Flora Biodiversity Assessment in Bonga, Boginda and Mankira Forest, Kafa, Ethiopia

Prepared by

Sisay Nune

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Acronyms

AAU	**Addis Ababa University**
CBD	Convention on Biological Diversity
CEEPA	Centre for Environmental Economics and Policy for Africa
CITES	Convention on International Trade in Endangered Species
CPPSLM	Country Partnership Program for Sustainable Land Management
EFAP	Ethiopian Forestry Action Program
EWNHS	Ethiopian Wildlife and Natural History Society
FPA	Forest Priority Area
GEF	Global Environment Facility
RFPA	Regional Forest Priority Areas
GPS	Global Positioning System
IBC	Institute of Biodiversity Conservation
IEEM	Institute of Ecological and Environmental Management
ITC	International Institute for Geo-information Science and Earth Observation
MoARD	Ministry of Agriculture and Rural Development
PFM	Participatory Forest Management
SNNP	Southern Nations Nationalities and Peoples
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WBISPP	Woody Biomass Inventory and Strategic Planning Project
dbh	Diameter at breast height
ETM	Enhanced Thematic Mapper
EU	European Union
UNESCO	United Nations Educational, Scientific and Cultural Organization
GIS	Geographical Information System
ILWIS	Integrated Land and Water Information System
FAO	Food and Agriculture Organization
EN	Endangered
VU	Vulnerable
NT	Near Threatened
LC	Least Concern
IVI	Important Value Index
SRTM	Shuttle Radar Topographic Mission

I. EXECUTIVE SUMMARY

a) This report is prepared for Ethiopian Wildlife and Natural History Society. The report comprises flora biodiversity of Bonga, Boginda and Mankira forests found in Kaffa zone of Southern Nations Nationaities and Peoples Region. Bonga forest is one of the Regional Forest Priority Areas (RFPA). It is estimated to cover an area of 163,000 ha. Mankira forest, which is estimated to cover 900 ha, is part of Bonga RFPA. Geographically Bonga RFPA is located $07^0$00'-$07^0$25'N latitude and $35^0$55'-$36^0$37'E longitude. Boginda forest covers 59447 ha. It is administratively located in Gewata wereda in Kaffa Zone. Geographically, the forest is situated between $07^0$20.000` to $07^0$ 33.400N latitude and $035^0$54.580` to $036^0$14 .570`E longitude, excluding the area under Wushwush Tea Development Enterprise. Both Bonga and Boginda forests are registered as Regional Forest Priority Area (RFPA).

b) Mainly, Enhanced Thematic Mapper (ETM) Land Sat Imagery band 1, 2 and 3 are used for land cover classification. Transects and quadrant method was the recommended survey method to assess flora species. Size of transect was 1000 meters long by 10 meters wide. Quadrants having different dimensions, i.e., 1m X 1m for ferns, herbs and grasses, 2m X 2m for trees and shrub seedlings and 5m X 5m for saplings were laid along the center at 50, 100, 150, …and 950 meters. Each species of tree, shrub and lianas greater than or equal to 10cm diameter within 50 X 10 meter transect were listed and counted. Numerically, 130, 60, and 40 sample plots are assigned for Bonga, Boginda and Mankira, respectively. Each plant species encountered within a transect is identified by its vernacular and scientific names and tallied. Most of the trees and shrubs are identified. Those species that could not be identified on the field were taken to the AAU National Herbarium, for identification. Trees and shrubs less than 10 cm diameter and higher than 1.3 meter are considered as saplings. Tree, shrub and lianas less than 1.3 meters high are recorded as regeneration.

c) In Bonga, seven major land covers are identified, namely Bamboo Forest, Dense Forest, Disturbed Forest, Intensively Cultivated, Moderately Cultivated, Highly Disturbed Forest, and Wetland. Similar land covers are identified in Boginda, too. More than 70 percent of each RFPA is covered by natural forests of different strata (dense forest, disturbed forest and

highly disturbed forest). In general about 92 tree/shrub/liana species above 10 cm diameter are recorded in the three study sites. On site specific basis 46, 70 and 54 tree/shrub/liana species are recorded in Mankira, Bonga and Boginda respectively. With respect to density of trees above 10 cm diameter Bonga forest has the highest (590), followed by Boginda forest (575) and Mankira forest (454). A total of 57 species in Bonga, 36 species in Boginda and 30 species in Mankira are recorded as regeneration. In the current survey 61.4 percent of trees having dbh greater or equal to 10 cm are represented as regeneration in Bonga. In Boginda 52.8 percent of trees/shrubs having 10 cm and above are recorded as regeneration, whereas in Mankira, 43.5 percent of trees greater than 10cm dbh are represented as regeneration. Species such as *Cordia africana* are not registered as regeneration in any of the three forest areas. This is probably because the species is an early colonizer (Friis1992). *Croton macrostacheys* too, as a pioneer species (light demanding), does not get adequate conditions for regeneration in a natural forest (Denich, 2006). But on road sides and wherever there is an opening, *Croton macrostacheys* is well grown and observed. Ficus species are also not represented in regeneration except *F. palmata* in Mankira. In total, including regeneration, saplings, herbaceous plants and grasses Bonga forest has the largest plant cover per ha (estimated to be more than 1,309,956). Mankira and Boginda have lower number of flora density, each comprising 510,120 and 386,600, respectively.

d) Endemic plants recorded in the current study and Schmitt C. B. (2006) are listed as follows: *Erythrina brucei, Milletia ferruginea, Solanecio gigas, Tiliacora troupinii, Vepris dainelli, Aframomum corrorima, Brillantaisia grotanellii, Satureja paradoxa, Vernonia tewoldei, Mikaniopsis clematoides, Lippia adoensis, Clematis longicauda, Clematis longicauda, Pilea bambuseti ssp aethiopica, Pentas tenuis, Dorstenia soerensenii, Phyllanthus limmuensis* and *Cyrtorchis ehrythraeae.*

e) The result of this survey indicates absence of constantly present species within the three forest sites which leads to the conclusion that each forest has a heterogeneous species composition. *Croton macrostachyus* in Mankira, *Milletia ferruginea* in Bonga and

Boginda are the most prevalent species. In this study there was no single tree or shrub species that is constantly present in all sample plots within the three study sites.

Most common tree/shrub species recorded in the three study sites are: *Croton macrostachyus, Phonix reclinata, Vepris dainelli, Sapium ellepticum, Pouteria adolfi-friedericii, Chionanthus mildbraedii, Draceaena steudneri, Schefflera volkensii, Milletia ferruginea, Chionanthus mildbraedii, Macaranga capensis,* and *Psychotria orophila.*

On the other hand, 9 species in Mankira, 30 species in Bonga and 18 species in Boginda are found to be rare species.

f) One study, (Reusing, M., 2000), indicated that settlement and population growth are the main causes for 50 percent of forest degradation (decline of forest quality); and deforestation in South West Ethiopia. During the current survey period it is learnt that the major causes of deforestation in Bonga, Boginda and Mankira, like everywhere in Ethiopia, are clearing and burning of the natural forest for cultivation of food crops, planting coffee (small and/or large scale), settlement, chasing wild animals, pit-sowing, harvesting of fuel wood, construction materials and cutting of big trees to harvest honey. As a result of heavy exploitation of selected trees such as *Cordia africana, Pouteria adolfi-friederici* and *Prunus africana*, these species are reported as endangered by some studies (Ensermu Kelbessa and Teshome Soromessa 2004, Girma Balcha et al, 2002, Schmitt C. B., 2006). The forests are also in the process of degradation due to a number of other factors such as coffee growing and livestock rearing in the forest. Although it is difficult to substantiate the cause of death of trees in this study, insect and pests introduced via animals and humans may attack and affect the vitality of the forest. In this study the number of stumps and dead trees were estimated and the following results are obtained: dead trees per hectare are 292 in Bonga, 433 in Boginda, and 359 in Mankira. The stumps were counted in order to evaluate level of exploitation and the results are 189 for Bonga, 27 for Boginda and 82 for Mankira. As the figure shows Bonga forest is more affected by logging than the rest of the forests. Because of absence of scientific management such as silvicultural practices, all forests of the country, as well as those in the study area, are mostly affected by thick climbers that are silviculturally and economically undesirable

species. As a result of this phenomena economically and silviculturally important tree species are crooked, bent and fluted. Regeneration status, too, might be influenced negatively. Trees that are dead are rotting in the forest. This might help in nutrient cycle but they might also harbor disease. Absence of management plan also leads to over exploitation where annual cut exceeds mean annual increment. In conclusion existing threat to the forests is associated with anthropogenic activities, that is, human induced pressure threatens the existing forests of Kaffa zone. The forests are in fragile and fragmented state. This great biodiversity coupled with the extreme threat caused by habitat destruction makes them part of the Eastern Afromontane biodiversity hotspot (Gil et al. 2004).

g. The three study areas are among the few forest areas of the country. These forest areas contributed to the world one internationally and economically significant plant, coffee. Wetlands and forests found at different altitude harbor different fauna and flora species that have high biodiversity value. Rivers that start from those wetlands and forests have both social and economical values. Despite the fact that the study areas are so important to the country and the world at large, pressure exerted by anthropogenic factors is highly/significantly affecting them. Unless prompt measures are taken the invaluable resource might be lost in a very short period of time. Therefore, putting the three forests in a Biosphere Reserve is highly important and should be done as soon as possible. Establishment of a Biosphere Reserve will save the last forests whereas local community will be benefited through sustainable management of the resources so that utilization will be optimized rather than maximized. Scientific research which may be undertaken in the study area would generate technologies appropriate to the local and national settings that may improve the quality of life of the rural livelihoods. Among many other benefits that can be derived from a Biosphere Reserve, financial mechanism for forest/nature management is worth mentioning.

1. INTRODUCTION

1.1 This report is prepared in Addis Ababa, by the flora expert whose name is indicated on the cover, on behalf of the Ethiopian Wildlife and Natural History Society (EWNHS). It provides information on the biodiversity of flora found in the study area. It gives description of existing habitat and species types. It assesses existing status and overall biodiversity values of the vegetation in the area. It also attempts to identify the threats to such vegetation.

1.2 The study area is dominated by forests but mostly it is fragmented. This fragmentation is mainly due to expansion of agriculture by clearing forest land. Expansion of settlements, both urban and rural, and cultivation are creating "Vegetation Islands" everywhere; except in extreme rugged terrains such as Boginda. Towns such as Gimbo, Bonga, Decha, Wushwush, Kobech, and Saja are inhabited with many people. Demand for wood increases as these towns expand. As a result nearby forests are highly affected. Commercial agriculture on tea and coffee is available in the study area (about 80 in the zone). Recent approach on out grower scheme on tea development is being intensified so that farmers are growing tea and selling it to the Wushwush tea development enterprise. (Wushwush is located at the western part of Bonga town.)

1.3 In addition to forest, the study area comprises agricultural fields which are currently being used for cereal production and perennial crops such as *Teff, maize, wheat and barely and Enset ventricosum.* Among other types of land cover observed wetlands are worth mentioning.

1.3.1 The main economic activity of the local people is agriculture. Growing coffee, banana and *Enset ventricosum* around homesteads are common. Many people also have coffee plots in the forest where they collect coffee beans every year for household consumption and for sell. In addition, honey, products of *Aframomum corrorima* and *Piper capense* (*timiz*) are collected from forests. The "Menja" People who live in the forest collect climbers and lianas for sale. They also hunt in the forest. Grass and

thatches collected from the forest become livestock feed. Livestock are observed in both forest land and agricultural fields.

1.4 The survey focused mainly on forest land and partly on agricultural land with relatively more natural trees on it and wetlands.

1.5 Agricultural expansion seems to be the number one reason for deforestation in the area (Annex III photos 1 - 3). Farmers clear the forest land and burn it or set fire in the forest in order to have space to plant crops. A recent phenomenon on distribution of land to youths is good example of this act. *Kebeles* that are short of land to distribute were seen giving forest land to the youths. Commercial agriculture has been disturbing the remnant forest. Tea development needs complete clearing of forest land while commercial coffee development is done after clearing most of the undergrowth and thinning of trees. Moreover, many environmentalists are concerned that different chemicals used in the plantations may harm the local ecosystem in general and useful insect population in particular. Therefore degradation and deforestation of forests as a result of agriculture and commercial farming may be significant.

1.6 The study area comprises three sites, Bonga, Mankira and Boginda forests. Bonga and Mankira forests are part of Bonga Forest Priority Area (FPA). But for this particular study they will be treated separately. Management status of these three forest areas differ between and sometimes within the forest. In Bonga some of the forests are managed through participatory forest management while some are handed over to the *Kebele* administration to protect them. The forest in Boginda is partly protected under a project financed by the EU and the rest is left for *Kebele* administration. In Mankira an attempt to put the forest under PFM has been initiated and the agreement process is started between local community and FARM Africa. The three forest areas comprise different vegetation density namely dense, disturbed and highly disturbed forest.

1.6.1 Highly disturbed forest land comprises areas that are highly affected by agricultural activities such as cash crop planting and also by settlements. Forest areas that were once occupied by settlement but currently abandoned are also under highly disturbed category. These areas are characterized by less number of trees than disturbed and dense forest lands. Disturbed forest has better canopy closure than highly disturbed

forest. Few tall trees and better undergrowth is available in such forests. Dense forest can be characterized by closed canopy and quite few thorny and shrubby species underneath. Similar bole diameters occupy similar canopy within dense forest stratum.

1.6.2 There are state owned plantations of different species, namely: *Cupressus lusitanica, Pines patula, Pinus radiate, Eucalyptes spp.*. These plantations are mostly found adjacent to natural forests. Privately owned trees are observed during the survey period. These trees are mostly planted around homesteads. Among the species farmers planted, eucalypts and cupresses dominate. These plantations are not indicated on map because of their size compared to spatial resolution of satellite image used.

1.7 The study area experience one long rainy season, lasting from March /April to October. The mean annual rainfall ranges from 1710 mm at Bonga station to 1892 mm at Wushwush station. Over 85 % of the total annual rainfall, with mean monthly values in the range of 125 - 250 mm occurs in the 8 months long rainy season. The mean temperature is 19.4°C at Bonga while it is 18.1°C at Wushwush station (Taye Bekele, 2003). Despite the fact that the data is meant for Bonga, due to absence of meteriological stations around Boginda, this value of Bonga can be taken for Boginda as well.

1.8 The aims of the assessment were:

- Take inventory of the characteristic macro flora, including endangered, rare and endemic tree and shrub species of Bonga, Boginda and Mankira forests, providing a species list as per the UNESCO Biosphere Reserve nomination form.
- Identify and document prevailing and potential main threats to the *threatened plant species* in the aforementioned three forests and in their surroundings,
- Identify and document prevailing and potential main *threats to the three forests* mentioned above,
- Assess, list and describe all major habitats and bio-geographical zones (e.g. tropical evergreen forest, savannah, woodland, intact or core areas...) in the three forests,

1.10. Previous Studies

Previously conducted researches and reports are well reviewed and summerised in Riechmann, D. 2007. Only relevant information regarding these past works and other works

had done by different authors not mentioned in Riechmann, Dennis 2007 are included in the current survey either in the form of comparison or complement.

2. METHOD OF ASSESSMENT

2.1 Institute of Ecology and Environmental Management (IEEM) Guideline on Ecological Impact Assessment (2006) was consulted during the study period. Calculation of different biodiversity indices was done based on ITC lecture notes which were prepared from the work of Anne E. Magurran, Princeton University Press (1988), Michael A. Huston, Cambridge University Press (1994) and John A. Wallwork, Academic Press, New York (1976). Aims and Methods of Vegetation Ecology by Mueller-Dombois and Ellenberg 1974 are consulted throughout the study period.

2.2 For vegetation classification of Ethiopia in general and the study area in particular, Friis, 1994, Chaffey, 1979, EFAP, 1994 and IBC, 2005 were used. Additional information related to vegetation (on the study area) is collected from Zonal Bureau of Agriculture and Rural Development, Zonal Bureau of Trade and Industry, Planning and Investment Desk.

2.3 The two remotely sensed data are the main tools, Landsat ETM 7 123 of 2002 and ASTER 321 RGB, used to stratify, determine transects' position and collect data. The remotely sensed data were analyzed using ERDAS IMAGINE 8.4, ILWIS 3.1, ArcGIS 9.1 and 9.2 and ArcView GIS 3.2. Digital image classification was conducted.

2.4 For plant identification Azene Bekele-Tessema with Ann Birnie and Bo Tenagnas, 1993, Edward, S. et al, 1995, Welde Michael, 1987 , Hedberg, I. & Edwards, S., 1995 and Hedberg, I. & Edwards, S., 1989 were used. Plants species that were not identified at field level were taken to Addis Ababa University, national herbarium for identification.

Desk Study Methods

2.5 Relevant biodiversity information was gathered mainly from Federal Environmental Protection Authority (EPA) and Institute of Biodiversity Conservation (IBC). Other

important information is collected from Ministry of Agriculture and Rural Development (MoARD) and Southern Nations Nationalities and Peoples Bureau of Agriculture and Rural Development (SNNPBoARD).

