ASSESSMENT OF THE DISTRIBUTION OF *MACARANGAKILIMANDSCHARICA* TREE SPECIES INMUKURAFORESTRESERVE.

A CASE STUDY OF RUSEBEYA AND MUKURA SECTORS IN RUTSIRO DISTRICT, WESTERN PROVINCE, RWANDA.

BY

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DECLARATION

I hereby declare that this research material is entirely my own work , does not breach any law of copyright and that it has never been submitted to any academic institution for any academic award whatsoever.

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APPROVAL

I certify that this dissertation entitled "**The distribution of *Macaranga kilimandscharica* tree species in Mukura forest reserve** "has been submitted under my supervision in partial fulfillment for the award of a Degree of Bachelor of Science in Environmental Management of Kampala International University.

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LIST OF ACRONYMS

IUCN:	International Union for Conservation of Nature
MINITERE:	The Ministry of Lands, Environment, Forests, Water and Natural Resources
CGIS – NUR:	The Geographic Information Systems & Remote Sensing Research and Training Center of the National University of Rwanda
ARECO:	Association Rwandaise des Ecologistes
WCS:	Wild life Conservation Society
FAO:	Food and Agricultural Organization
DBH:	Breast height Diameter
ARCOS:	Albertine Rift Conservation Society
R D B :	Rwanda development Board
NGO :	Non-governmental organization
EN:	Endangered
VU:	Vulnerable

OPERATIONAL DEFINITIONS

Species: is often defined as the largest group of organisms capable of interbreeding and producing fertile offspring

Species distribution: is the manner in which a biological taxon is spatially arranged

Vegetation density: Number of individual plants of a given species in a unit of area

Environment: Is the totality of nature that include both biotic and a biotic

Components and which include components such as biosphere, hydrosphere, lithosphere and atmosphere

Habitat: is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism

Threat: Negative event that can cause a risk to become a loss, expressed as an aggregate of risk, consequences of risk, and the likelihood of the occurrence of the event

Diameter at breast height (DBH): is a standard method of expressing the diameter of the trunk or bole of a standing tree measured at 1.3 meters above ground

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ABSTRACT

Macaranga kilimandscharica (Umusekera) family Euphorbiaceae is one among the tree species which occur in Mukura forest reserve which is threatened by local people due to its uses such as fire wood , charcoal , timber ,medicine , and poles for house construction . Despite that, it is being threatened within Mukura forest reserve yet its distribution, density and habitat status are unknown. This study was conducted within Mukura forest to find out the distribution in the different habitats to know its status and prevent its extinction. The objectives of this study were to identify the habitat type in which *Macaranga kilmandscharica* occurs (open forest, secondary forest and others) , to identify the likely effects to the survival of *Macaranga kilmandscharica* in the different habitats, to determine the relationship between the density at DBH (Breast height Diameter) of *Macaranga kilmandscharica* and habitat type .Different materials and methods such as decameter for measuring distances, digital camera for taking photos, colored tape to mark the plots, data sheets to record the data collected on the field, DBH tape for measuring the diameter at breast height (DBH) of trees and notebook, pen and markers used. Two transects of 1km each and Plots of 50x 50m on alternate sides were established along the transects at 50m interval. The results from this study revealed that *Macaranga kilimandscharica* occurs in secondary forest, open forest, cleared, burned zone, fern as well as marsh. Fire wood collection, grass collection, grazing *Macaranga* cutting, mining and other tree species cutting were identified as human activities disturbing the survival of *Macarangakilimandscharica* within Mukura forest, while the natural disturbance was presence of *Sericostachys scandens*. It has determined that the DBH of *Macaranga kilimandscharica* degraded habitats is significantly different from non-degraded habitats ($f = 5.34$, $p = 0.000123$, $df = 5$ and 207 $p < 0.05$ Anova single factor).

CHAPTER ONE

1.0 Background of the study

Rwanda hosts 2,150 species of plants ,however , the number of plants found in Rwanda is far from being totally known (MINITERE 2007).*Macaranga kilmandscharica*: (local name *Umusekera*) family Euphorbiaceae is among the tree species harvested most and threatened by the communities living around Mukura forest. It is harvested for accessing resources such as firewood, medicinal plants, charcoal, houses construction and handicraft material (Kasangaki and Nsabagasani 2012).

Many strategies have been implemented to counteract the effects of deforestation, however, the Rwanda forests such as Mukura Forest Reserve remains under pressure from a large and growing rural human population in need of land and forest resources such as firewood and timber.

Mukura Forest reserve is a highland forest located in the Western province of Rwanda and covers 1,798 ha in size, the forest is located in a densely populated landscape (668 inhabitants per km2) with more than 85% of the population living below the international poverty line. (ARECO and WCS, 2006).

Deforestation is a global problem. A growing world population has resulted in increasing demands for goods from forests, including timber and land for agricultural and settlement. This has resulted in heightened forest fragmentation and habitat destruction (FAO, 2003).

1.1. Problem statement

Even though different governmental and non-governmental institutions such as R D B ,ARCOS, ARECO Rwandanziza have tried their best to deal with Mukura forest reserve conservation issues; nowadays *Macaranga kilimandscharica* is still threatened by local people due to its uses such as firewood ,charcoal, timber, medicine for stomachaches and poles for house construction and fences(ARCOS , 2012) .*Macarangakilmandscharica* has been negatively impacted due to the numerous uses. This shows that *Macaranga kilimandscharica* plays a vital role in the livelihood of people living around Mukura forest reserve and yet it's distribution, density and habitat status are unknown.

