▪ Replant cleared trees ▪ Provide employment opportunities ▪ Alternative energy sources ▪ Afforestation and re-afforestation ▪ Enforcement ▪ Community participation ▪ Institutional strengthening NFA, District, Sub-county ▪ Clarify on the chain of command for EPPF
2	Agricultural encroachment	▪ Unclear forest boundaries ▪ High population ▪ Poor agricultural practices(lack of agro inputs ▪ Political interference ▪ Poor implementation of policies ▪ Poor governance	Positive ▪ Improved livelihoods ▪ Increased income Negative ▪ Intra community conflict ▪ Reduction or loss of forest products and services ▪ Climate change	▪ Forest degradation and deforestation ▪ Biodiversity loss ▪ Soil erosion	▪ Open and regularly maintain boundaries ▪ Sensitization ▪ Regular patrols ▪ Law enforcement ▪ Eviction of encroachers ▪ Promote use of appropriate agricultural technologies ▪ Promotion of CFM ▪ Political will

		▪			
3	Population pressure	▪ Early marriages ▪ Migration ▪ High fertility ▪ Polygamy ▪ Cultural and religious beliefs ▪ Ignorance ▪ Unemployment	▪ Scramble for resources ▪ Scarcity of resources ▪ Conflict over use of resources ▪ Outbreak of diseases	▪ Forest encroachment ▪ Un sustainable use	▪ Enhance Family planning ▪ Sensitization and education ▪ Creation of employment opportunities ▪ Intersect oral planning and coordination ▪
4	Illegal acquisition of land titles in the forest/land grabbing	▪ Poor governance ▪ Poor policy implementation ▪ Corruption	▪ Reputation/Deprivation of access and user rights	▪ Degradation and deforestation ▪ Reduction of forest cover ▪ Change of land use	▪ Sensitization ▪ Cancellation of illegal land titles ▪ Prosecution ▪ Eviction ▪ Institutional/sectoral coordination (MWE/NFA& Ministry of Lands Housing and development/ Uganda lands commission)
5	Infrastructural development e.g. Roads, power lines, dams, industries, etc.	▪ Poor planning ▪ Lack of inter-sectoral planning	▪ Access to improved infrastructure and markets ▪ Loss of forest benefits ▪	▪ Forest degradation and deforestation ▪ Habitat fragmentation ▪ Biodiversity loss	▪ Coordinating planning for infrastructural development (MWE, NFA, UNRA, Min of works and transport, UETCL, UEDCL, ERA, Railways, NWSC, NEMA)
6	Political interference	▪ Corruption ▪ Greed ▪ Nepotism ▪ Poor governance (Lack of respect for institutions/ systems) ▪ Unclear forest boundaries	▪ Conflicts ▪ Short term /selfish benefits ▪ Lawlessness	▪ Forest degradation and deforestation ▪ Biodiversity loss	▪ Restoration of good forest governance ▪ Respect of rule of law ▪ Discipline/prosecute offenders ▪ Eviction of encroachers ▪ Cancellation of illegal land titles ▪ Re-opening and maintenance of forest boundaries
7	Inadequate funding	▪ Poor priority setting ▪ Budget deficit ▪ Poor governance	▪ Loss of employment ▪ Loss of services	▪ Inadequate forest management and protection	▪ Resource mobilization ▪ Improve Institutional reputation/image ▪ Lobby government for increased budget allocation ▪ Accountability/transparency
8	Hostilities of some	▪ Corruption	▪ Short term and selfish	▪ Forest	▪ Sensitization