2.6 The study area was classified using remote sensing and GIS. Unsupervised classification was made using ERDAS IMAGINE 8.4, whereas supervised classification was done using ILWIS. ILWIS assists classification of vegetation (user-friendly) through its feature space. The two classifications were compared and by applying expert knowledge (and train the software by training points) collected from field seven major classes were determined. These seven major classes were identified latter as dense forest, bamboo forest, intensively cultivated land, exposed surface, moderately cultivated areas, wetland, disturbed forest and highly disturbed forest. In Boginda bamboo forest doesnot exist.

2.7 Transect lines were selected by closely examining the classified map especially on vegetation part (forest land) (see annex V for distribution of transects). Major interest area for flora assessment in Bonga, Mankira and Boginda were vegetated area especially forest covered lands. Geographical position of transects' starting points were identified and recorded into Global Positioning System (GPS). Simultaneously azimuth is determined and recorded in note book.

2.8 standard data collection formats were prepared.

The study Area

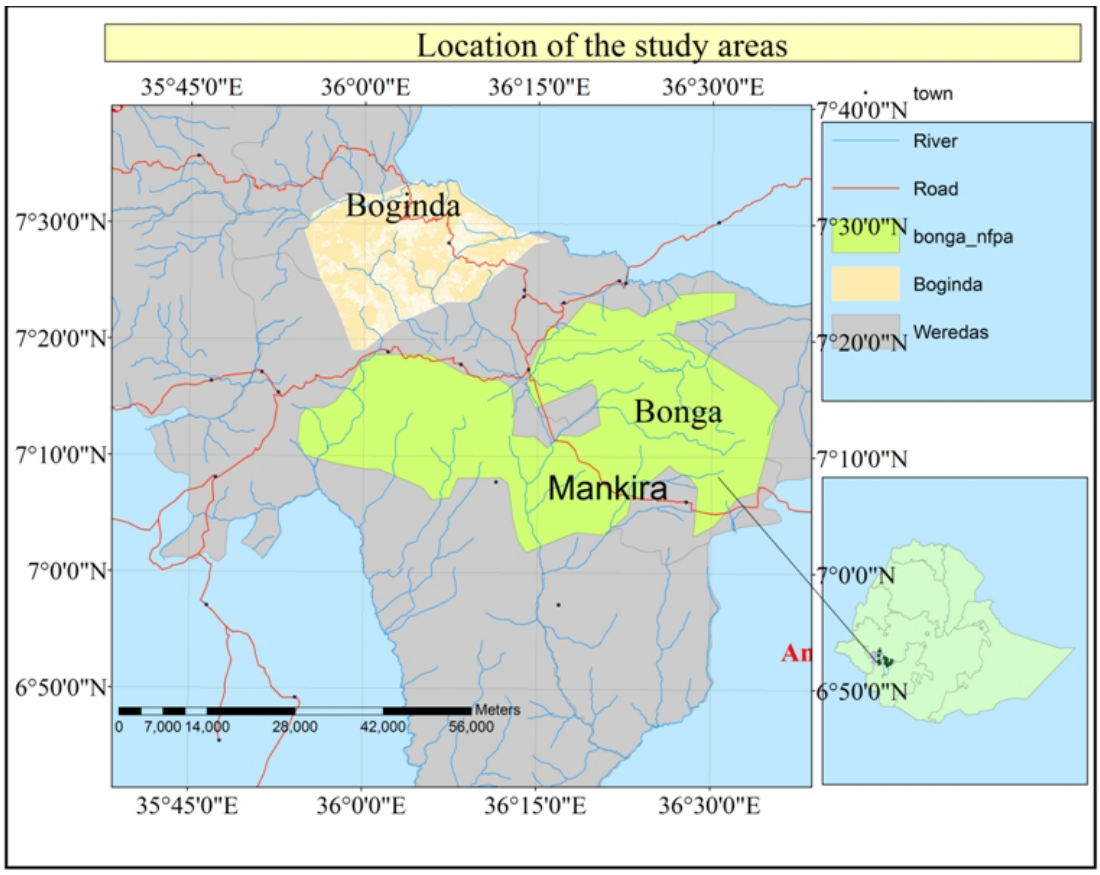
The study area is found in Kafa Zone of Southern Nations, Nationalities and Peoples Regional State.

Bonga forest is one of the Regional Forest Priority Areas (RFPA). It is estimated to cover an area of 163,000 ha. Mankira forest, which is estimated to cover 900 ha, is part of Bonga RFPA. Geographically, Bonga RFPA is located $07^0$00'-$07^0$25'N latitude and $35^0$55'-$36^0$37'E longitude.

According to Girma Balcha et al, 2004, Boginda forest covers about 7,500ha. But in this study wider area is considered, 59447 ha. It is administratively located in Gewata wereda in Kafa Zone. Geographically, the forest is situated between $07^0$20.000` to 07^0 33.400N latitude and

$035^{0}54.580`$ to $036^{0}14$ .570`E Longitude, excluding Wushwush tea development enterprise. Both Bonga and Boginda forests are registered as Regional Forest Priority Area (RFPA).

Map 1. The study Area (Bonga, Boginda and Mankira)



Source: WBISPP, 2004 (geodata) and SUPAK 2002.

Field Survey Methods: Flora

2.9 Transects and quadrant method was the recommended survey method to assess flora species. Size of transect was 1000 meter long and 10 meters wide. Quadrants having different dimensions, i.e., 1m X 1m for ferns, herbs and grasses, 2m X 2m for trees and shrub seedlings and 5m X 5m for saplings were laid along the center at 50, 100, 150, …and 950 meters for estimation of their relative abundance. Each species of tree, shrub and lianas greater than or equal to 10 cm diameter within 50 X 10 meter transect were listed and counted. Diameter at breast height of each tree listed is measured. Height of each tree is estimated. The survey period was between mid February and end of March and lasted for 30 days. Two teams were involved. GPS, Silva compass, diameter tape, plant press, used-news papers, cutters, and measuring tape were the main instruments and tools used during the survey. All observation was made by naked eyes.

2.10 Due attention is given to relatively naturally vegetated areas, in particular forest areas. Representative area for each site was sampled. The classified (stratified) map was used for the whole period. In terms of size Bonga forest is the biggest. Boginda and Mankira cover less size, respectively. Therefore, the number of sample plots in each forest varies accordingly. Numerically 130, 60, and 40 plots are assigned for Bonga, Boginda and Mankira, respectively. Out of 130 plots in Bonga 20 plots are sampled in agricultural land. Sample plots are distributed proportional to the size of the area.

2. 11 One transect line comprises 10 sample plots. The first sample plot is chosen randomly. It starts 50 meters from the edge of the forest to avoid "edge effect". Along each transect line, the following information is collected:

- Tree, shrub and lianas
- Herbs and ferns
- Grasses
- Regeneration and saplings for trees, shrubs and lianas
- Number of dead trees

2.12 An attempt was made to collect lichens, mosses, liverworts, epiphytes, and fungi. These plants were not encountered within 1m X 1m quadrants. However, outside the quadrant, on a tree bole, branches and dead woods quite large amount of such plants were observed. Fern species that are encountered within 1 m X 1m are recorded.

2.13 Each plant species encountered within transect is identified by its vernacular and scientific names and tallied. Most of the trees and shrubs are identified. Those species that could not be identified on the field were taken to the AAU National Herbarium, for identification. Trees and shrubs less than 10 cm diameter and higher than 1.3 meter are considered as saplings. Tree, shrub and lianas less than 1.3 meters high are recorded as regeneration.

2.14 Within each 1m X 1m quadrant small herbaceous plants, grasses, trees and shrub seedlings were surveyed (photo 19 & 20). Tree and shrub seedlings are recorded separately.

2.15 Important observations noted as threats to forest are:

- ♦ Agricultural expansion, both for subsistence and commercial purpose, (including fire)- this phenomena is pressurizing the forests in almost all directions.
- ♦ Settlement (wood for construction and fuel); settlements in the area seem to be formed as a competition for land with no pattern.
- ♦ Free grazing in the forest.

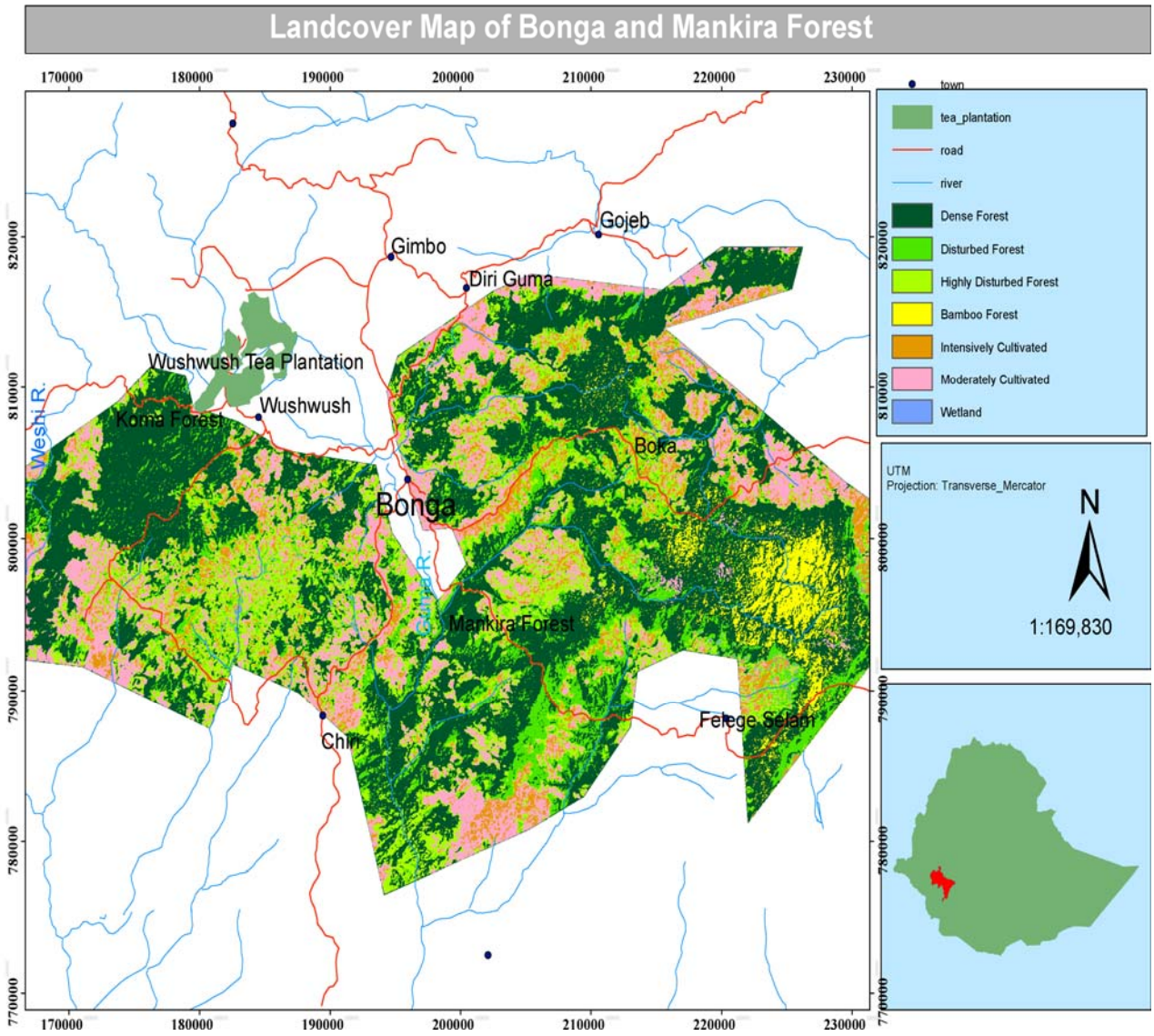
3 RESULTS

In this section major land covers and their extent is analyzed based on remote sensing and GIS; number of individuals and species recorded within each stratum are presented.

3.1. Major land covers

Seven major land covers are identified, namely Bamboo Forest, Dense Forest, Disturbed Forest, Intensively Cultivated, Moderately Cultivated, Highly Disturbed Forest, Wetland (map 2 & figure 1). The total size of the study area and extent of each land cover is illustrated in Table 1 below.

Map 2. Digitally analyzed Map of Bonga and Mankira Forest



Source: Flora biodiversity assessment, 2008

Figure 1. Estimated Landcover of Bonga (including Mankira)

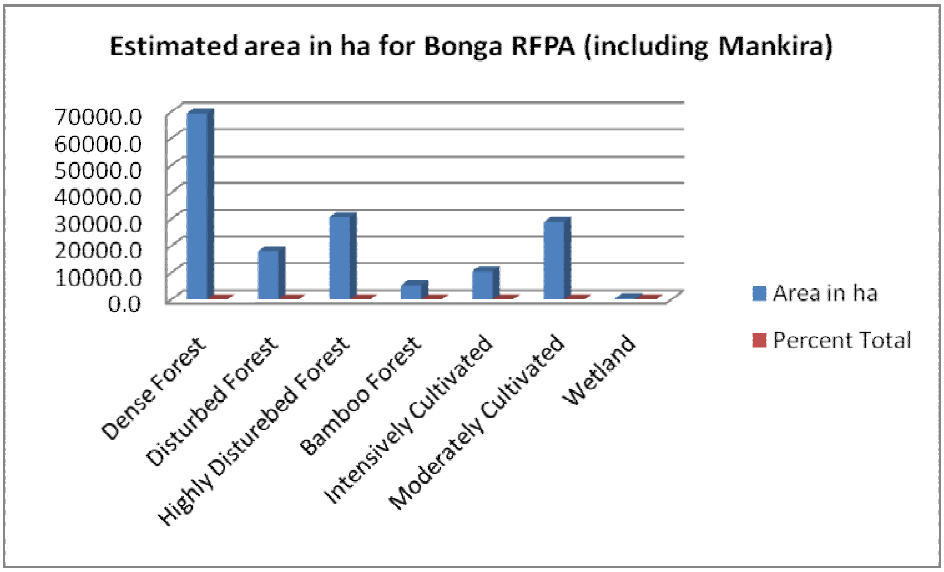


Table 1. Extent of major land covers in Bonga and Mankira

BONGA-NFPA	Area in ha	Percent total
Dense Forest	69361.4	42.5
Disturbed Forest	17961.9	11.0
Highly Disturbed Forest	30675.8	18.8
Bamboo Forest	5421.9	3.3
Intensively Cultivated	10494.1	6.4
Moderately Cultivated	28858.2	17.7
Wetland	486.6	0.3
Total	163259.8	100.0

Source: Flora biodiversity assessment, 2008

From the above Table it is possible to conclude that more than 70 percent of the study area is covered by natural forests of different strata (dense forest, disturbed forest and highly disturbed forest). Moderately cultivated land, where the area is stocked with trees of different density, comprises 17.7 percent. Intensively cultivated land is characterized by less number of trees and shrubs in the area than moderately cultivated land. This land cover comprises about 6.4 percent. Dense forest covers more than 40 percent of the total

area. Disturbed and highly disturbed forest each comprises 11 and 18.8 percent, respectively. Wetlands area is not much in this part of the forest when compared with Boginda.

Boginda

Similar to Bonga RFPA, seven major land covers are identified. These land covers are Dense Forest, Disturbed Forest, Intensively Cultivated, Moderately Cultivated, Highly Disturbed Forest, Wetland and Exposed Surface (map 3 & figure 2). The total size of the study area and extent of each land cover is illustrated in Table 2 below.