This study therefore is to find out the distribution in the different habitat to prevent it from getting extinct.

1.2. Main objective.

The main objective of this study was to assess the distribution and habitat status of *Macaranga kilmandscharica* tree species in Mukura forest reservein Rusebeya and Mukura sectors , Rutsiro District, Western Province, Rwanda .

1.3. Specific Objectives

The specific objectives to achieve were as follows

- To identify the habitat type in which *Macaranga kilimandscharica* occurs (i.e.closed forest, secondary forest and others) .
- To identify the likely human activities disturbing the survival of *Macaranga kilimandscharica* in the different habitats.

- To determine the relationship between the density at DBH (Diameter Breast Height) of *Macaranga kilimandscharica* and habitat type.

1.4. Hypotheses.

The null hypotheses is that

- There is no significant difference between the DBH of *Macaranga kilimandscharica* within degraded and non-degraded habitats.

1.4. Scope of the study

This study assessed only the distribution of *Macaranga kilimandscharica* tree species in Mukura forest reserve in Rusebeya and Mukura sectors in Rutsiro District. This was done by looking at DBH in the different habitats along 2 transects of 1 km where plots of 50x50m were sampled at alternate sides .

1.5. Significance of the study

This study provided useful information that would be used by the decision makers to plan for further research and monitoring.

It can also be used as a basic tool towards designing the best management measures of Mukura forest reserve as well as improving the livelihood the communities living around that ecosystem .

CHAPTER TWO

LITERATURE REVIEW

2.1. Description of *Macaranga kilimandscharica* tree species.

Macaranga kilimandscharica (Umusekera) is placed in the Euphorbiaceae family tribe Acalypheae and has close affinities with the genus Acalypha (Smith AR. 1987). The generic name is after a Madagascan native name and the specific epithet kilimandscharica refers to Mount Kilimanjaro area of Tanzania. It is a small to medium semi-deciduous tree 4.5-18 m, or large tree up to 27 m, often with a pyramidal crown, much branched, branches ascending, or with a broad, spreading crown. Bark green at first, later becoming greyish white, light or dark grey Stem smooth or longitudinally striated or fluted, with fluted stems. Young shoots and inflorescence-axes densely ferruginous tomentellous at first, later glabrescent.

Leaves triangular-ovate, base cuneate, rounded, truncate or rarely subcordate, occasionally peltate, apex acuminate, 5-15 cm x 3-10 cm. 3- nerved from the base, rusty -tomentellous but glabrescent, densely glandular-punctate beneath. Inflorescence 2-10 cm long, cyathia yellow-green. Male inflorescence paniculate, bracts ovate lanceolate, 8-15 cm long, 2-3 mm wide, male flowers subsessile, stamens 2, filaments fused basally, anthers obscurely 4-thecous, 0.5 mm across. Female inflorescence racemose to subpaniculate, female flower pedicels 1-2 mm long, calyx cupular splitting into 2-3 lobes which flatten as the fruit matures, ovary 1-2 lobate, 1-1.5 mm long, 1-2 mm wide, densely yellowish granulate-glandular. The fruit is dull green, subglobose or 2-lobed, 4-6 mm x 5-11 mm densely glandular, 1-seeded. (Orwa et Al. 2009).

Picture 1: Macaranga kilimandscharica

Source: Field data

2.2. Distribution of *Macaranga kilimandscharica*

Worldwide, *Macaranga* (Euphorbiaceae) is a genus of approximately 280 species, distributed in Asia and in Africa. In Asia it is distributed in Indonesia, Polynesia and strongly centered in the Malesian region (Whitmore, 1967).

In Africa is distributed in the Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Rwanda, Sudan, Tanzania, Uganda, Zambia on the altitude between 1 300 and 3 000 m within the regions which receive the mean annual rainfall between 1 500 mm and 2 500 mm and mean annual temperature between 18° C and 26°.C (Orwa et al. 2009).

In Rwanda it is distributed within Mukura forest, Gishwati forest, Nyungwe national park and Volcanoes national park (Jean Combe, 1977).

2.3. Utilization of *Macaranga kilimandscharica*

The wood is used for light construction, planks, low-grade furniture, knife sheaths, boxes, beehives, xylophones, water pots and stools, and as firewood. In Burundi the leaves are used as

vegetable. Medicine: Root extracts are drunk for bilharzia treatment and the leaves are used as medicine for stomach-aches and allergies, a decoction of boiled roots is used for treating cough and a root extract to cure bilharzia. In north-western of Ethiopia a ground piece of fresh root is put in local beer, and a cup is drunk to cure male infertility. It is also used as a coffee shade tree in the Ethiopian highlands, in Zimbabwe powdered roots are roots are used as an aphrodisiac. The flowers are scented and attract honey-bees.

Erosion control: It is planted for shade in coffee plantations and for soil conservation. This is a useful pioneer species with potential use in protecting soils on logged sites, Leaf litter from the tree enriches surrounding soil, Boundary or barrier or support: Dry wood from *Macaranga* have been used for fencing.