	communities	▪ Nepotism ▪ Scarcity of resources ▪ High demand for forest product and services ▪ Unemployment	benefits ▪ Loss of life and property	degradation and deforestation ▪ Encroachment ▪ Biodiversity loss	▪ Initiate CFM ▪ Prosecute offenders ▪ Discipline errant staff
9	Invasive species - Broussonetia papyrifera (paper mulberry)	▪ Encroachment/ habitat modification ▪ Poor forest management practices	▪ Reduction of preferred species ▪ Increased biomass including fodder	▪ Reduction in biodiversity ▪ Increased forage for wildlife	▪ Control the spread of the invasive species ▪ Putting the species to industrial use.
10	Uncontrolled brick making and sand mining	▪ Demand for building materials ▪ Poor regulation ▪ Poor law enforcement	▪ Revenue ▪ Creation of breeding grounds for mosquitoes causing malaria ▪ Causes insecurity	▪ Reduction in biodiversity ▪ Habitat degradation ▪ Forest cover loss	▪ Regulate off take levels ▪ Enforce environmental laws ▪ Put in place mitigation measures ▪ Diversify sources of building materials
11	Unclear forest boundaries	▪ Insufficient funding ▪ Land disputes	▪ Continuous conflicts ▪ Loss of property ▪ Uncertainty over ownership (Cannot develop their own land for fear of eviction)	▪ Encroachment ▪ Loss of biodiversity ▪ Deforestation ▪ Degradation ▪	▪ Open and maintain the boundaries ▪ Erect permanent forest boundary infrastructure such as pillars, directional trenches, live markers and cairns ▪ Community sensitization ▪ Lobby government for funds ▪ Resource mobilization
12	Urbanization	▪ Population increase ▪ Un employment ▪ Creation of more administrative units ▪ Poor planning and governance	▪ Increase proximity to services ▪ Employment	▪ Encroachment ▪ Loss of biodiversity ▪ Deforestation ▪ Degradation ▪ Pollution	▪ Proper planning ▪ Law enforcement ▪ Community sensitization ▪ Creation of employment ▪ Family planning ▪ Provision of alternative energy sources
13	Industrialization	▪ Government policy	▪ Employment ▪ Improved infrastructure ▪ Improved services	▪ Encroachment ▪ Loss of biodiversity ▪ Deforestation	▪ Proper planning ▪ Respect of law ▪ Good governance ▪ Provide alternative sources of

				▪ Degradation ▪ Pollution	energy for factory workers
14	Uprooting planted trees	▪ Animal rearing ▪ Community farming ▪ Poor monitoring ▪ Poor tending operations ▪ Infrastructural developments	▪ Land for agriculture ▪ Conflicts	▪ Poor tree establishment ▪ Forest degradation ▪ Biodiversity loss	▪ Community sensitization ▪ Regular forest patrols/protection ▪ Control/eliminate Taungya ▪ Improve monitoring operations ▪ Plan infrastructural developments ▪ Better management enforcement ▪ Adhere to agreements in case of CFM
15	Forest fires	▪ Drought ▪ Community ▪ Hunters ▪ Herbalists ▪ Natural fires ▪ Malice	▪ Loss of life and property ▪ Loss of benefits (products and services from the forest) ▪	▪ Deforestation ▪ Biodiversity loss ▪ Extinction of certain species	▪ Enforcement ▪ Community sensitization/ training ▪ Forest fire protection including maintenance of fire lines/breaks ▪ Community tree planting ▪ Controlled early bush burning
16	Diseases and pests	▪ Poor agriculture practices ▪ Poor species selection during planting ▪ Poor silvicultural/ management practices ▪ Climate change ▪ Ignorance ▪ Lack of technical support	▪ Poor yield ▪ Loss of revenue ▪	▪ Decline in productivity ▪ Forest degradation	▪ Provide improved/resistant varieties ▪ Ensure technical guidance ▪ Pests/disease management/control
17	Vermin	▪ Degradation/ Loss of habitat	▪ Crop loss ▪ Loss of life ▪ Loss of revenue ▪ Reduction in time for other economic activities ▪ Increase in the rate of School dropouts	▪ Natural Seed dispersal ▪ Damage seedlings planted for restoration or enrichment ▪ Forest destruction by communities	▪ Vermin control ▪ Planting of unpalatable crops

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