Map 3. Boginda Landcover Map

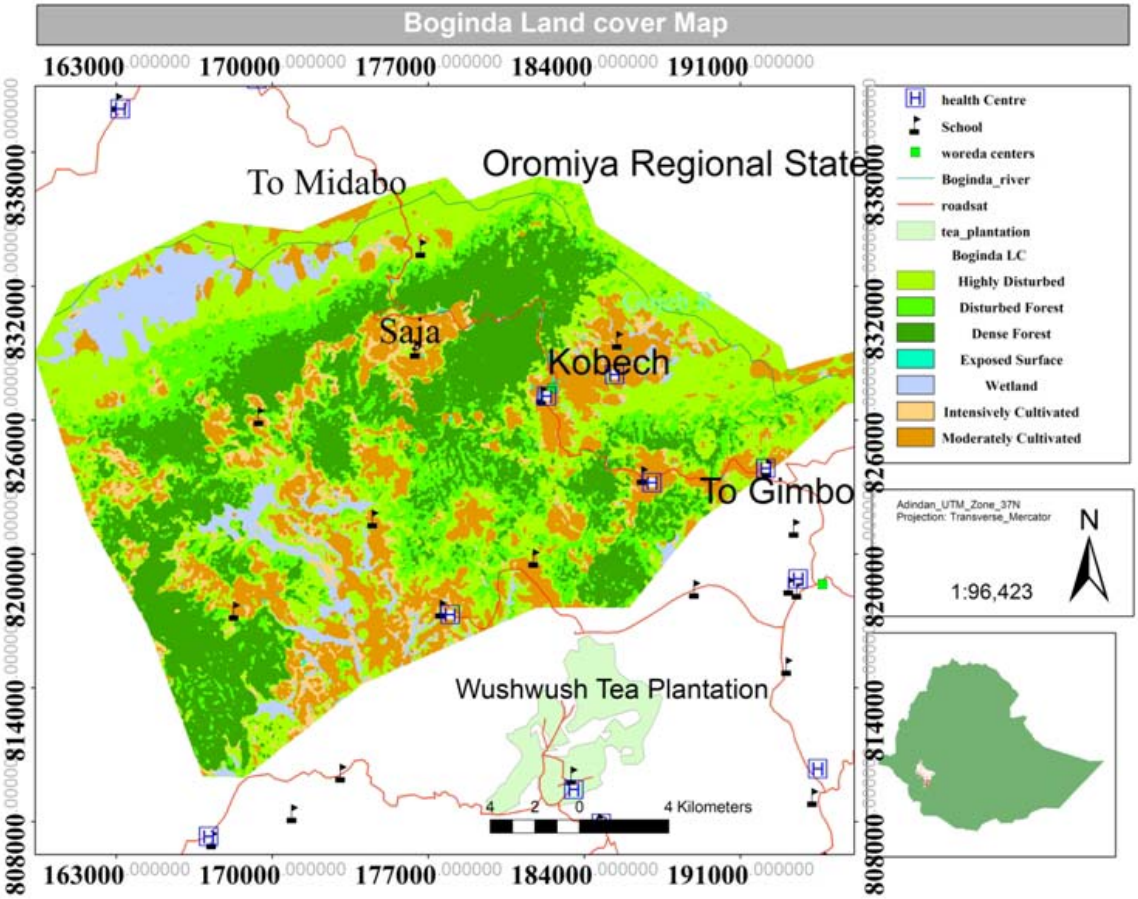
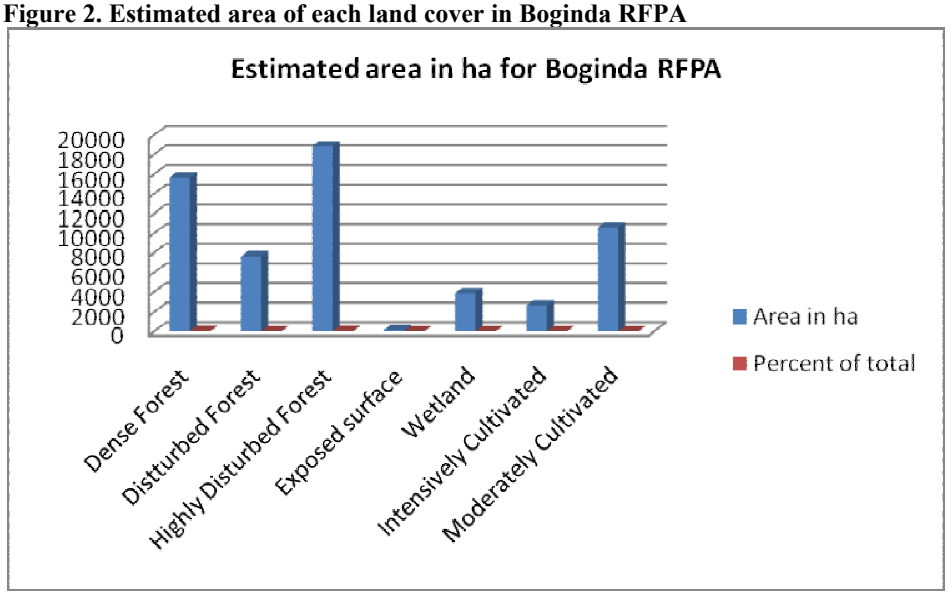


Table 2. Estimated area of each land cover in Boginda RFPA

BOGINDA RFPA	Area in hectare	Percent of total
Dense Forest	15666.3	26.4
Disturbed Forest	7629.2	12.8
Highly Disturbed Forest	18867.8	31.7
Exposed surface	119.9	0.2
Wetland	3879.9	6.5
Intensively Cultivated	2679.9	4.5
Moderately Cultivated	10603.9	17.8
Total	59446.9	100.0

Source: Flora biodiversity assessment, 2008

Figure 2. Estimated area of each land cover in Boginda RFPA



Over 70 percent of the study area is covered by forests of different strata, dense, disturbed and highly disturbed comprising 26.4, 12.8 and 31.7 percent respectively. Wetland covers 6.5 percent of the total area.

3.3 Floristic composition and density of flora

3.3.1 Trees, shrubs, and Lianas

In this document shrubs are considered as trees.

3.3.1.1 Floristic composition of Bonga is dominated by broadleaved tree species. One coniferous tree species, i.e., *Podocarpus falcatus,* exists, though it wasn't recorded in any of the plots. This list of species includes only trees above 10 cm diameter. The registered broadleaved tree species are listed as follows:

A. In Bonga

Alangium chinense, Albizia gummifera, Allophyllus abyssinicus, Allophyllus macrobotrys, Apodytes dimidiate, Bersama abyssinica, Canthium oligocarpum, Cassipourea malosana, Celtis africana, Chionanthus mildbraedii, Clausena anisata, Cordia africana, Croton macrostachyus, Cyathea manniana, Dracaena afromontana, Dracaena fragrans, Draceaena steudneri, Ehertia cymosa, Erythrococca trichogyne, Fagarobsis angolensis, Ficus ovata, Ficus palmate, Ficus thonningii, Galineiera saxifrage, Hibiscus calyphyllus, Illex mitis, Justica schimperiana, Landolphia buchananii, Landolphia owerensis, Macaranga capensis, Maesa lanceolata, Maytenus gracilipes, Milletia ferruginea, Ocotea kenyensis, Olea welwitschii, Oxyanthus specious, Pittosporum viridiflorum, Polyscias fulva, Pouteria adolfi-friederici, Prunus africana, Psychotria orophila, Rothmannia urcelliformis, Rytigynia neglecta, Salacia congolensis, Sapium ellepticum, Schefflera abyssinica, Sericostachys scandens, Stephania abyssinica, Syzygium guineense, Tiliacora troupinniCuf, Trilepisium madagascariense, Vepris dainelli, Vernonia amygdalina, Vernoia ariculifera

B. In Mankira

Psychotria orophila, Milletia ferruginea, Erythrococca trichogyne, Bersama abyssinica, Schefflera abyssinica, cachno, Ficus ovata, Albizia gummifera, Maesa lanceolata, Draceaena afromontana, Rothmannia uricelliformis, Galineiera saxifrage, Cordia africana, Clausena anisata, Cissampelos pareira, Diospyrose abyssinica, Landolphia owerensis, Vernonia amaygadlina, Isoglosa somalensis, Flacortia indica, Polyscias fulva, Pouteria adolfi-friedericii, Carex chlorosaccus, Vepris dainelli, Grewia ferruginea, Rytigynia neglecta, Prunus Africana, Oxyanthus

specious, Macaranga capensis, Sapium ellepticum, Allophyllus abyssinicus, Cyathea manniana, Chionanthus mildbraedii, Ficus sur, Pittosporum viridiflorum, Ficus palmate, Trichilia dregeana, Celtis africana, Croton macrostachyus, Cassipourea malosana, Ehertia cymosa, Apodytes dimidiate, Olea welwitschii, Phonix reclinata, Syzygium guineense and *Draceaena steudneri*

C. In Boginda

Allophyllus abyssinicus, Allophyllus macrobotrys, Apodytes dimidiate, Canthium oligocarpum, assipourea malosana, Celtis africana, Chionanthus mildbraedii, Croton macrostachyus, Cyathea manniana, Draceaena steudneri, Fagarobsis angolensis, Ficus palmate, Hibiscus calyphyllus, Illex mitis, Justica schimperiana, Landolphia buchananii, Macaranga capensis, Maytenus gracilipes, Ocotea kenyensis, Olea welwitschii, Oxyanthus specious, Pittosporum viridiflorum, Polyscias fulva, Pouteria adolfi-friederici, Prunus Africana, Rytigynia neglecta, Salacia congolensis, Sapium ellepticum, Syzygium guineense, Trilepisium madagascariense and *Vepris dainelli*

D. Species encountered in all the study sites (Bonga, Boginda and Mankira):

Albizia gummifera, Draceaena afromontana, Allophyllus abyssinicus, Draceaena steudneri, Apodytes dimidiate. Ehertia cymosa, Bersama abyssinica, Erythrococca trichogyne, cachno, Carex chlorosaccus, Cassipourea malosana, Celtis africana, Ficus ovata, Ficus palmate, Chionanthus mildbraedii, Ficus sur, Cissampelos pareira, Clausena anisata, Flacortia indica, Galineiera saxifrage, Cordia africana, Croton macrostachyus, Grewia ferruginea, Isoglosa somalensis, Landolphia owerensis, Macaranga capensis, Maesa lanceolata, Milletia ferruginea, Olea welwitschii, Oxyanthus specious, Phonix reclinata, ittosporum viridiflorum, Polyscias fulva, Pouteria adolfi-friedericii, Prunus africana, Psychotria orophila, Rothmannia uricelliformis, Rytigynia neglecta, Sapium ellepticum, Schefflera abyssinica, Syzygium guineense, Trichilia dregeana , Vepris dainell and *Vernonia amaygadlina*

E. Species that are encountered in Bonga and Boginda, but not in Mankira:

Allophyllus macrobotrys, Allophyllus macrobotrys, Canthium oligocarpum, Canthium oligocarpum, Dracaena fragrans, Dracaena fragrance, Illex mitis, Landolphia buchananii, Landolphia buchanani and*, Maytenus gracilipes*

F. Species which are encountered in Mankira and Boginda, but not in Bonga:

Ehertia cymosa and *Erythrococca trichogyne*

G. Species that is encountered in Mankira and Bonga but not in Boginda:

Phonix reclinata

3.3.1.2 The ten most recorded tree/shrub/liana species in the transect representing Mankira are *Vepris dainelli* (8.59%), *Landolphia buchananii* (7.16%), *Croton macrostachyus* (6.5%), *Sapium ellipticum* (5.29%), *Pouteria adolfi-friederici* (4.85%), *Draceaena steudneri* (4.63%), *Chionanthus mildbraedii* (4.41%), *Ehertia cymosa* (3.30%), *Celtis africana* (3.30%) and *Milletia ferruginea* (3.08%).

3.3.1.3 The ten most recorded tree/shrub/liana species in the transect representing Bonga forest are *Draceaena steudneri* (12.74%), *Schefflera volkensii* (6.89%), *Allophyllus macrobotrys* (5.20%), *Landolphia owerensis* (4.24%), *Phonix reclinata* (3.97%), *Maesa lanceolata* (3.58%), *Eugenia bukobensis* (2.54), *Syzygium guineense* (2.5%), *Galineiera saxifraga* (2.37%) and *Vepris dainelli* (2.23%).

3.3.1.4 The ten most recorded tree/shrub/liana species in the transect representing Boginda forest are *Sericostachys scandens* (8.20%), *Allophyllus abyssinicus* (5.65%), *Dombeya torrida* (5.56%), *Ehertia cymosa* (4.87%), *Allophyllus macrobotrys* (4.8%), *Syzygium guineense* (4.24%), *Prunus africana* (4.17%), *Psychotria orophila* (3.82%), *Oncoba routledgei* (3.82%) and *Cyathea manniana* (3.82%).

In general about 92 tree/shrub/liana species above 10 cm diameter are recorded in the three study sites. On site specific basis 46, 70 and 54 tree/shrub/liana species are recorded in Mankira, Bonga and Boginda, respectively. With respect to density of trees above 10 cm diameter Bonga forest has the highest (590), followed by Boginda forest (575) and Mankira forest (454).

3.3.2 Regeneration

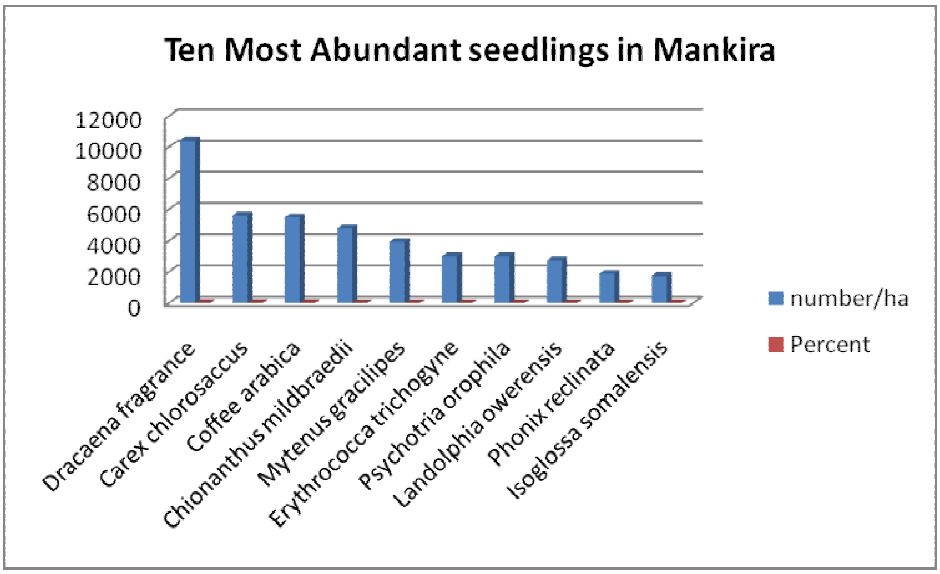
3.3.2.1 Regeneration of trees/shrubs and lianas recorded are listed as follows:

A. Mankira (30 species):

Erythrococca trichogyne, Psychotria orophila, Landolphia owerensis, Phonix reclinata, Isoglossa somalensis, Rothmannia urcelliformis , Clausena anisata, Ehertia cymosa, Prunus africana, Vepris dainelli, Clerdendrum myricoides, Milletia

ferruginea, Phytolacacca dodecandra, Bersama abyssinica, Ficus palmate, Grewia ferruginea, Pittosporum viridiflorum, Pouteria adolfi-friederici, Schrebera alata, Allophyllus macrobotrys, Lepidotrichilia volkensii, Albizia gummifera, Allophyllus abyssinicus, Galineiera saxifrage and *Tiliachoro troupinii*

Figure 3. Regeneration in Mankira

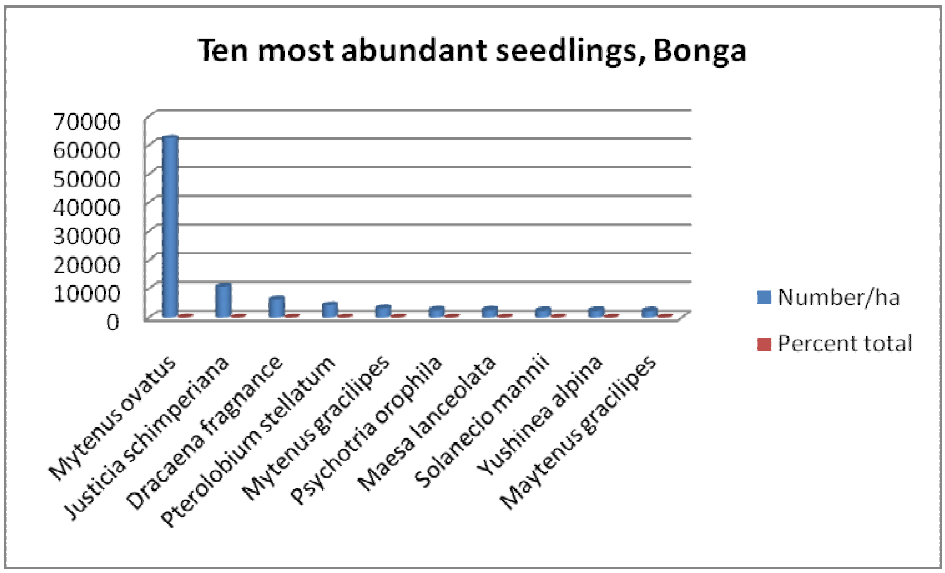


B. Bonga (57 species)

Maytenus ovatus, Justicia schimperiana, Maesa lanceolata, Trilepisum madagascariense, Dracaena fragnance, Sapium ellipticum, Vernonia spp, Pterolobium stellatum, Celtis gomphophylla, Mytenus gracilipes, Psychotria orophila, Solanecio mannii, Yushinea alpine, Maytenus gracilipes, Coffea arabica, Rubus apetalus, Acanthus eminens, Celtis africana, Galineiera saxifrage, Prunus africana, Urera hypselodendron, Ekebergia capensis, Vernonia amygdalina, Hibiscus berberidifolius, Pouteria adolfi-friederici, Ricinus communis, Bersama abyssinica, Vepris dainelli, Milletia ferruginea, Schrebera alata, Allophyllus abyssinicus, Chionanthus mildbraedii, Allophyllus macrobotrys, Dracaena steudneri, Phytolacacca dodecandra, Clausena anisata, Rytigynia neglecta, Teclea nobilis, Albizia gummifera, Canthium oligocarpum, Cissus petiolata, Euphorbia ammpliphylla, Euphorbia ampliphylla, Phonix reclanata, Pittosporum viridiflorum, Ritchiera steudneri, Cissampelos pareira, Brucea antidysenterica, Pteridium aquilinum, Rhamnus prinoides, Dombeya torrid, Dracaeana

afromontana, Olea welwitschii, Oxyanthus speciosus, Pavetta abyssinica, Rothmannia urcelliformis, Tinospora caffra and *Tragia sp*