Useful pioneer species with potential use in protecting soils on logged sites, Leaf litter from the tree enriches surrounding soil, Boundary or barrier or support: Dry wood from *Macaranga* have been used for fencing.

Fuel: Macaranga is used as a firewood source. Timber: Wood pink, soft, straight grained; weight 54-68 kg/cu ft, difficult to saw and apt to split in seasoning. Has been used for boxes and crates in Kenya.

Production and international trade: The timber of *Macaranga* is traded under the names *'muhaa'*, '*mukuhakula*', '*muhoti*' and '*omuburashasha*

Handling after harvest: It is recommended to treat logs with preservatives soon after felling to avoid losses by blue stain attack

Prospects : The multiple uses and the fast growth of *Macaranga capensis* and other *Macaranga* species make them interesting for more intensive local utilization, especially in higher-altitude agroforestry systems, e.g. as shade trees in coffee plantations. Suitable management systems should be developed to optimize production (Orwa et al, 2009)

2.4. Relationship of *Macaranga kilimandscharica* and habitat types

Many species of this tree genus inhabit disturbed areas such as clearings, gaps, and forest edges. These habitats have enormously increased in extent over the last 100 years and the fast-growing

Macaranga species have spread and become one of the most conspicuous trees in cleared areas (Whitmore , 1967).

Macaranga kilimandscharica is a fast growing pioneer species of mountain evergreen forest. It regenerates vigorously in clear-felled areas, secondary forest, forest edges, riverine forest and disturbed places. Usually associated with *Albizia gummifera*, *Polyscias fulva* or *Vernonia subuligera*, it often replaces selectively logged *Ocotea usambarensis.*

In disturbed forest *Macaranga* is used in the research as species indicator for example Webster, 1994; Slik and Welzen, 2001studied the possible indicator role of *Macaranga* species for forest disturbance (fire, selective logging and shifting-cultivation). *Macaranga* speciesare two closely related genera belonging to the Euphorbiaceae.

Macaranga species is closely related to forest structure and the amount of disturbance in a plot, these species can also be used to predict forest structural variables and disturbance levels in the plots. Indeed most forest structural variables could be predicted quite accurately by using just a small set of *Macaranga* species. J.W. Ferry Slik, Paul J.A. Keßler, Peter C. van Welzen (1996) in their research using plots found that Macaranga species prefer lightly disturbed forest conditions ,the burned forest types were mainly characterized by *Macaranga* species. An important difference between the species found characteristic for repeatedly burned (shifting-cultivation) forest and forest that was burned once is that the species in repeatedly burned (shifting-cultivation) forest start reproducing 1–3 years after germination, while the species indicating forest that burned once start reproducing 5–15 years after establishment (Davies, 1996; Slik, personal observation) .

A case study of the mixed lowland dipterocarp forest of East Kalimantan in Indonesia by J.W. Ferry Slik, Paul J.A. Keßler, Peter C. van Welzen (1996)

The results from this study revealed that Macaranga and Mallotus as indicators for the type of disturbance twelve *Macaranga* and nine *Mallotus* species were found in the 45 plots the *Macaranga* species were usually present in both the ITCI and the Wanariset plots, while most *Mallotus* species occurred either only in ITCI or only in Wanariset of the twelve *Macaranga* species, nine(75%) were significantly more common in secondary than in primary forest, while two species (17%) were significantly more common in primary forest ,of the nine *Mallotus* species, five (56%) were significantly more common in secondary than in primary forest, while three species (33%) were significantly more common in primary forest. Most of the species showed clear relationships in distribution to forest disturbance types.

The best indicators for primary forest were *Mallotus penangensis* and *Macaranga lowii*. Secondary forests could be distinguished from primary forests very accurately by looking at the relative frequency and mean abundance of a small set of *Macaranga* species. The presence of *Macaranga gigantea*, *Macaranga hypoleuca* and *Macaranga pearsonii* was important in this respect, with IVs around 90%, which indicates that they were present and common in almost all secondary forest plots. Within the secondary forests, the selectively logged forests were characterized by two *Mallotus* species, while the fire affected forests were characterized by a mixture of *Macaranga* and *Mallotus* species.

The forest structural variables (environmental variables) correlated well with the first axis of the CCA (0.96) which explained 33.3% of the variance present in the data. The second axis had a correlation of 0.80 with the environmental variables and explained 22.2% of the data variance. Primary forest, selectively logged forest, forest burned once and repeatedly burned forest (used for shifting-cultivation) formed recognizable groups in the CCA. Along the second axis of the CCA the ITCI plots were separated from the Wanariset plots. The direction of the environmental variables is best represented by the visible disturbance variable. A clear pattern is visible along this axis, with all the primary forest plots on the right, followed to the left by selectively logged plots, forest plots that burned once, and on the extreme left the repeatedly burned plots (shifting-

cultivation). Projecting the plots on this axis gives a generalized idea of their level of disturbance similarly, projecting the *Macaranga* and *Mallotus* species on this axis gives an estimate of the species disturbance level preference It shows that most *Macaranga* species prefer intermediate to high levels of disturbance.