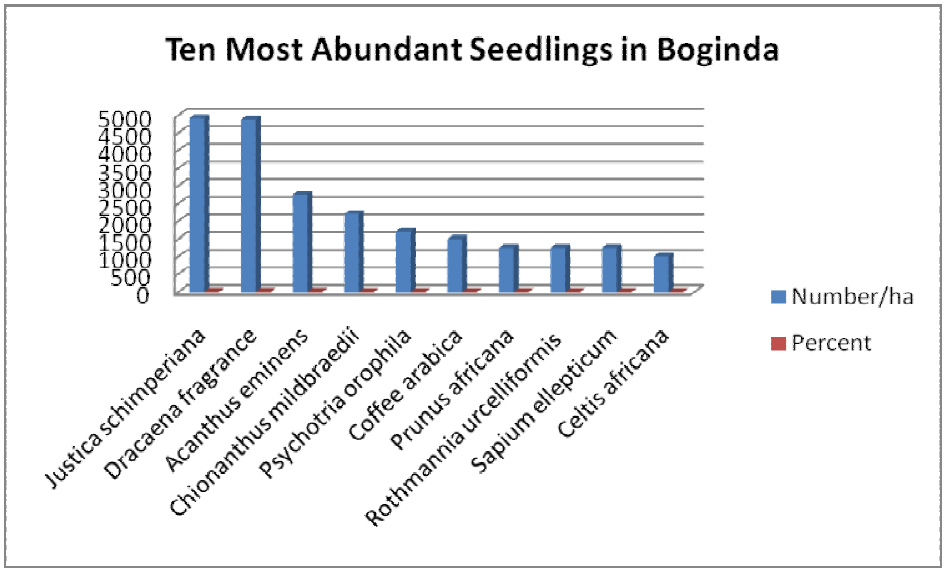
Figure 4. Regeneration in Bonga



C. Boginda (39 species):

Landolphia buchananii, Justicia schimperiana, Dracaena fragrance, Justica schimperiana, Acanthus eminens, Chionanthus mildbraedii, Psychotria orophila, Coffea arabica, Prunus africana, Rothmannia urcelliformis, Sapium ellepticum, Celtis africana, Maesa lanceolata, Rytigynia neglecta, Mytenus gracilipes, Galineiera saxifrage, Vepris dainelli, Albizia gummifera, Marsdenia spec, Oxyanthus speciosus, Phonix reclinata, Pouteria adolfi-friederici, Vernonia sp, Clausena anisata, Allophyllus macrobotrys, Pavetta abyssinica, Bersama abyssinica, Allophyllus abyssinicus, Cassipourea malosana, Dracaeana afromontana, Draceaena steudneri, Embelia schimperi, Erythrococca trichogyne, Macaranga capensis, Milletia ferruginea, Stephania abyssinica, Syzygium guineense, Trilepisium madagascariense and *Tritemma maurtianum*

Figure 5. Regeneration in Boginda



Summary:

The highest regeneration per hectare is recorded in Bonga forest (137,546), *Maytenus ovatus* being the most abundant species, 62,500. The least recorded species in this area are *Dracaeana afromontana, Olea welwitschii, Oxyanthus speciosus, Pavetta abyssinica, Rothmannia urcelliformis, Tinospora caffra* and *Tragia sp,* each 250 per ha. Next to Bonga in decreasing order are Mankira and Boginda each comprising 34,417 and 55,200 seedlings per ha, respectively. In Boginda the highest recorded species is *Justica schimperiana* (4,917 per ha) whereas in Mankira the highest recorded seedling is *Dracaena fragrance* (10438 per ha). The least recorded (seedling) species in Boginda are *Allophyllus abyssinicus, Cassipourea malosana, Dracaeana afromontana, Draceaena steudneri, Embelia schimperi, Erythrococca trichogyne, Macaranga capensis, Milletia ferruginea, Stephania abyssinica, Syzygium guineense, Trilepisium madagascariense, Tristemma maurtianum* (each 250 seedlings per ha). Similarly, the following species are the least recorded in Mankira (250 seedlings per ha): *Lepidotrichilia volkensii, Albizia gummifera, Allophyllus abyssinicus, Embelia schimperi, Galineiera saxifrage* and *Tiliachoro troupinii*

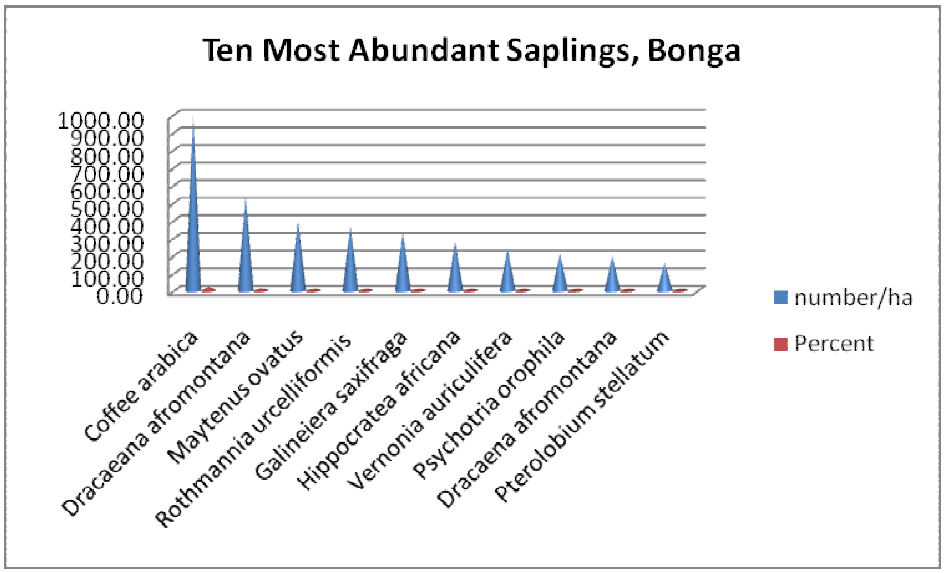
3.3.3 Saplings

3.3.3.1 Regeneration of trees/shrubs and lianas recorded are listed as follows:

A.Bonga (21 species)

Albizia gummifera, Bersama abyssinica, Buddleja polystachya, Coffea arabica, Dracaeana afromontana, Dracaena afromontana, Erythrococca trichogyne, Ficus ovata, Ficus sur, Galineiera saxifrage, Hippocratea africana, Hypericum revoltum, Maesa lanceolata, Maytenus ovatus, Milletia ferruginea, Psychotria orophila, Pteridium aquilinum, Pterolobium stellatum, Rothmannia urcelliformis, Schefflera abyssinica and *Vernonia auriculifera*

Figure 6. Saplings in Bonga

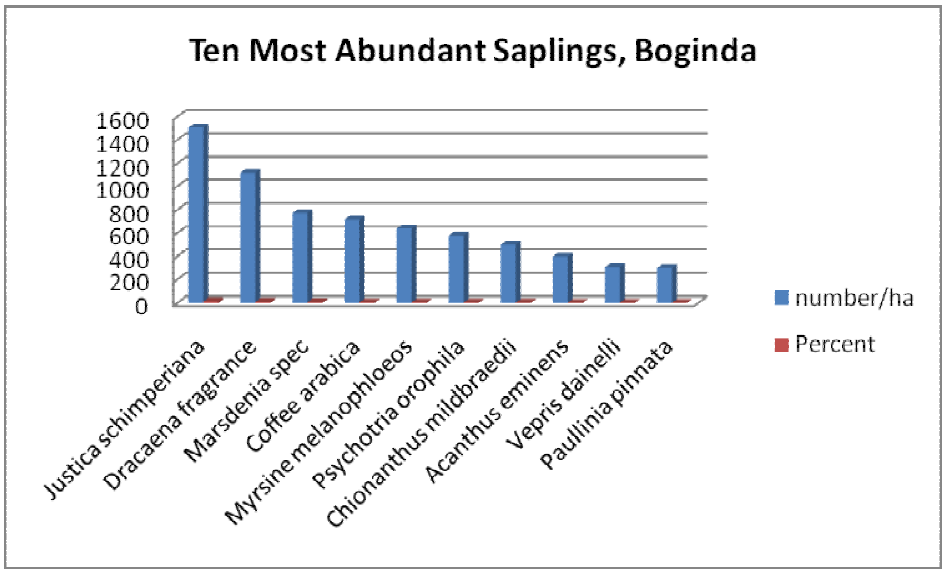


B.Boginda (54 species)

Acanthus eminens, Alangium chinense, Albizia gummifera, Allophyllus abyssinicus, Allophyllus macrobotrys, Apodytes dimidiate, Bersama abyssinica, Canthium oligocarpum, Cassipourea malosana,Chionanthus mildbraedii, Cissus petiolata, Clausena anisata, Coffea arabica, Cyphomandra betacaea, Cysthea manniana, Deinbollia kilimandscharica, Dracaeana afromontana, Dracaena fragrance, Draceaena steudneri, Ehertia cymosa, Erythrococca trichogyne, Ficus ovata, Galineiera saxifrage, Hibiscus berberidifolius, Justica schimperiana, Landolphia buchananii, Landolphia owerensis, Macaranga capensis, Maesa lanceolata, Marsdenia spec, Milletia ferruginea, Myrsine melanophloeos, Mytenus gracilipes,

Olea welwitschii, Oncinotis tenuiloba, Oxyanthus speciosus, Paullinia pinnata, Pavetta abyssinica, Phytolacacca dodecandra, Pittosporum viridiflorum, Prunus africana, Psychotria orophila, Rothmannia urcelliformis , Rubus apetalus, Rytigynia neglecta, Sapium ellepticum, Schrebera alata, Sericostachys scandens, Solanecio gigas, Stephania abyssinica, Teclea nobilis, Vepris dainelli, Vernonia amygdalina and *Vernonia sp*

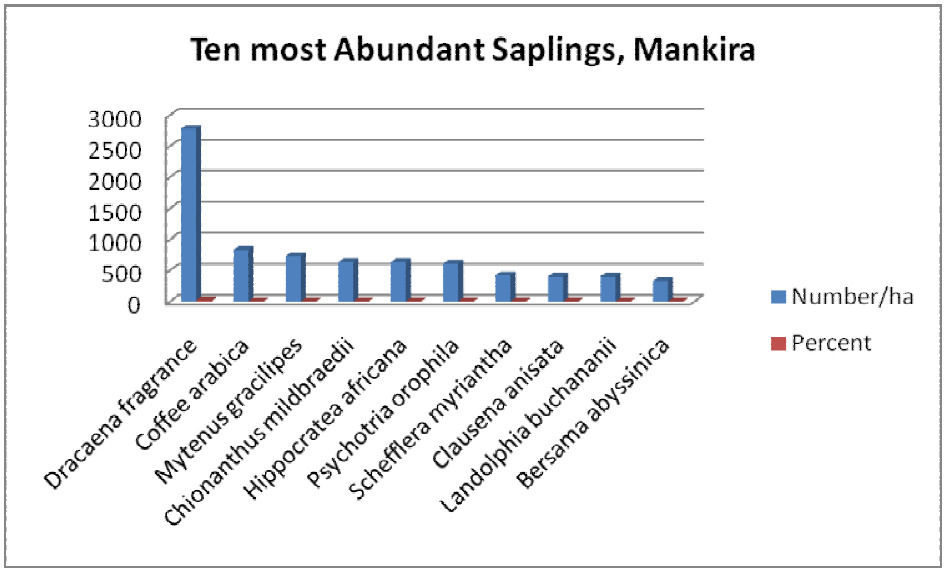
Figure 7. Saplings in Boginda



C.Mankira (46 species)

Dracaena fragrance, Coffea arabica, Mytenus gracilipes, Chionanthus mildbraedii, Hippocratea africana, Psychotria orophila, Schefflera myriantha, Clausena anisata, Landolphia buchananii, Bersama abyssinica, Pavetta abyssinica, Rubus apetalus, Rothmannia urcelliformis, Allophyllus macrobotrys, Pittosporum viridiflorum, Albizia gummifera, Cysthea manniana, Dracaeana afromontana, Phonix reclinata, Vepris dainelli, Ficus palmate, Galineiera saxifrage, Maesa lanceolata, Oxyanthus speciosus, Rhamnus prinoides, Cissus petiolata, Draceaena steudneri, Ehretia cymosa, Isoglossa somalensis, Milletia ferruginea, Pterolobium stellatum, Rytigynia neglecta, Tiliacora troupinii, Vernonia amygdalina, Dregea rubicund, Canthium oligocarpum, Diospyros abyssinica, Ehertia cymosa, Flacortia indica, Landolphia owerensis, Celtis africana, Allophyllus abyssinicus, Olea welwitschii, Apodytes dimidiate, Erythrococca trichogyne and *Pouteria adolfi-friederici.*

Figure 8. Saplings in Mankira



Summary:

The highest saplings per hectare are recorded in Mankira forests (12,796), *Dracaena fragrance* being the most abundant species, 2,780. The second highest saplings per hectare recorded are *Coffea arabica,* 840. The least recorded species in Mankira are *Apodytes dimidiate, Erythrococca trichogyne, Pouteria adolfi-friederici,* each 40 per ha. Next to Mankira in decreasing order are Boginda and Bonga each comprising 11,156 and 4,332 saplings per ha respectively. In Boginda the highest recorded species is shrub, *Justica schimperiana (1507 per ha) whereas* in Bonga the highest recorded sapling is *Coffea arabica* (989 per ha). The least recorded (saplings) species in Boginda are *Alangium chinense, Allophyllus macrobotrys, Cassipourea malosana, Cyphomandra betacaea, Draceaena steudneri, Ehertia cymosa, Ficus ovata, Hibiscus berberidifolius, Oxyanthus speciosus,Phytolacacca dodecandra, Pittosporum viridiflorum, Schrebera alata, Solanecio gigas, Teclea nobilis (*each 40 saplings per ha). Similarly the following species are the least recorded in Bonga (40 seedlings per ha)*: Albizia gummifera, Erythrococca trichogyne, Ficus ovata, Ficus sur, Pteridium aquilinum* and *Schefflera abyssinica*

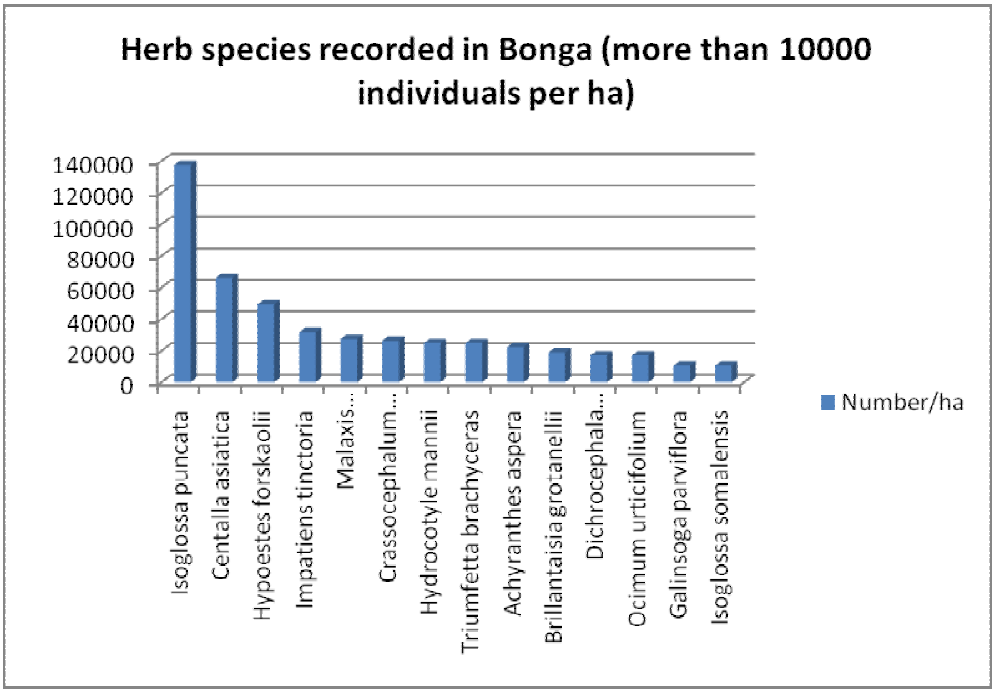
3.3.4 Herbaceous plants

A. Bonga forest (50 species)

3.3.4.1 Herbaceous plants recorded in all transects in Bonga forest are *Isoglossa puncata, Centalla asiatica, Hypoestes forskaolii, Impatiens tinctoria, Malaxis weberbaueriana, Crassocephalum macropappum, Hydrocotyle mannii, Triumfetta brachyceras, Achyranthes aspera, Brillantaisia grotanellii, Dichrocephala integrifolia, Ocimum urticifolium, Galinsoga parviflora, Isoglossa somalensis, Dichondra repens, Momordica foetida, Nervilia bicarinata, Persicaria glabra, Aframomum corrorima, Dicliptera laxata, Habenaria petitiana, Satureja paradoxa, Dorstenia brownie, Lantana trifolia, Pavonia spp, Peperomia abyssinica, Salacia congolensis, Mictactis bojeri, Peperomia molleri, Sida rhombifolia, Datura stromonium, Euphorbia schimperiana, Pavonia urens, Vernonia hochstetteri, Carduus leptacanthus, Cynoglossum amplifolium, Rumex nepalnsis, Piper capense, Elatostema monticola, Gloriosa superb, Ipomoea cairica, Vernonia tewoldei, Rungia grandis, Ocimum sp, Cyperus sp, Laggera pterodonta, Pilea johnstonii, Hydrocotyle manii* and *Pentas lanceolata*

3.3.4.2 The most abundant herb species recorded in Bonga forest is *Isoglossa puncata* (20.57 percent) (Figure 9). Next come in descending order *Centalla asiatica, Hypoestes forskaolii, Impatiens tinctoria, Malaxis weberbaueriana, Crassocephalum macropappum, Hydrocotyle mannii,* comprising 9.87, 7.35, 4.75, 4.11, 3.96, 3.74 percent, respectively. The least recorded *Cyperus sp, Laggera pterodonta, Pilea johnstonii, Hydrocotyle manii, Pentas lanceolata. Aframomum corrorima and Piper capense,* the two economically important herb species, comprise 9781 and 3447 per ha, respectively.