CHAPTER THREE

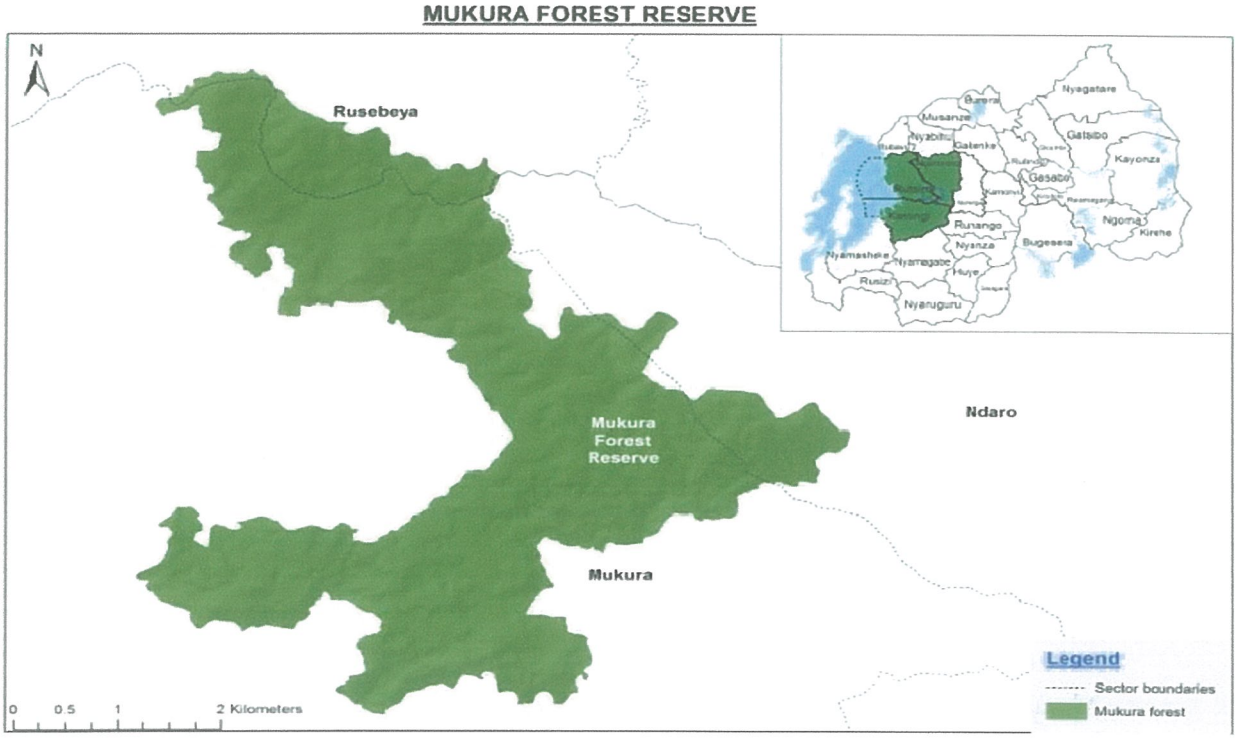
METHHODS AND MATERIALS

3.1. Description of the study area.

3.1.1. Geographic location of Mukura forest.

The Mukura Forest is located within the Albertine Rift Region in Rwanda's Western Province, within the Congo-Nile crest covers .This ancient forest range with areas of endemic species in Africa and the world is split in four important protected areas in Rwanda which include: the Nyungwe, Mukura and Gishwati forests and the Volcano Park. (ARECO and WCS, 2006)

Map 1 :Locational map of Mukura Forest Reserve.(source :ARCOS)



Annual temperature is 15 °C with altitude of 2600 m.a.s.l (average),

It receives Annual rainfall of 1500 mm (erratic). As the relief is very accented and the tree cover is very low, there is a high risk of soil erosion and thereby land degradation.

It was gazetted a reserve since 1951and covered 3000 ha. Until today about 50% of the forest's surface is lost due to deforestation, paralleled with high loss of biodiversity (highly disturbed). Currently, 1600 ha are left. This amounts to an alarming situation which arose for several reasons.

The population around Mukura forest is 600 inhabitants per km^2 and this aggravates deforestation and consequently erosion. The monthly income of households is US$ 3,

Mukura forest hosts an interesting biodiversity of 243 plant species 77 bird species including 15 Endemic to the Albertine Rift and 3 IUCN threatened species namely Grauer's Rush Warbler (EN), Grey Crowned Crane (EN) and Kivu Ground Thrush (VU) (ARCOS 2012) .

The main crops grown around Mukura forest include Irish potatoes, maize, peas and beans. Some livestock farming is also practiced, mainly cattle and sheep.

3.2. Data collection

3.2.1.Transects and plots

This study used two transects named A located in Rusebeya and B in Mukura Sectors of 1km each which were selected from the existing ones already established by other researchers to avoid the increase of the disturbances. 10 plots of 50 x 50m on alternate sides were established along each transect at 50m interval. The distances of the transects and plots were measured using the

decameter and marked using rubber. In each plot all stems of Macaranga kilimandscharica were counted and their DBH (1.3m above the ground) of each stem was measured using the DBH tape and recorded on data sheet using pencil.

3. 2 .2. Habitat type data collection.

During this study, the habitat types within each plot were identified and recorded on data sheets using these categories primary forest, secondary forest, human clearing, burned zone, marsh, fern and others.

3.2.3. Human activities

Each human activity and natural disturbance observed along the transect was recorded on data sheet and it was counted each time it was observed to be used for ranking.

3.3. Data analysis.

Data collected were entered in excel to create the data file. Statistical test Anova one way was used to investigate the differences between the means of DBH and to assess the relationship between the density at DBH of Macaranga kilimandscharica and habitat type.

CHAPTER FOUR.

RESULTS AND DISCUSSION

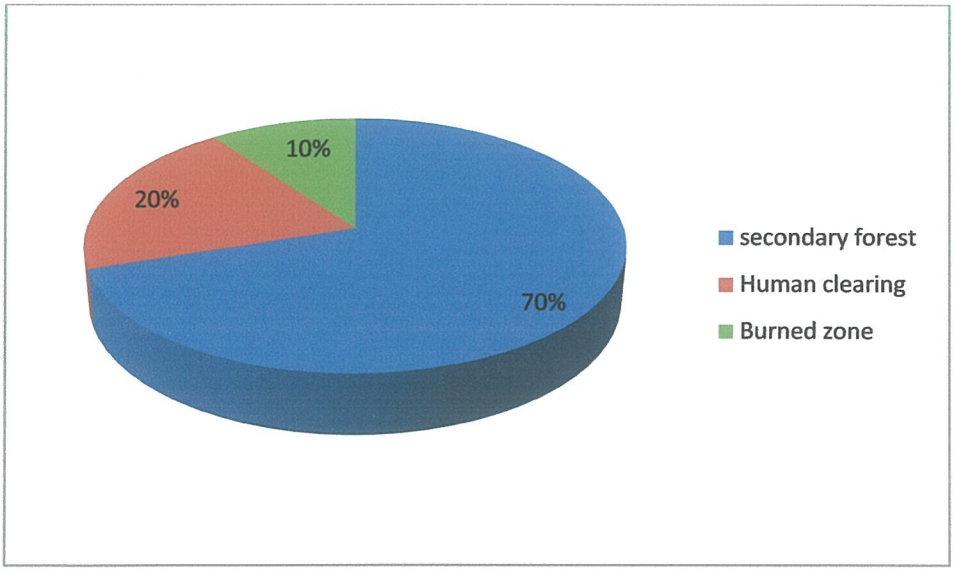
4. 1. Identification of the habitat type in which *Macaranga kilimandscharica* occurs.

The data collected revealed that Macaranga kilimandscharica occurs in all habitats that is closed forest, secondary forest, burned zone, human clearing zone, marsh and fern.

Secondary forest was the habitat with the highest percentage 83.5%, followed by Burned area 4.6%, human clearing 3.7%, closed forest 3.2%, fern and marsh 2.3 % each.

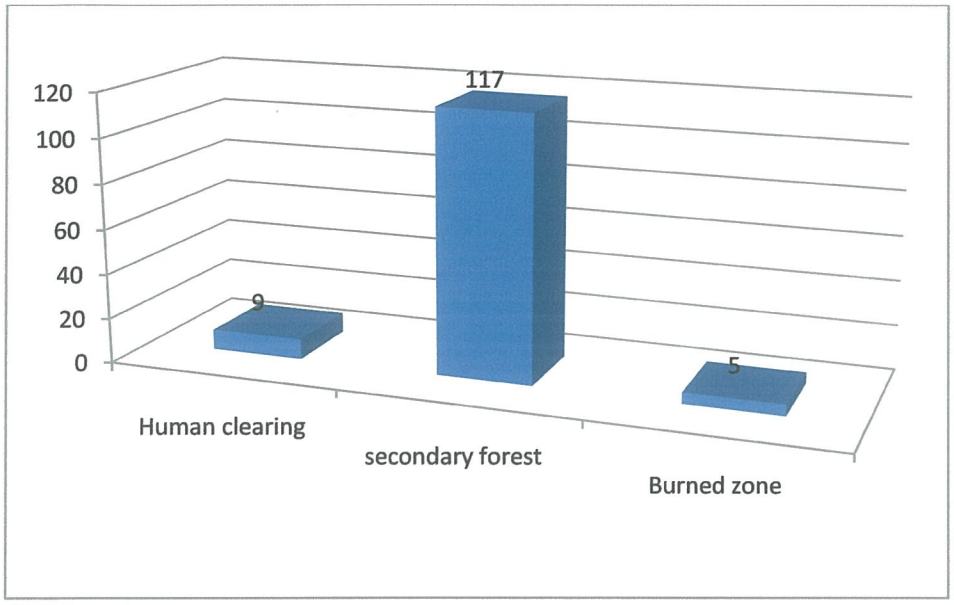
The results of habitat type identification within plots along both transects are presented in the graphs below.