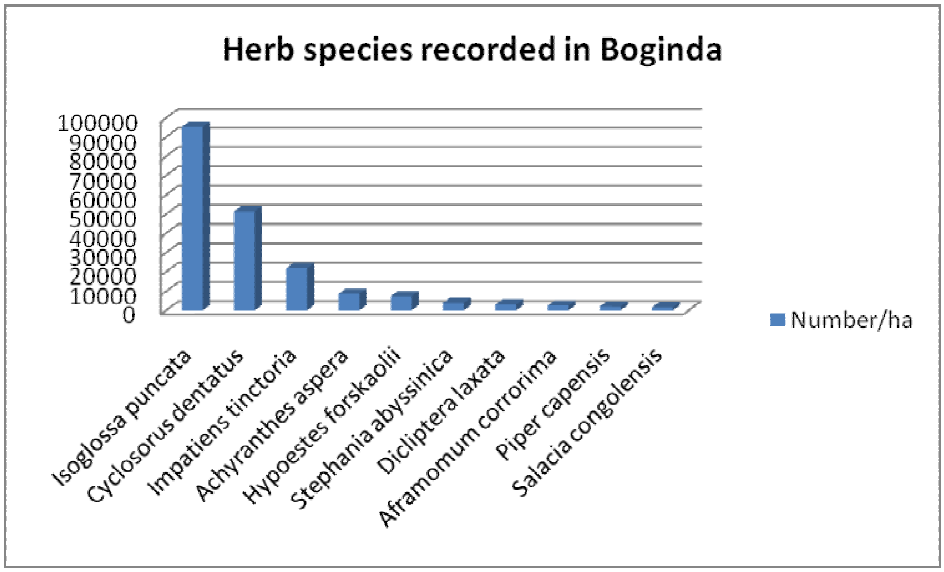
Figure 9. Herb Species of Bonga



B. Boginda (16 species)

3.3.4.1 Herbaceous plants recorded in all transects in Boginda forest are *Isoglossa puncata, Cyclosorus dentatus, Impatiens tinctoria, Achyranthes aspera, Hypoestes forskaolii, Stephania abyssinica, Dicliptera laxata, Aframomum corrorima, Piper capensis, Salacia congolensis, Vernonia hochstetteri, Carduus leptacanthus, Dorstenia brownie, Pavonia schimperiana* and *Sida rhombifolia.*

Figure 10 Herb species of Boginda



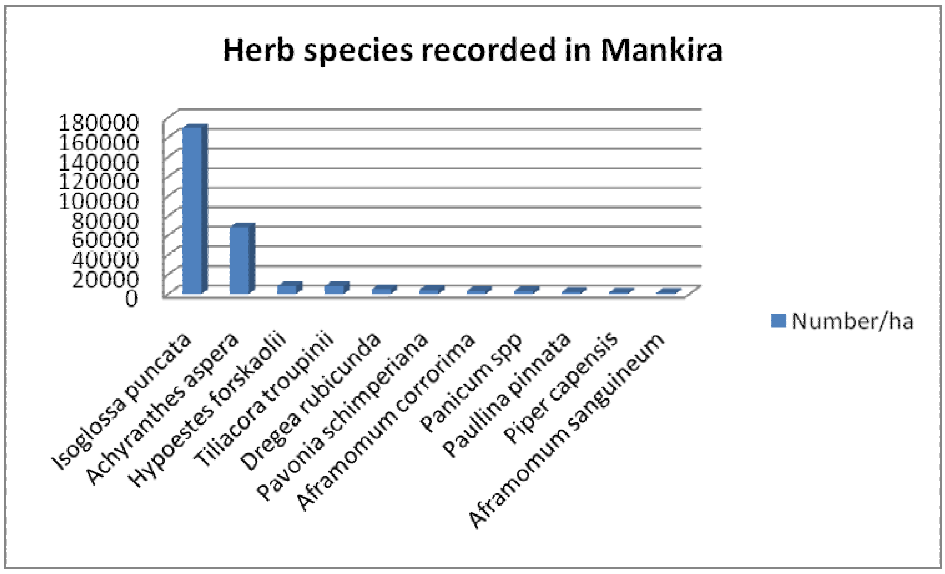
3.3.4.2 The highest herbaceous plants per hectare recorded in Boginda forest is *Isoglossa puncata* (more than 95500) (figure 10). *Sida rhombifolia* has been the least recorded species, 80 per ha. Economically important herb species such as *Aframomum corrorima* and *Piper capensis* comprise 2500 and 2000 per ha, respectively.

C. Mankira Forest (11 species)

3.3.4.1 Herbaceous plants recorded in all transects in Mankira forest are *Isoglossa puncata, Achyranthes aspera, Hypoestes forskaolii, Tiliacora troupinii, Dregea rubicund, Pavonia schimperiana, Aframomum corrorima, Panicum spp, Paullina pinnata, Piper capensis* and *Aframomum sanguineum*

3.3.4.1 The highest herbaceous plants per hectare recorded in Mankira forest is *Isoglossa puncata* (more than 160000). *Aframomum sanguineum* is the least recorded, 1000 per ha. Economically important herb species such as *Aframomum corrorima* and *Piper capensis* comprise 3000 and 1370 per ha, respectively.

Figure 11. Herb Species of Mankira



Herbaceous and Wood Climbers

Bonga

Herbaceous climbers recorded within Bonga forest are *Microglossa pyrifolia, Peponium vogelii, Stephania abyssinica and Zehneria scabra* that comprise 11, 22, 30.5 and 36.6, respectively.

Similarly woody Climbers recorded are*: Landolphia buchananii, Embelia schimperi, Jasminum abyssinicum, Paullinia pinnata, Rubus steudnerii, Tiliacora troupinii, Clematis hirsute, Hippocratea goetzei.* The highest recorded woody climber in Bonga is *Landolphia buchananii* (14804 per h or 24.9 percent). The next highest species recorded is *Paullinia pinnata* (11333 per ha or 25.95 percent). The least recorded is *Embelia schimperi* and has a density of 2917 per ha (4.9 percent).

Boginda

During survey period climbers were recorded and their density per ha has been:

Clematis spp, 4000; *Embelia schimperi,* 250; *Landolphia buchananii,* 12583.

Mankira

Recorded climbers in Mankira are *Landolphia buchanani, Peponium vogelii,* and *Embelia schimperi.* Their density (per ha) is 11833, 36000 and 250*,* respectively. As it is indicated *Peponium vogelii* is the highest recorded and *Embelia schimperi* is the least. However, *Peponium vogelii* is herbaceous climber; the other two are woody climbers.

Summary

The highest number of herbs per hectare is recorded in Bonga forests (668700). The second highest number of herbs recorded is in Mankira (273620). In Boginda about 202465 herbs per hectare are recorded. *Isoglossa puncata* is the highest number recorded in the three study areas: Bonga (137545), Boginda (95500) and over 169000 per hectare in Mankira.

3.3.6 Grasses

A. Bonga

3.3.6.1 Twelve major grass species are recorded, namely: *Tectaria cf. gemmifera, Setaria megaphylla, Oplismenus undulatifolius, Carex chlorosaccus, Cyperus rotundus, Poecilostachys oplismenoides, Leptaspis zeylanica, Panicum spp, Pseudechinolaena polystachya, Olyra latifolia* and *Oplismenus hirtellus.*

Table 3. Grass species recorded and their abundance, Bonga

Scientific Name	Number/ha	Percent
Tectaria cf. gemmifera	281000	56.3
Setaria megaphylla	49667	10.0
Oplismenus undulatifolius	49500	9.9
Carex chlorosaccus	41500	8.3
Cyperus rotundus	38000	7.6
Poecilostachys oplismenoides	12000	2.4
Leptaspis zeylanica	10000	2.0
Panicum spp	5500	1.1
Pseudechinolaena polystachya	4000	0.8
Olyra latifolia	3625	0.7
Oplismenus hirtellus	3000	0.6
Total	497792	

B. Mankira

3.3.6.2 Four major grass species are recorded, namely: *Oplismenus undulatifolius, Olyra latifolia, Cynodon spp. and Carex chlorosaccus (Table 4).*

Figure 12. Grass speicies recorded in Bonga

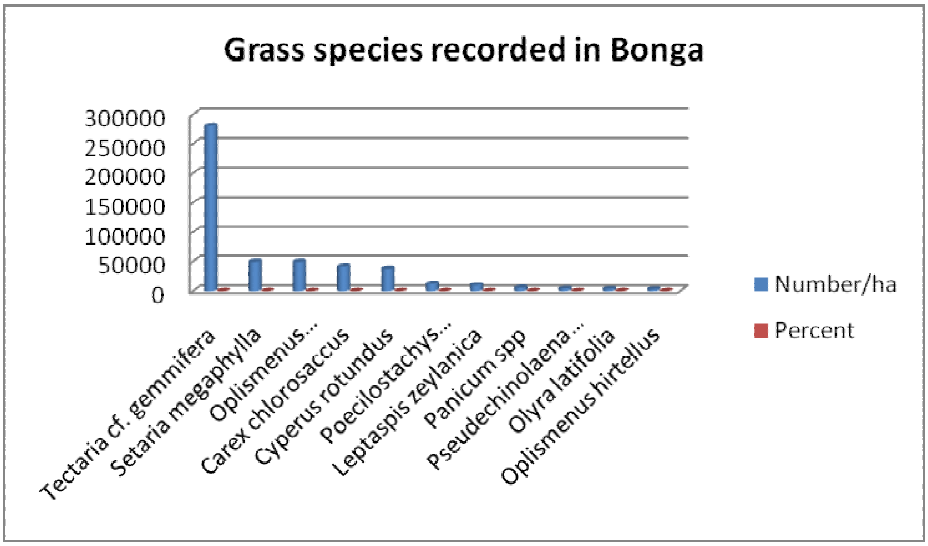
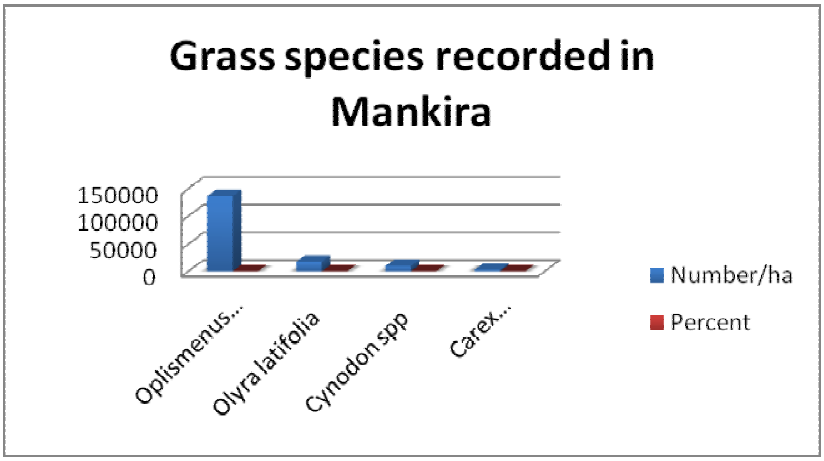


Table 4. Grass species recorded and their abundance, Mankira

Scientific Name	Number/ha	Percent
Oplismenus undulatifolius	137000	81.5
Olyra latifolia	18000	10.7
Cynodon spp	10000	6.0
Carex chlorosaccus	3000	1.8
Total	168000	

Figure 13. Grass species of Mankira



C. Boginda

Olyra latifolia, Poecilostachys oplismenoides and *Oplismenus undulatifoliu* are the only three grass species recorded in this study site.

The highest recorded grass species is *Oplismenus undulatifolius*; 120,000.

Summary

The highest grass species per hectare is recorded in Bonga (nearly 500,000). Within this forest area, *Tectaria cf. gemmifera* is the most abundant species, 281,000. The least recorded species is *Oplismenus hirtellus, 3000* (figure 12). On the Mankira forest less amounts of grass is recorded, nearly 170,000. In this forest *Oplismenus undulatifolius* is the highest number recorded (137,000) and accounts for more than 80 percent of the density (figure 12). *Carex chlorosaccus* is the least recorded species in Mankira forest.

3.3.7 Agricultural Land

A. Trees/shrubs (Bonga only) = 20 plots

3.3.7.1 Trees and shrubs recorded in agricultural land include the following:

Eucalyptes spp, Milletia ferruginea, Cordia africana, Croton macrostachyus, Albizia gummifera, Papaya carica, Vepris dainelli, Coffea arabica, Sapium ellipticum, Draceana steudneri, Erythrina brucei, Ficus ovata, Ficus sur, Maesa lanceolata, Landolphia owerensis, Euporbia abyssinica, Celtis africana, Ehertia cymosa, Schefflera abyssinica, Syzygium guineense, Clausena anisata, Enset ventricosa, Vernonia amygdalina, Flacortia indica, Polyscias fulva, Erythrina abyssinica, Ficus ovata, Ficus palmate, Trichilia dregeana, Olea welwitschii, Phonix reclinata

3.3.7.2 More than 90 trees per ha are estimated, the highest recorded being Eucalyptes species (12.5%). Most of this species are planted around homesteads and sometimes along the roads. Next to Eucalyptes, *Milletia ferruginea, Cordia africana, Croton macrostachyus* and *Albizia gummifera* are kept in farmland for the different uses they give to the households. These species comprise 11.5, 9.4, 9.4 and 6.3 percent of the total recorded trees. The least recorded trees (tree per ha) are *Schefflera abyssinica, Syzygium guineense, Clausena anisata, Enset ventricosa, Vernonia*

amygdalina, Flacortia indica, Polyscias fulva, Erythrina abyssinica, Ficus ovata, Ficus palmate, Trichilia dregeana, Olea welwitschii and *Phonix reclinata.*

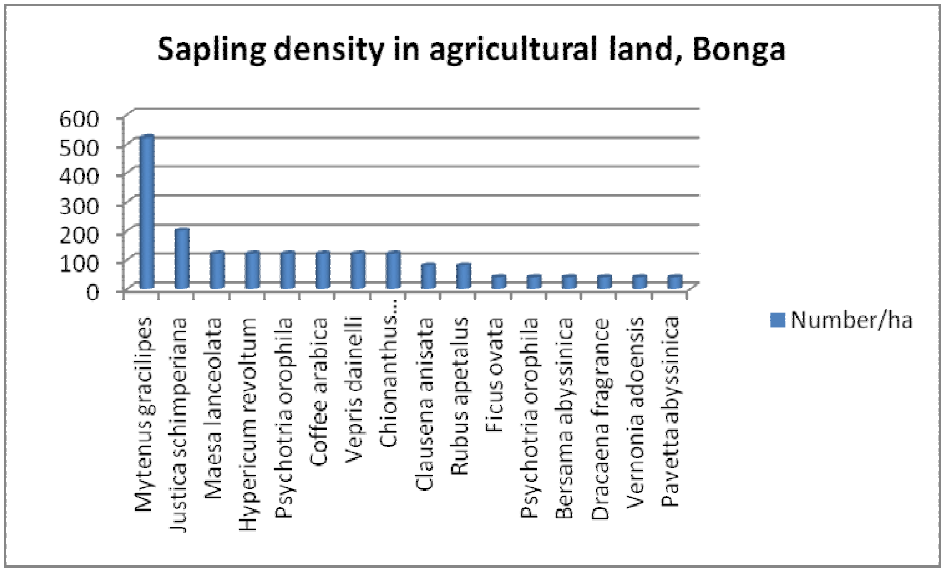
B. Saplings and Regeneration

Saplings

3.3.7.3 Species recorded as sapling are *Maytenus gracilipes, Justica schimperiana, Maesa lanceolata, Hypericum revoltum, Psychotria orophila, Coffea arabica, Vepris dainelli, Chionanthus mildbraedii, Clausena anisata, Rubus apetalus, Ficus ovata, Psychotria orophila, Bersama abyssinica, Dracaena fragrance, Vernonia adoensis* and *Pavetta abyssinica.*

3.3.7.4 Maytenus gracilipes is the highest recorded species (520 per ha or 28.3 percent). The following species comprise more than 6 percent of the total registered: *Justica schimperiana (10.9), Maesa lanceolata (6.5), Hypericum revoltum (6.5), Psychotria orophila (6.5 Coffea arabica (6.5)* and *Vepris dainelli (6.5).*

Figure 14. Saplings recorded in agricultural land



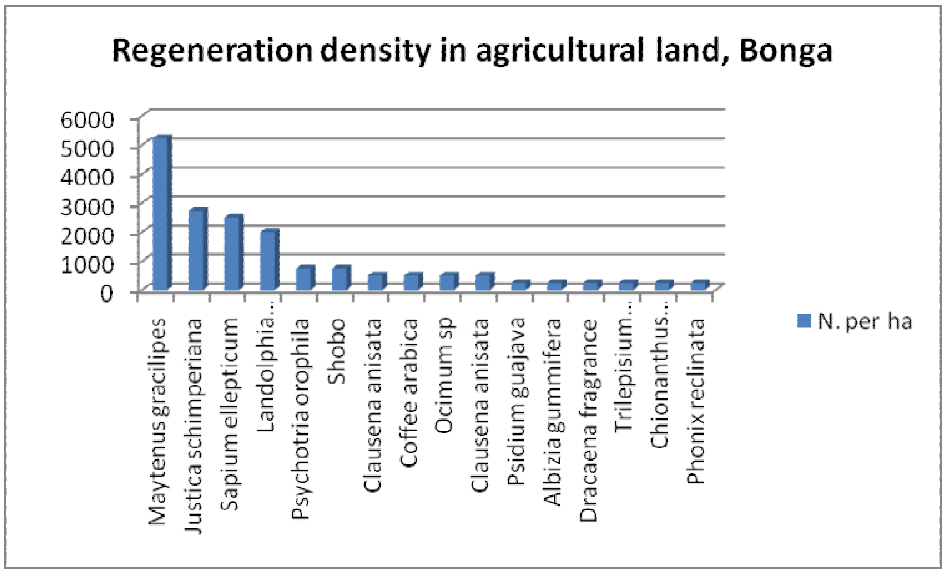
Regeneration

3.3.7.5 Species recorded as regeneration are *Maytenus gracilipes, Justica schimperiana, Sapium ellepticum, Landolphia buchanani, Psychotria orophila, Shobo, Clausena anisata, Coffea arabica, Ocimum sp, Clausena anisata, Psidium guajava,*

Albizia gummifera, Dracaena fragrance, Trilepisium madagascariense, Chionanthus mildbraedii and *Phonix reclinata.*

3.3.7.6 Similar to saplings, *Maytenus gracilipes* has the highest number of all regeneration recorded (5250 per ha or 31.8 percent of all recorded). *Justica schimperiana, Sapium ellepticum (*wC) are the next abundant plants recorded. The least recorded species is *Phonix reclinata.* Inaddition to economically important species, coffee, fruit tree species such as *Psidium guajava* is observed and recorded.