Figure 1. Habitat types identified along transect A



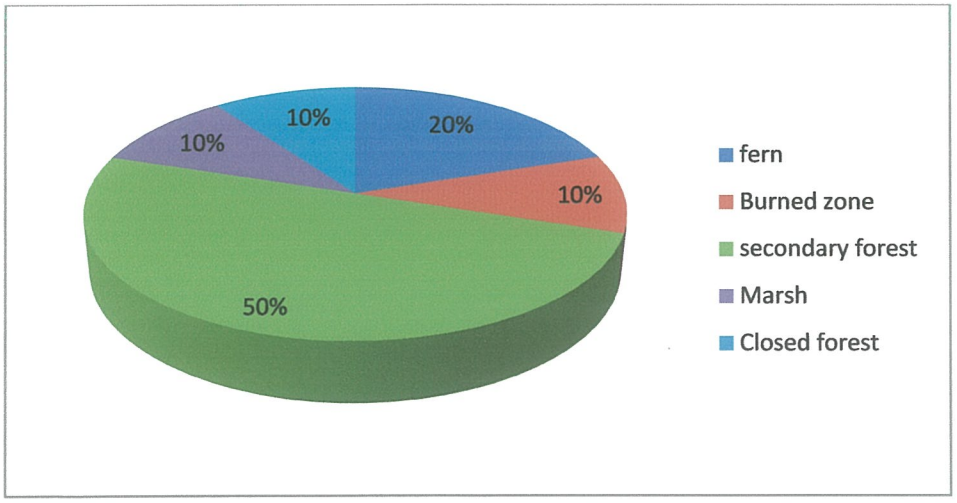
Source : research data .

Figure 2 .Number of stems of *Macaranga kilimandscharica* counted within each habitat type along transect A.



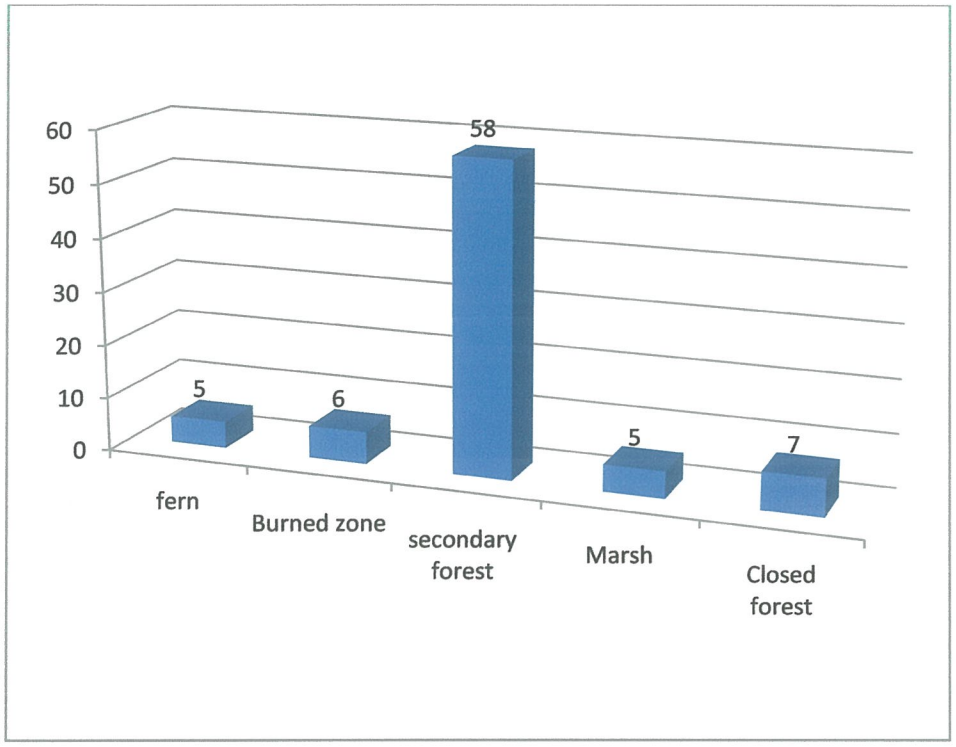
Source: research data.

Figure 3. Habitat types identified along transect B



Source : research data .

Figure 4. Number stems of *Macaranga kilimandscharica* counted within each habitat type along transect B.



Source: research data

4.2. Human activities disturbing the survival of *Macaranga kilmandscharica.*

Signs of illegal activities encountered along the transects included fire wood collection, grass collection, grazing, *Macaranga* cutting ,mining and other tree species cutting while the natural disturbance identified was presence of *Sericostachys scandens*

Grazing was mostly observed as an illegal activity within the forest (Fig 5). The frequent signs of illegal activities within the forest reserve may be attributed to the weak enforcement of forest regulations. Several reports have reported poor or lack of enforcement of forest reserve regulations within Mukura forest (ARCOS, 2014). If the forest reserve and its resources are to be conserved in perpetuity, government and its development partners need to invest in enforcing the existing laws and where these are found wanting, new one should be enacted.

4.2.1. Grazing and grass collection illicit

As free lands for pastures are insufficient around Mukura forest reserve due to explosive population increase –herds are often found grazing in the forest. The signs observed show that the people enter in the forest with domestic animals others enter in the reserve for grass harvesting for various use. The local people reported that some of them they use it in agriculture as fertilizers. During this study we found where domestic animals damaged the Macaranga by routing out eating its young braches as well as where people cut Macaranga while collecting the grass. These show that grazing and grass collection impact negatively on the survival of Macaranga within Mukura forest reserve.

4.2.2. Mining

Mining for Columbite- tantalite as early as 1935, following the introduction of alluvial mining techniques by the Belgian colonial administration. Currently, three legal mining companies are recognized in the vicinity of Mukura Forest namely RAP, ROKA and COAMEKI. While mining sites are supposed to be outside the forest, mining tends to be concentrated at the edge of the Forest. Miners dig up the whole trees, make huge tunnels and leave uncovered big holes that enhance land slide in this fragile mountain conditions, leading to risks of accidents and loss of human lives.

Picture 2:Mukura forest under illegal mining /Photos by Martin

Source: Field data.

Mining affects negatively the survival of Macaranga by destroying heavily its habitat in that forest by tree cutting, rooting out and digging big holes for making space and ploughing water channels for leaching minerals .

4.2.3.*Sericostachys scandens*

Sericostachys scandens is a widespread indigenous invasive climber that is reported to cover most parts of the habitat of *Macaranga kilimandscharica*. Where present, it creates a mono-dominant under-story and mid-canopy patches that covers many hectares of the forest. The question has often arisen as to the role that forest elephants and buffalo may have played in shaping the abundance and distribution of *Sericostachys* Mukura Forest. The recent extirpation of large herbivores, including forest elephants (Loxodonta africana cyclotis) and buffalo (Syncerus caffer nanus), are believed to have reduced grazing and trampling pressure on this native species, allowing it to become an "intrusive and destructive" factor to the growth of other native flora including Macaranga (MINITERE, 2003).

4.2.4. Fire wood collection

Firewood shortages are a well-known problem and are attributed to communities in this region having few forest plantations. As a result, local populations turn to the forest to cut trees including Macaranga such that they get dry and used as fire wood this reduces the number of stems available in that forest reserve and destroys its habitat

Picture 3 .Wood fire collection in the Mukura forest reserve of *Macaranga kilmandscharica*

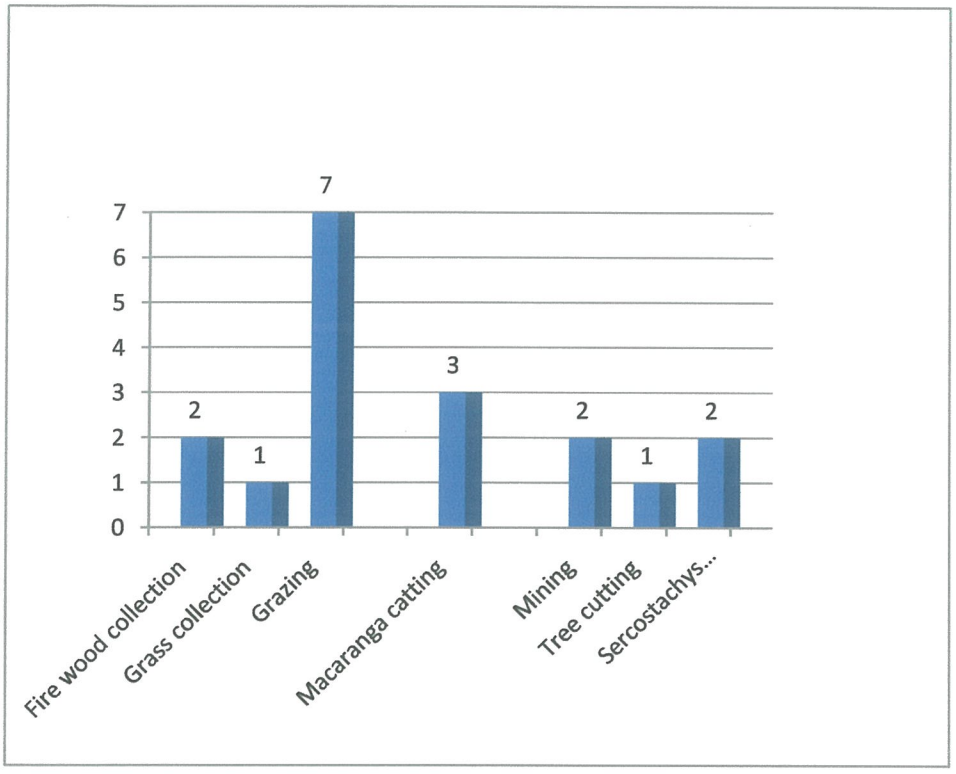
Source :Field data.

4.2.5. *Macaranga* and others tree species cutting.

This consideration gathers together threats such as gathering plants, fuel wood, medicinal herbs, non-timber harvesting and charcoal making; cutting fire wood and debarking trunks for traditional medical purposes were also reported by local people. Cutting Macaranga and other species would

have high incidences on the forest due to strong demand of fuel wood both in rural and urban areas.

Figure 5.Activities disturbing the survival of *Macaranga kilmandscharica*



4. 3. Relationship between the density at DBH of *Macaranga kilimandscharica* and habitat

The result from statistical analysis showed that the DBH of *Macaranga kilimandscharica* in degraded habitats is significantly different from non-degraded habitats ($f = 5.34$, $p = 0.000123$, $df = 5$ and 207 $p < 0.05$ Anova single facto).This significant difference could be attributed to the high competition that take place in closed forest than in the secondary forest as well as waterlogged in marsh areas which would inhibit the growth of the size of the trees.

CHAPTER FIVE

5. 0. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUTION.

From the study findings, I conclude that *Macaranga kilimandscharica* within Mukura reserve occurs in all habitats but mainly secondary forest with the highest percentage 83.5%, followed by Burned area 4.6%, human clearing 3.7%, closed forest 3.2%, fern and marsh 2.3 % each .This could be attributed to its biological and ecological characteristics such as prolific seeder, vigorous regeneration and fart growing.