Figure 15. Regenerations of woody species in Agricultural Land



Herbaceous plants

Herbaceous plants recorded in agricultural lands are:

Hypoestes forskaolii, Asplenium sp, cynoglssum coeruleum, Achyranthes aspera, Hypoestes forskaolii, Landolphia buchanan and, *Vigna unguiculata.*

The highest number of species recorded in the study period is *Hypoestes forskaolii* (17000 or 38.6 percent).

3.3.5 Comparison of Forest areas (Bonga, Boginda and Mankira) with respect to density of flora

a. Forest

All flora recorded (grass, herb, regeneration, saplings of woody plant, shrubs, and trees) per ha are combined and their density per ha is presented in the Table below (Table 5 & figure 16 consecutively). Accordingly Bonga forest[1] has the largest plant cover per ha (estimated to be more than1,309,956). Mankira and Boginda have lower number of floral density, each comprising 510,120 and 386,600, respectively. The reason for such big variation could be that average slope inclination of sample plots in Bonga forest fell in slopes less than 30 percent. Boginda has the steepest gradient and average slope of all sample plots is estimated as 53 percent. Mankira on the other hand has 36 percent average gradient of sample plots.

When an area is steep, undergrowth condition might not be as flourishing as gentle slope or flat area because soil might be washed to gorges and downslopes during rainy season. Other factor could be that most of the areas are occupied by forest coffee either intensively or extensively managed or not managed at all. Presence of management of coffee influences undergrowth condition as most of the undergrowth is cleared to reduce competition and allow access to human movement.

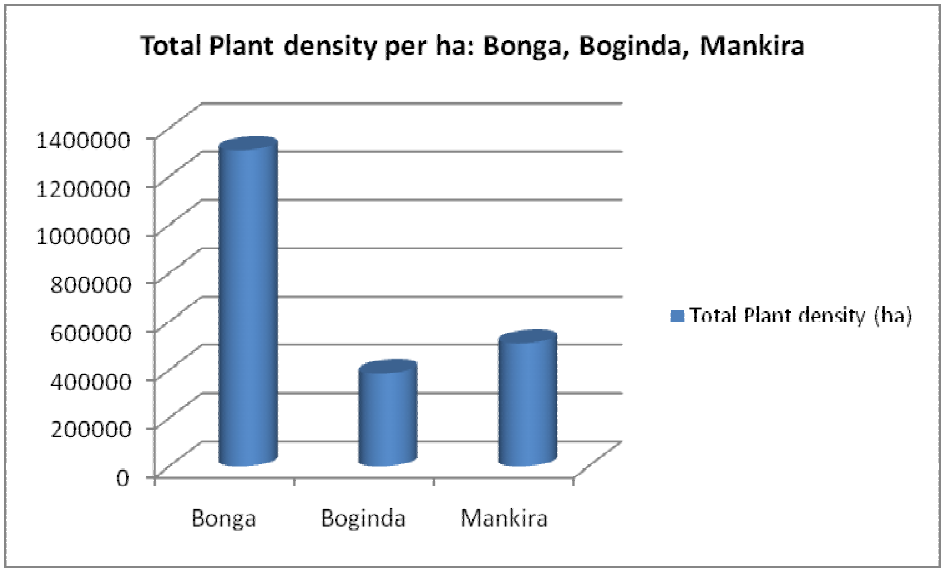
Table 5. Density of plants per stratum

Forest area	Number of plants per hectare
Bonga	1309956
Boginda	386600
Mankira	510120

Source: Flora Biodiversity Assessment, 2008

[1] See annex I for definitions of forest, shrubs and tree

Figure 16. Density of plants per stratum



Source: Flor Biodiversity Assessment, 2008

Endemic plants recorded in the study area are shown in Table 6 below.

Table 6. Endemic plants in the study area

No.	Scientific Name	Family	Habit	Remark	Status
1	*Erythrina brucei*	Papilionoideae	*T*	*E*	
2	*Milletia ferruginea*	Fabaceae	*T*	*E*	*LC*
3	*Solanecio gigas*	Asteraceae	*s*	*E*	*LC*
4	*Tiliacora troupinii*	Menispermaceae	*wC*	*E*	*VU*
5	*Vepris dainelli*	Rutaceae	*sT*	*E*	*LC*
6	*Aframomum corrorima*	Zingiberaceae	H	E	VU
7	*Brillantaisia grotanellii*	Acanthaceae	H	E	VU
8	*Satureja paradoxa*	Lamiaceae	H	E	
9	*Vernonia tewoldei*	Asteraceae	H	E	EN
10	*Mikaniopsis clematoides**	Asteraceae	hC	E	LC
11	*Lippia adoensis**	Verbenaceae	s	E	LC
12	*Clematis longicauda**	Ranunculaceae	wC	E	
13	*Pilea bambuseti ssp aethiopica**	Urticaceae	H	E	
14	*Pentas tenuis**	Rubiaceae	s	E	R
15	*Dorstenia soerensenii**	Moraceae	H	E	VU
16	*Phyllanthus limmuensis**	Euphorbiaceae	s	E	VU
17	*Cyrtorchis ehrythraeae**	Orchidaceae	H-epi	E	

Source: Flor Biodiversity Assessment, 2008

* *taken from* Schmitt C. B. (2006). T=Tree; s=shrub; wC=woody climber; sT=small tree; H=herb; hC= herb climber; LC= least concerned; VU=Vulnarable, EN= Endangered, R=Rare, epi= epiphytic.

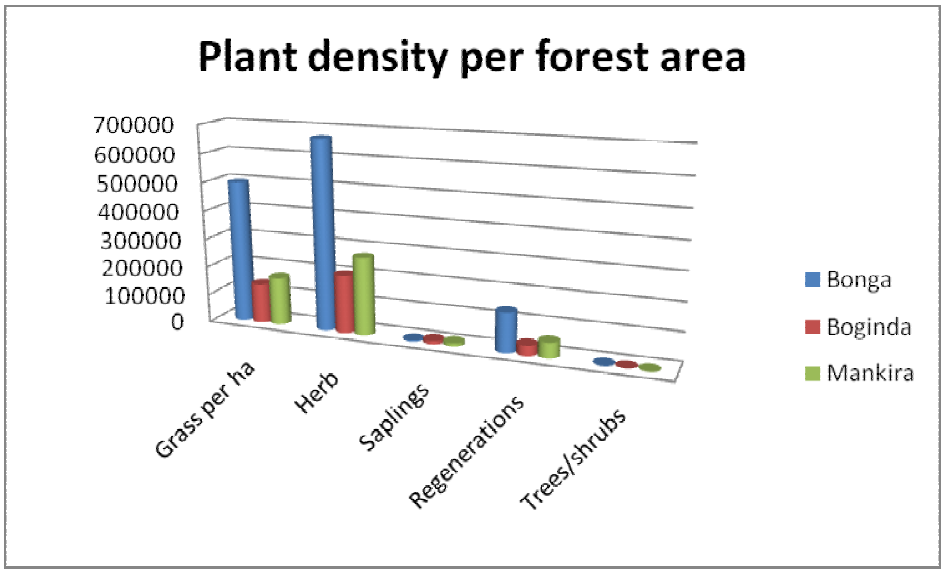
Within each study area the total plant cover is estimated and shown in the following Table (Table 7) and figure 17.

Table 7. Total Plant Density per ha per Forest Area

Forest Name	Grass	Herb	Saplings	Regeneration	Trees/shrubs
Bonga	498792	668700	4332.33	137546	586
Boginda	138000	202465	11156	34417	562
Mankira	168000	273620	12796	55250	454

Source: Flora Biodiversity Assessment, 2008

Figure 17. Total Plant Density per Forest Area



4. DISCUSSION AND CONCLUSION

4.1 General

4.1.1. Biodiversity Conservation and Threats

Biodiversity Conservation

Forests of the world harbor over 50% of the world's biodiversity (Anonymous, 1999). Forests hold most of the world's estimated three to ten million-possibly as many as 30 to 50 million- plant and animal species (Woods-Schank, 1990). The same study cautions 'If the destruction of biotopes continues at its current rate, a quarter of all plant families and associated fauna will have become extinct in the next century. The extinction of one species endangers or drives into extinction several other animal and plant species.'

Ethiopia has diverse agro-ecological zones (about 32 are identified so far) and in each zone different soil types, rainfall intensity and pattern, evapo-transpiration and vegetation are believed to be found. This diversity, among others, created favorable habitat for different flora and fauna. The severe reduction in forest cover, however, poses a serious threat to this biodiversity (EFAP, 1994a).

Flora of Ethiopia is estimated in the range of 6,500 to 7,000 species of which 12 percent are endemic (EFAP, 1994), 10-12 percent endemic.

According to Tesfaye Awas 2007, vegetation of Ethiopia is physiogonomically divided into nine vegetation types[2], and has four phytogeographical areas, namely; Afromontane, Sudanian, Somali-Masai and Sahelian. Afromontane vegetation dominates the mountain massifs either side of the rift valley (White, F.1983 cited in EFAP, 1994). Montane evergreen forest found in Afromonatne vegetation zones includes mainly dry evergreen Juniperus, Olea, and Podocarpus forests. There is also mixed evergreen and moist evergreen forest. The Afromonatne flora overall is 75 percent endemic. The Somali-Masai and Sudanian areas contain flora and fauna which probably have fewer country-

[2] Desert and semi-desert scrubland; Lowland (semi-) evergreen forest; Acacia-Commiphora small-leaved deciduous woodland and savanna; Evergreen scrub; Moist evergreen montane forest/Afromontane rain forest; Dry evergreen and montane forest and grassland; Afroalpine and sub-afroalpine zone; Riparian/riverine and swamp vegetation.

specific endemics than the Afromontane. These categories contain one-third endemic species whereas Afromonatne comprises approximately half of endemic species (EFAP, 1994). The Afromonatane have conservation priorities which are peculiarly Ethiopian (EFAP, 1994, synopsis report)

Ethiopia faces biodiversity losses that are associated both commercial and subsistence cultivation. Annually, more than 150,000 hectares of forest land is cleared (EFAP, 2004). "The forest resources are seriously threatened by deforestation, habitat destruction and subsequent decline in regeneration, forest fire and vegetation clearance for farm/settlement establishment" (IBC 2005).

Cognizant of the problems associated with biodiversity loss in the country different policies and strategies are in place among which Environmental Policy of Ethiopia, National Policy on Biodiversity Conservation and Research, Forest Policy and Forest Proclamation No.542/2007 (a proclamation to provide for the Development conservation and utilization of forests) are worth mentioning. Environmental policy was issued on April 2nd, 1997, by Environmental Protection Authority in collaboration with the Ministry of Economic Development and Cooperation. The policy has 10 sectoral policies, among which genetic species and ecosystems biodiversity is one of them.

Ethiopia is signatory to most of the key environmental conventions such as the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (UNCCD), the Convention on Climate Change (UNFCCC) and the Convention on International Trade in Endangered Species (CITES). Acknowledging such important conventions and owning them as the law of the country shows the government's commitment to protect the environment. These conventions help in assisting forest cover increase through financial mechanisms. For example Global Environment Facility (GEF) is a medium sized grant (Anonymous, 2007) that provides opportunity for different environment related pilot activities such as Country Partnership on Sustainable Land Management (CPPSLM).

Ethiopia's high forests were designated as National Forest Priority Areas (NFPA) in the 1980s for their impact on watershed management and their biodiversity significance.

These high forests constitute only 3.56 percent of the total land mass of the country (WBISPP, 2004). Ca 300 or more tree species are believed to be found in these forests, of which 25 are regarded as commercial species and 30 are regarded as potentially usable for the mechanical wood industry (EFAP, 1994).

Later in mid 1990s NFPAs were put under the management of Regional States and became Regional Forest Priority Areas (RFPA). Bonga Forest Priority Area is under one of Southern Nations Nationalities and People's Regional Forest Priority Areas. Mankira is part of this RFPA. Boginda forest was not delineated or demarcated as a forest priority area until 2002. In 2002 in collaboration with Ministry of Agriculture and Bureau of Agriculture of SNNP the forest area was demarcated. Since then this forest is registered as RFPA (Personal communication, Tsegaye Fikadu).

Threat

Reusing, M., 2000 analysed satalite images of forest regions of Ethiopia between 1973 and 1976 and proved that the high forest cover was above 4.5 percent during that period. Currently, as mentioned above, the forest cover is estimated as 3.56 percent (WBISPP, 2004). Every year above 160,000 ha of natural forests are deforested (Reusing, M., 2000), Around 1900 almost the entire Southwestern Ethiopian highlands were covered by montane rainforest and between 1971 and 1997 about 7.8 percent of total highforests or 23, 5400 ha was deforested (Reusing, M.,2000). The author indicated that settlement and population growth are the two main causes for 50 percent of forest degradation (decline of forest quality); and deforestation in South West.

The major causes of deforestation in Bonga, Boginda and Mankira, like everywhere in Ethiopia, are clearing and burning of the natural forest for cultivation of food crops, planting coffee (small or large scale), settlement, chasing wild animals, pit-sowing, harvesting of fuel wood, construction materials and cutting of big trees to harvest honey. As a result of heavy exploitation on selected trees such as *Cordia Africana, Pouteria adolfi-friederici* and *Prunus africana* , these species are reported as endangered by some studies(Ensermu Kelbessa and Teshome Soromessa 2004, Girma Balcha et al, 2002, Schmitt C. B. , 2006).

The forests are also in the process of degradation due to a number of other factors such as coffee growing in the forest, livestock rearing, and harvesting of fuelwood and construction material. During clearing of the forest floor for coffee plantation everything is cleared or slashed down. Hence seedlings and sometimes saplings of important tree species are cleared together. In order to allow sun light some canopy trees are also cut down. Livestock are seen in almost all forest areas and unless they are controlled they can affect plant growth through trampling, browsing, breaking young saplings and trees.

Although it is difficult to substantiate the cause of death of trees in this study, insect and pests introduced via animal and human may attack and affect the vitality of the forest. Any scar created on a tree as result of animal or human contact may cause disease later on it could kill the tree. In this study the number of stumps and dead trees were estimated and the following results are obtained: dead trees per hectare are 292 in Bonga, 433 in Boginda, and 359 in Mankira. The stumps were counted inorder to evaluate level of exploitation and the results are 189 for Bonga, 27 for Boginda and 82 for Mankira. As the figure shows Bonga forest is more affected by logging than the rest of the forests.

Because of absence of scientific management such as silvicultural practices, all forests of the country, as well as those in the study area, are mostly affected by thick climbers that are silviculturally and economically undesirable species. As a result of this phenomena economically and silviculturally important tree species are crooked, bend and fluted. Regeneration status too might be influenced negatively. Trees that are dead are rotting in the forest. This might help in nutrient cycle but they might also harbor disease. Absence of management plan also leads to over exploitation where annual cut exceeds mean annual increment.

In conclusion existing threat to the forests is associated with anthropogenic activities. Schmitt C. B. 2006, referring Gil et al., 2004 has emphasized how important Ethiopian forests are in terms of gene pool and number of endemic species. However, the author witnessed that human induced pressure threatened the existing forests of Kaffa zone. The forests are in fragile and fragmented state. This great biodiversity coupled with the

extreme threat caused by habitat destruction makes them part of the Eastern Afromontane biodiversity hotspot (Gil et al., 2004).