It was also observed that the human activities disturbing survival of *Macaranga kilimandscharica* within Mukura forest reserve are fire wood collection, grass collection, grazing *Macaranga* cutting, mining and other tree species cutting while the natural disturbance identified was presence of *Sericostachys scandens* .Grazing was mostly observed as an illegal activity within the forest.

From study results it was showed that the DBH of *Macaranga kilimandscharica* degraded habitats is significantly different from non-degraded habitats ($f = 5.34$, $p = 0.000123$, $df = 5$ and 207 $p < 0.05$ Anova single factor.

5.2. RECOMMENDATIONS

The Ministry of Lands, Environment, Forests, Water and Natural Resources should regularly monitor the status and trend of *Macaranga kilimandscharica* as well as other species to guide decision making towards conservation of Mukura forest, encourage households to develop individual woodlots so as to counter the increasing demands of fuel woods currently satisfied by collecting of forest resources as well as promote agroforestry around Mukura forest reserve where multipurpose trees should be planted to help reduce the rate of erosion, increasing soil fertility, providing fodder to animals and solving a bit the problem of fire woods

The government, NGOs and other stakeholders should contribute effectively in raising the standards of living of rural population through income generating projects which are essentially oriented in conservation and sustainable management in Mukura forest.

All stakeholders playing a role in conservation of Mukura forest reserve should build the capacity of locally assigned wardens and policemen in conservation aspects so as to fully invest them in safeguarding of Mukura forest, to raise awareness of local community on the value of conservation of Mukura forest reserve, build their capacity through field-learning practices.

The government should upgrade Mukura Forest Reserve to a national park and work on promotion of harmony between nature and people.

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APPENDIX 1. DATA FILE

DAY	MONTH	YEAR	OBSERVAYOR	LOCALITY	TRANSECT.	PLOT	STEM	DBH	HABITAT TYPE	HUMAN ACTVIT
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	1	34.4	secondary forest	Grazing
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	2	16.5	secondary forest	Grass collectio
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	3	14.2	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	4	16.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	5	31	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	6	24,7	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	7	6.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	8	6.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	9	17.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	10	8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	11	19.3	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	12	18.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	13	19.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	14	20	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	15	17.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	16	6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	17	10	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	1	18	7.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	1	18	secondary forest	Macaran cutting
9	JUNE	2014	MARTIN &ERASTE	RUSEBEYA	A	2	2	40.1	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	3	6.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	4	7.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	5	5.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	6	6.8	secondary forest	

9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	7	24.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	8	15.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	9	32.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	10	18.2	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	11	11.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	12	10.2	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	13	11.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	14	17	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	15	19.9	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	16	39	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	17	36	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	18	44.1	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	19	32.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	2	20	22.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	1	10	secondary forest	Fire woo collectio
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	2	25	secondary forest	Grazing
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	3	33.3	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	4	21.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	5	35.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	6	10.9	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	7	23.9	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	8	42.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	3	9	36.8	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	1	11.3	secondary forest	Fire collectio
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	2	45.3	secondary forest	Macaran cutting
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	3	12.3	secondary forest	

9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	4	18.1	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	5	45.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	6	55	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	7	63.2	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	8	45.6	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	9	23	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	10	33.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	11	44.3	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	12	13	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	13	49.5	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	14	44	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	15	33.4	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	16	44.9	secondary forest	
9	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	4	17	13	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	5	1	10.3	Human clearing	Grazing
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	5	2	11.8	Human clearing	Grass collectio
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	5	3	16	Human clearing	Tree cutt
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	5	4	13	Human clearing	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	5	5	15	Human clearing	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	6	1	20	Human clearing	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	6	2	10	Human clearing	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	6	3	12	Human clearing	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	1	13.3	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	2	11.3	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	3	45.5	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	4	10	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	5	8.4	secondary forest	

10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	6	36.6	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	7	7.6	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	8	20.1	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	9	38.5	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	10	49.7	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	11	57.1	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	12	53.4	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	13	33.7	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	14	49.9	secondary forest	
10	JUNE	2014	MARTIN &ERASTE	RUSEBEYA	A	7	15	51.1	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	16	34.4	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	7	17	22.2	secondary forest	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	8	1	13.6	Burned zone	Grazing
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	8	2	17.8	Burned zone	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	8	3	24	Burned zone	
10	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	8	4	11	Burned zone	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	1	45.6	secondary forest	Macaran cutting
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	2	23.8	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	3	24.6	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	4	18.5	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	5	19.8	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	6	23.8	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	7	6.6	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	8	11.8	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	9	14.7	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	10	8.8	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	11	12.4	secondary forest	

11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	12	45	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	13	15	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	9	14	23	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	1	30.4	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	2	22.2	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	3	45	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	4	32	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	5	46.6	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	6	23.9	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	7	10.4	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	8	23.6	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	9	11.3	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	10	3.5	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	11	38.4	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	12	34.5	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	13	25	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	14	38	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	15	42.6	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	16	16	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	17	19.4	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	18	33.3	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	19	35	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	20	36	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	21	12	secondary forest	
11	JUNE	2014	MARTIN & ERASTE	RUSEBEYA	A	10	22	23.8	secondary forest	