4.2. Limitations

Unlike western countries such as the UK, Ethiopia does not have guidelines or directives on habitat evaluation, habitat action plans, valuing species and so on. However, the government of Ethiopia noticed the presence of high pressure on few species such as *Podocarpus falcatus, Cordia africana, Juniperus excelsa, Hagenia abyssinica* and *Prusnus africana* and legislated on the limited utilization of such species. But nationally a law regarding as to which species are to be protected is not yet in place. It is expected that the Ministry of Agriculture and Rural Development will announce the list of protected species in the near future.

Among Annex I list of species in CITES, a few plant species are found in Ethiopia. These species are shown in annex 6.3. However except *Prunus africana* no species under Annex I is recorded in the study area.

For land cover land use mapping mainly Landsat image was used. The result found is small scale map. ASTER image was received at a latter stage but it doesnot cover the whole study area (the three sites). If the full range is received, final mapping will be done using ASTER.

4.3. Vegetation

According to A. Aalbaek &T.Kide, 1993, the vegetation in the study area is found within three seed zones: Western Lower Broadleaved Afromontane Rainforest, Central wet Bradleaved Afromonatne rainforest and Eastern Higher broadleved Afromontane Rainforest. Friis, 1992 classified the study area as "Afromontane Rain Forest". This Afromontane rain forest is found on altitudes between 1500 and 2500 masl, with average annual temperature 18-20 ^{0}c and rainfall between 1500 mm and greater than 2000 mm. The rainy season is between April and October (Friis, 1992).

According to Taye Bekele, 2003, there are three types of vegetation, namely: Upland Rain forest Vegetation, Upland Humid Forest Vegetation and Arindunaria/Bamboo thicket. The author described this zonation based on altitudinal variation. The upland rain forest vegetation, upland humid forest vegetation and arindunaria thicket are located at altitudinal range between 1500- 2200, 2450-2800 and 2400-3050 masl, respectively. The current survey is conducted within the three zones. Vegetation listed in Taye Bekele, 2003 is in agreement with findings of the current survey.

In this phytogeography, Friis, 1992 listed 23 tree species as medium sized canopy tree which can attain 10-30 meter high. These species area:

Albizia gummifera, A. schimperiana, A. grandibracteata, Blighia unijugata, Cassipourea malosana, Celtis africana, Croton macrostacheyus, Ekebergia capensis, Euphorbia ampliphylla, Ficus sur, Ficus ovata, Ficus thonningii, Ocotea kenyensis,Ilex mitis, Olea welwitschii, Polycias fulva, Prunus africana, sapium ellipticum, syzygium guineense and *Schefflera abyssinica*. Friis reported that *Pouteria adolfi-friederici* is the only emergent species from a 20-30 meter high canopy. On the other hand, Chaffey, 1979, reported that in addition to *Pouteria adolfi-friederici, Ficus species* and *Syzygium guineense* are in the canopy. Schmitt C. B**.,** 2006 agrees that the top canopy is occupied by *Pouteria adolfi-friederici* that can attain a height of above 40 meters. Other trees that can grow up to 40 meters, according to the same author, are *Olea welwitschii* and *Trilepisium madagascariense*.

Combining the findings of the three authors may give full picture of what the upper canopy of the forest look like. The results given by the individual researchers may have varied due to difference in the material and methods each used. Hence, it can be concluded that upper canopy of this forest is occupied by *Pouteria adolfi-friederici, Ficus species, Syzygium guineense, Olea welwitschii* and *Trilepisium madagascariense*. In the current study at higher altitude at about 2500 masl, *Schefflera volkensii* and *Hagenia abyssinica* are found at the upper canopy. At about the same altitude pure bamboo stand is also mapped.

With regard to lower canopy of trees and shrubs, both Friis and Chaffey listed more or less similar species, namely: *Allophyllus abyssinicus, Bersama abyssinica, Cassipourea malosana, Dracana afromontana, Draceana steudneri, Ehretia cymosa, Lepidotrichilia volkensii, Linociera giordanii, Maesa lanceolata, Maytenus species* and *Strychos mitis*.

Other smaller trees that are recorded by both authors and also in the current survey include; *Blighia unjugata, Bridelia micrantha, Dombeya torrid, Elaeodendron buchananii, Flacurtia indica, Nuxia congesta, Octea kenyensis, Rothmannia uricelliformis, Ritchiea albersii, Schrebera alata, Teclea nobilis* and *Vepris dianellii.*
Among smaller trees listed by Friis but not by Chaffey, the following are recorded in the current survey: *Apodytes dimidiate, Brucea antidysenterica, Coffea arabica, Clausena anisata, Erythrina bruci, Galineiera saxifrage, Milletia ferruginea, Oxyanthus specious, Phonix reclinata, Pittosporum viridiflorum, Psychotria orophila, Rothmannia uricelliformis, Solanecio mannii, Oncoba routledgei, Enset ventricosa* and *Chionanthus mildbraedii.*

Chaffey and Friis covered quite an extensive forest region of south-west Ethiopia. The current study and the work of Schmitt C. B., 2006 are limited to a certain area. This could bring variation in the results. Chaffey has made, probably, the first national inventory in the country and his sample covered quite a large area compared with that of Friis and the current survey.

Chaffey reported that in Kaffa province (which used to cover a larger area than now) there were six sawmills among which Jimma Plywood Factory was one. 90 percent of the raw material input for this plywood factory was reported to be ***Pouteria adolfi-friederici.*** Kaffa forests used to supply an amount of 28,000m^3 round timbers every year (Chaffey, 1979). Major species logged during the period include (Chaffey, 1979): *Pouteria adolfi-friederici, Apodytes dimidiate, Cordia africana, Croton macrostachyus, Ekebergia capensis, Hagenia abyssinica, Prunus africana, Olea aricana, Olea welwitschii, Polyscias fulva, Olea capensis* and *Syzygium guineense*.

Upper storey species recorded by Getachew Berhane and Yoseph Assefa in IBC 2002 in Boginda forest are: *Pouteria adolfi-friederici, Prunus africana, Syzygium guineense, Polyscias fulva, Croton macrostachyus, Bersama abyssinica, Schefflera abyssinica, Macaranga capensis* and *Bersama abyssinica.*

Understorey tree species that can attain up to 30 cm dbh, but typically smaller according to Chaffey, are recorded. These include *Allophyllus macrobotrys, Psychotria orophila, Vernonia sp* and *Rytigynia neglecta* .They are similar to the species identified in the work of Chaffey. *Coffea arabica* occurs naturally as an understory shrub at elevation between about 1000 and 1800 masl (Chaffey, 1979).

Friis, 1992 recorded 25 species of lianas, and numerous species reported as epiphytes including ferns, lycopods, orchids, *Peperomia* (Piperae.), and *Scadoxus nutants* (Amarylliadac.). He indicated how the undergrowth is very rich where he claimed to record more than 110 species.

4.3.2. Stem per hectare and number of species

On average within the three strata the number of stems per hectare recorded in this study is 586 for Bonga, 562 for Boginda and 454 for Mankira, whereas, Chaffey has estimated stems per ha for all species having diameter greater than 30 cm and found out 125. Lamprecht, 1989, quoting Veillon, 1976 has reported stem per ha having diameter 10 cm and above for Venezuelan cloud forest (montane) as 745. Getachew Berhane and Yoseph

Assefa in IBC, 2002 made an assessment of Boginda forest (Kaffa). In their assessment, they came up with 479 stems per hectare (dbh 10 cm and above).

Ensermu Kelbessa and Teshome Soromessa, 2004 recorded 57 woody species for Bonga forest. In moist tropical undisturbed forest (excluding herbs and grasses) about 746 trees per ha and 65 tree species were recorded (Bokor, 1979 cited in Lamprecht, 1989). In Bonga, Boginda and Mankira the number of species recorded in the current survey, including regeneration and saplings are 89, 74 and 66, respectively.

In the current survey the density of woody species (including regeneration and sapling) in Bonga, Boginda and Mankira is 142464, 46135 and 68500, respectively. The highest woody species in Bonga is *Maytenus ovatus* (62500). Whereas in Boginda and Mankira *Justica schimperiana* and *Dracaena fragrance* are the highest woody species recorded. *Coffea arabica* in Bonga is the 5th highest recorded (3316). In Boginda it is the 6th abundant species (2220). However, in Mankira it is the 2nd highest recorded woody species (6340).

It is possible to conclude that the result of the current study is comparable with aforementioned studies. However, there are few variations e.g., between Ensermu Kelbessa and Teshome Soromessa, 2004 versus the current findings on the number of species; and density of trees estimated by Lamprecht, 1989 versus the current study. In the current study wider area is accounted especially in terms of altitudinal range and more sample plots are taken than Ensermu Kelbessa and Teshome Soromessa, 2004. As it is mentioned under section 4.3 above logging practice has been conducted within Kaffa forest. It might be the reason for the current lower number of stems per ha than the estimate made by Lamprecht,1989.

4.3.3 Regeneration per hectare

Lamprecht, 1989 referring Bokor, 1979 indicated that on average 72,000 seedlings per ha (maximum 124,000) between 0.3 and 1.3 meter in height are recorded in tropical moist forest. In Bonga, Boginda and Mankira on average 137,546, 34,417 and 55,250 regenerations are estimated, respectively. Getachew Berhane and Yoseph Assefa in IBC,

2002 recorded very low number of seedlings, 5888, which is almost 10 times less than the current survey.

A total of 30 species in Mankira, 36 species in Boginda and 57 species in Bonga are recorded as regeneration. Getachew Berhane and Yoseph Assefa in IBC, 2002 recorded 27 species for Boginda forest. The result is quite comparable. Ensermu Kelbessa and Teshome Soromessa, 2004 reported that 25 species were not represented as regeneration in Bonga forest (out of 57). In the current survey 61.4 percent of trees having dbh greater or equal to 10 cm are represented as regeneration in Bonga. In Boginda 52.8 percent of trees/shrubs having 10 cm and above are recorded as regeneration, whereas in Mankira, 43.5 percent of trees greater than 10 cm dbh are represented as regeneration.

Species such as *Cordia africana* are not registered as regeneration within the three forest areas. Probably this is because the species is an early colonizer (Friis, 1992). *Croton macrostacheys* too, as pioneer species (light demanding), does not encounter adequate conditions for regeneration in a natural forest (Denich, 2006). But on road sides and wherever there is an opening, Croton is well grown and observed in many places. Ficus species are also not represented in regeneration except *F. palmata* in Mankira.

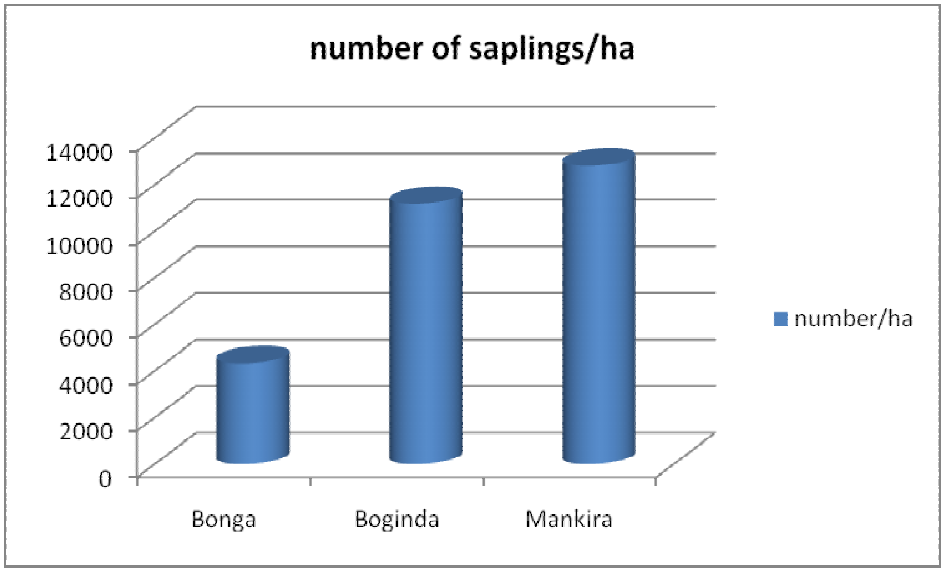
From the upper canopy species (*Pouteria adolfi-friederici, Ficus species, Syzygium guineense, Olea welwitschii*, *Trilepisium madagascariense, Schefflera volkensii* and *Hagenia abyssinica), Pouteria adolfi-friederici* is represented as regeneration within the three study sites. *Trilepisium madagascariense* is represented as regeneration within two of the study sites, in Bonga and Boginda. *Syzygium guineense* and *Olea welwitschii* are represented as regeneration in one study site only, in Boginda and Bonga, respectively.

4.3.4 Saplings per hectare

Density of saplings recorded are 4332 in Bonga, 11156 in Boginda and 12796 in Mankira. Density of saplings in Boginda and Mankira are comparable but lesser number of tree saplings is recorded in Bonga. The reason could be that since Bonga forest is in general denser than the other two forests (refer section 4.3.2), competition might limit emergence/performance of saplings. But with regard to number of trees above 10 cm dbh

the opposite is true, i.e. less number of trees is recorded in Mankira preceded by Boginda and Bonga.

Figure 18 Number of saplings per hectare in Bonga, Boginda and Mankira



4.3.4 Small herbaceous plants and grasses

Ensermu and Teshome, 2004 listed herbs and grasses found in Bonga forest but did not report their density and distribution. Getachew Berhane and Yoseph Assefa in Girma Balcha et al. (eds.-2004) did not indicate any ground flora except woody plants for Boginda. In this study the result is shown in section 3.3.4 & 3.3.6 above. But, Schmitt C. B., 2006 reported presence and distribution of herbs and grass species. In their report Herbs, grasses, ferns and fern-allies were recorded with presence-absence data. They recorded 75 and 12 species of herbs and grasses. In the current survey 55 species of herbs and 13 species of grasses are recorded in Bonga and Mankira. In Boginda 15 herb species and 3 grass species are recorded. All records under discussion (indicated in the current survey) are records made in the forest and in the sample plot.

4.3.5 Total Values of Bonga, Boginda and Mankira, Community Type

a. Menale and Sisay (2007) made a study on valuation of Ethiopian forest and its contribution to national economy. The study is submitted to the sponsor, the Center for Environmental Economics and Policy for Africa (CEEPA), housed in University of Pretoria. The authors developed an excel model to analyze the accounting. By employing the model the value of forest of Bonga, Boginda and Mankira was estimated. Based on the study an attempt to valuate part of service value of the forest and timber asset within these three forests is made. Among service functions, in addition to timber, Carbon sequestration, Biodiversity value, watershed value is estimated. Value of four years' average forest coffee sold in domestic and international market is included[3]. Other values such as grazing, thatch, source of pollen for agriculture could be estimated but there is no reliable socio-economic data in this regard. Accordingly, for timber, Carbon sequestration[4], water shade protection[5], and biodiversity (medicinal) value[6] 564477035, 892530493, 19993967 and 913600 USD; and 378854.3 USD[7] from coffee (in total 1,478,293,949USD) is estimated, respectively.

b. Local communities are dependent on the existing forest for a number of products and services that include collection of fire wood, construction material, grasses and thatch, medicinal plants, coffee, coffee shade, and other many non-timber forest products. In addition the ecosystem service is always taken for granted. Cropping is taking place every year (there is no irrigation scheme; cropping is n rainfed). Forests are the main vegetation types that are maintaining such ecosystem services in balance. Therefore, affecting the forest area means indirectly affecting the local people. Thus a mechanism must be devised to let the local communities participate in deciding on any development program planned to

[3] Kaffa Forest Coffee Farmers Cooperation Union.
[4] Cost of Carbon offset 16.13 USD/t

[5] ETB 25.52 per ha
[6] 1.8 USD per ha
[7] Approximately 1USD is taken as equivalent to 8.6 birr

be undertaken in the area, so that appropriate (i.e. socially accepted and environmentally sound) measures may be taken. The existing PFM program needs to be strengthened.

C. Five frequency classes are recognized and shown in the following Table.

Lamprecht, 1989 has indicated as it is customary practice to assign the various species to five classes based on their absolute[8] frequencies and depicted as follows (Table 8):

Table 8. Frequency class of tree/shrub/lianas species in the study area

Class	Absolute Frequency	Presence[9]
A=I	1-20	Rare
B=II	21-40	Seldom Present
C=III	41-60	Often present
D=IV	61-80	Mostly present
E=V	81-100	Constantly Present

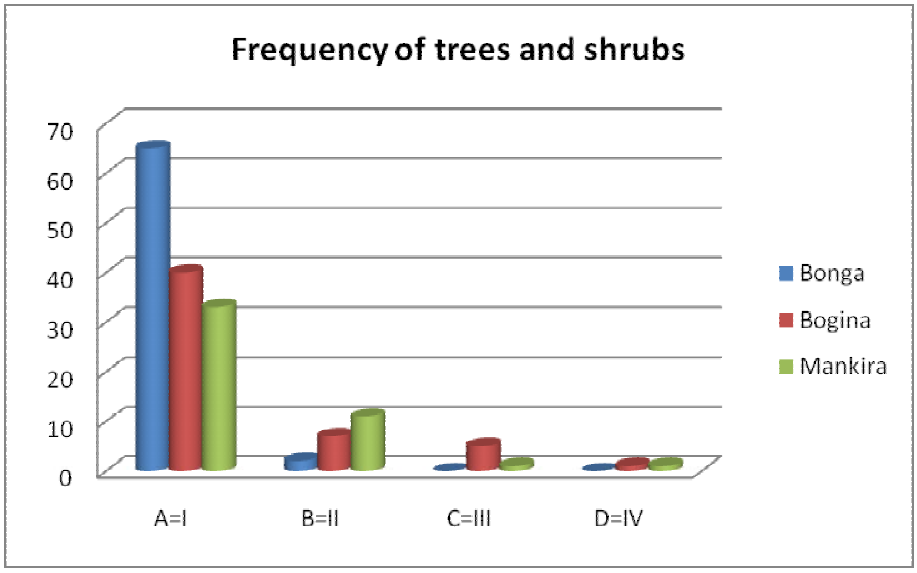
Accordingly, all the species registered in the three forests are grouped in this category to see whether each forest is heterogeneous or homogeneous. Lamprecht, 1989 indicated that diagrams with high values in D/E and low values in A/B indicate constant or similar tree species composition (homogeneous). A high degree of floristic heterogeneity is found when the situation is reversed i.e. when the values of D/E are low and the values of A/B are high.

The following Table and figure are the result of the current survey. High values in the three forests are in A/B. Hence it can be concluded that the forests' floristic composition with regard to trees/shrubs and lianas greater than 10 cm are heterogeneous. Getachew Berhane and Yoseph Assefa in IBC, 2002 got similar result for Boginda forest.

[8] Expressed as percentage
[9] Based on Lecture note on "General Ecology", Wondogenet College of Forestry.

Class	Bonga	Boginda	Mankira
A=I	65	40	33
B=II	2	7	11
C=III	0	5	1
D=IV	0	1	1
E=V	0	0	0

Figure 19. Frequency class and number of species in each frequency class and forest area



The result of this current survey indicates absence of constantly present species within the three forest sites which leads to the conclusion that the forests have a heterogeneous species composition (figure 19). *Croton macrostachyus* in Mankira, *Milletia ferruginea* in Bonga and Boginda are the most present species. In this study there was no single tree or shrub species that is constantly present within the three study sites. This is probably due to favorability of the environment to accommodate different species. Hence except for few individual species there was not much predominance everywhere. With regard to density, the most populous trees above 10 cm diameter in Mankira, Bonga and Boginda are summarized in the following Table (Table 9).

Table 9. Density of trees/shrubs per ha in Mankira, Bonga and Boginda

Scientific Name	Mankira	Bonga	Boginda
Vepris dainelli	39		
Phonix reclinata	33		
Croton macrostachyus	30		
Sapium ellepticum	24		
Pouteria adolfi-friedericii	22		
Draceaena steudneri	21		
Chionanthus mildbraedii	20		
Draceaena steudneri		75	
Schefflera volkensii		41	
Allophyllus macrobotrys		31	
Landolphia owerensis		25	
Phonix reclinata		23	
Maesa lanceolata		21	
Eugenia bukobensis		15	
Milletia ferruginea			47
Cyathea manniana			33
Sapium ellepticum			32
Macaranga capensis			28
Draceaena steudneri			24
Oxyanthus specious			24
Psychotria orophila			22

The following species are recorded in more than 50 percent of the surveyed sample plots:
Bonga: *none*. Number of sample plots in Bonga is very much higher than that of Boginda and Mankira. That could be one of the reasons.
Boginda: *Vepris dainelli, Chionanthus mildbraedii, Milletia ferruginea.*
Mankira: *Croton macrostachyus*

Using the sum of relative frequency and relative abundance of species Distribution Index (DI) was estimated (Schmitt C. B., 2006). Accordingly, the following results have been found concerning common species and are shown in Table below (Table 10). Occasional and rare species are listed in annex II, Table 16. In total 9 species in Mankira, 30 species in Bonga and 18 species in Boginda are found to be rare species.

Table 10. Common species in Mankira, Bonga and Boginda

Mankira	Bonga	Boginda
Croton macrostachyus	*Draceaena steudneri*	*Milletia ferruginea*
Phonix reclinata	*Schefflera volkensii*	*Chionanthus mildbraedii*
Vepris dainelli		*Macaranga capensis*
Sapium ellepticum		*Vepris dainelli*
Pouteria adolfi-friedericii		*Psychotria orophila*
Chionanthus mildbraedii		

Common = DI greater than 9; Occasional=DI greater than 2; Rare=DI<2 (Schmitt C. B. 2006).

Rare species recorded in Schmitt C. B., 2006 includes *Alangium chinense, Cassipourea malosana, Celtis africana, Croton macrostachys, Cordia africana, Ficus ovata, Hallea rubrostipulata, Albizia grandibracteata, Ficus vasta* and *Vangueria apiculata.* Common species and occasional species recorded in their study will be indicated in the annex II (Table 17).

With regards to endemic and level of threat to them (endangered [EN], vulnerable [VU] near threatened [NT] and least concern [LC], the following species are listed in Schmitt C. B., 2006 and Ensermu Kelbesa & Teshome Soromessa, 2004: *Aframomum corrorima* (VU), *Brillantaisa grotanellii* (VU), *Crassocephallus macropsppum* (LC), *Crotalaria gillettii* (NT), *Dorstenia soerensenii* (VU), *Erythrina bruci* (LC), *Lippia adonsis* (LC), *Milletia ferruginia* (LC), *Pycnostacys abyssinica* (NT), *Satureja paradoxa* (NT), *Scadoxus nutans* (EN), *Tiliacora troupinii* (VU), *Vepris dianellii* (NT), *Vernonia leopoldi* (LC). This species are endemic (Ibid).

Important Value Index (IVI)

Important value is calculated for each species by taking the sum of relative frequency, relative dominance and relative abundance. The importance value of a species reaches a maximum of 300 in stands consisting of only one tree species (Mueller-Dombois and Ellenberg, 1974). According to Lamprecht, 1989 surveys that yield more or less the same importance value index for the characteristic species should indicate the same or at least similar stand composition and structure, site requirements and comparable dynamics. The

most important species (>=10cm dbh) in each forest area which have IVI greater than 10 are presented in the following Table (Table 11).

Table 11. Important species in Mankira, Bonga and Boginda

Mankira	Bonga	Boginda
Croton macrostachyus (26)	*Draceaena steudneri (17)*	*Chionanthus mildbraedii (17)*
Phonix reclinata (21)	*Schefflera volkensii (15)*	*Milletia ferruginea (17)*
Sapium ellepticum (21)	*Schefflera abyssinica (14)*	*Prunus Africana (15)*
Celtis africana (13)	*Milletia ferruginea (10)*	*Olea welwitschii (14)*
Vepris dainelli (13)	*Olea welwitschii (10)*	*Macaranga capensis (13)*
Cordia africana (12)		*Schefflera abyssinica (12)*
Cachno (10)		*Landolphia owerensis (12)*
Diospyrose abyssinica (10)		*Syzygium guineense (12)*
Milletia ferruginea (10)		*Vepris dainelli (10)*
Chionanthus mildbraedii (10)		*Allophyllus abyssinicus (10)*
		Sapium ellepticum (10)
		Pouteria adolfi-friederici (10)

Surprisingly, except for *Dracaena afromontana, D. steudneri* and *Bersama abyssinica*, all species indicated in the Table 10 are expressed as important species by Getachew Berhane and Yoseph Assefa in IBC, 2002. Species that are not characterized as important but found to be important in this study are *Syzygium guineense*, *Allophyllus abyssinicus*, *Sapium ellepticum*, *Landolphia owerensis* and *Olea welwitschii.*

In general, with regard to forest in the study area, it is hardly possible to separate or to map distinctively different communities as most of the tree species are overlapping. Community type may be classified based on three systems viz. physiognomic, floristic and dynamic system[10]. Despite the fact that we talk about one community type, as Friis (1994) categorized it - Afromontane Rain Forest- for this particular site floristic classification is chosen and "association" where naming is made based on the basis of **common dominant species** in several stands (Mankira, Bonga and Boginda in this case). Accordingly, in Bonga forest *Draceaena steudneri and Schefflera volkensii;* in Mankira forest *Croton macrostachyus, Phonix reclinata* and *Vepris dainelli;* and in Boginda *Milletia ferruginea, Chionanthus mildbraedii* and *Macaranga capensis* are found to be

[10] Based on Lecture note on "General Ecology", Wondogenet College of Forestry

common and dominant species. The associated trees are overlapping especially between in Bonga and Boginda forest. The overlapping of species in Bonga, Mankira and Boginda forest is expressed in Jaccard's index and Sørensen's Index (Table 12).

Table 12. Biodiversity Indices of trees/shrubs and lianas greater or equal to 10cm dbh

Biodiversity Indices	Bonga	Mankira	Boginda
Margalef	8.34	7.36	10.82
Menhinick's	2.25	2.16	2.88
Shannon	3.13	3.06	3.27
Evenness	0.79	0.80	0.77
Simpson	0.03	0.04	0.04
Berger-Parker	0.08	0.09	0.13
Jaccard's index (site Boginda and Bonga forest)	52.33		
Jaccard's index (site Boginda and Mankira)	57.14		
Jaccard's index (site Bonga and Mankira forest)	40.24		
Sørensen's Index (site Boginda and Bonga forest)	73		
Sørensen's Index (site Boginda and Mankira)	72		
Sørensen's Index (site Bonga and Mankira forest)	57		

From the above Table it is possible to observe Shannon index between the three forests is comparable, 3.13, 3.06 and 3.27, consecutively.

Index of Similarity according to Jaccard is a very simple mathematical expression for the similarity of plant communities and is expressed by Community coefficient of Jaccard (Mueller-Dombois and Ellenberg, 1974). It is based on the presence-absence relation between the number of species common to two areas (or communities). Accordingly, similarity of the three forests is estimated and the result is shown in Table 12 above. In general, the similarity between the three forests is not that much strong. But Sørensen's Index indicates stronger similarity than Jaccard's Index. According to Mueller-Dombois and Ellenberg, 1974 Sørensen's Index is mathematically more satisfactory as it includes a statistically probability term and also it gives greater weight than Jaccard's to the species that recur in the two test areas than to those that are unique to either area (see the formula below).

$$IS_J = \frac{C}{a+b+C} * 100$$ Jaccard (=J) Based on presence of species only.

$$IS_s = \frac{2c}{A+B} * 100$$ Sørensen (=S) Based on presence of species only.

Where:

IS_J=Jacard's Index

ISs= Sørensen's Index

a = unique species in one of the forest area (x)

b = unique species in the other forest area (y)

c = common species for both forest area

A = all species in forest x

B = all species in forestry

5. PROPOSAL FOR CORE, BUFFER AND TRANSITIONAL AREAS

Understanding concepts of core, buffer and transition as described by UNESCO 2006[11] vis-a-vis the existing management system in those three study areas was necessary before mapping the area into these three functional zones. The procedure used to map this out is the following:

- The flora in general is under high pressure mainly as a result of anthropogeneic reasons. The current survey and other studies conducted before revealed that biodiversity in the forest are higher than those on other landcover. Therefore maintaining the existing forest cover is taken as the first criteria for categorizing the land in one of the three mentioned functions.
- Steep sloped areas are more prone to landslide and soil erosion than gentle slopes. In the study area many places that are threatened by erosion and landslide are observed. Especially in the absence of good vegetation cover this problem affects wide areas as the natural topography of Bonga is highly slopping ranging from 10 % to over 60 % (TAM Agribusiness 2004 cited in Riechmann D., 2007). Thereore from **SRTM** database slope percent was calculated and classified into two classes namely slope class I and slope class II. Slope class I comprises slopes less than or equal to 30 percent and slope class II comprises areas that are greater than 30 percent.
- Altitude was taken as one criterion for this zonation. But this altitude variation does not apply for "Dense Forest" stratum. Similar to slope classifiction altitude above sea level of the study area is divided into two: areas greater than 1900 masl and, areas less than 1900 masl. This division is considered because of the distribution of *Coffea arabica.* According to Kaffa zone Agriculture and Rural Development Bureau, the altitudinal range of coffee does not exceed upper limit of 1900 though Schmitt C. B., 2006 reported that wild coffee grows throughout the forest until 2,050 masl except for extremely shaded and humid sites.

[11] See annex I for definition

- River systems in the study area, like elsewhere in Ethiopia, are not protected or there is no law regarding their conservation or protection. River systems have high ecological and environmental importance. Most of all, rural people use these rivers as source of water for drinking and washing. In the study area this phenomen is well observed. Social services derived from the rivers in the study area include, among others, washing, drinking water for animals and human, artisan fishing. Therefore the river system needs to be protected. Another reason for considering rivers in the biosphere criteria is that they can serve as a wildlife corridor between different habitats along the rivers, i.e., rivers flow from higher altitudes to lower altitudes. Therefore seasonal movement of wildlife might be present and such movement can be facilitated by those corridors.

Therefore the three zones are classified based on the following able and the resulting zones are depicted in map 4 and 5.

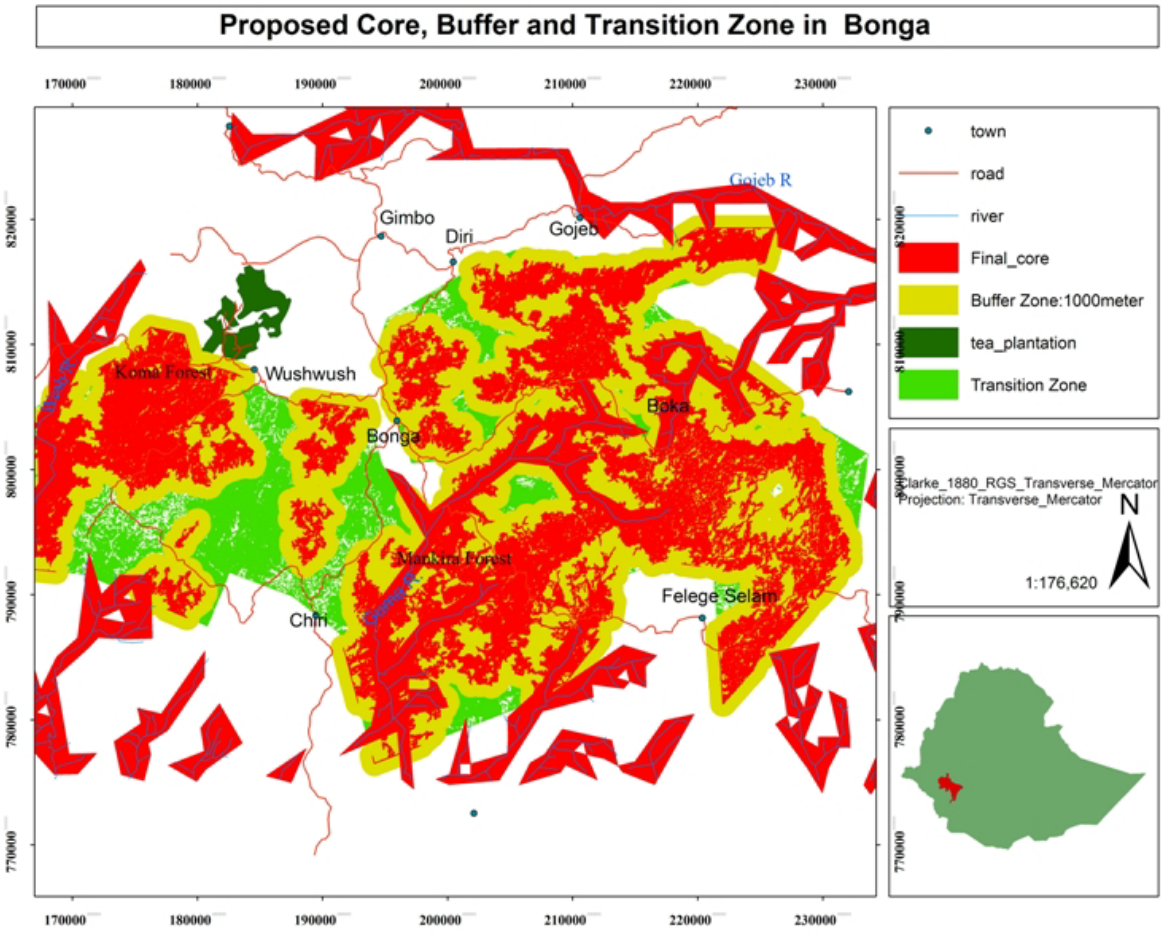
Table 13. Criteria considered to determe core, buffer and transitional zones

No.	Land Cover/use	Slope class percent		Altitude in meter	
		Less than or equal to 30	Greater than 30	Less than 1900	Greater than or equal to 1900
1	Dense Forest	Core	Core	Core	Core
2	Disturbed Forest	Buffer	Core	Core	Buffer
3	Highly Disturbed Forest	Buffer	Buffer	Buffer	Buffer
4	Intensively Cultivated	Transitional	Transitiona	Transitional	Transitional
5	Moderately Cutivated	Transitional	Transitional	Transitional	Transitional
6	Wetland	Buffer	Buffer	Buffer	Buffer
7	Bamboo Forest	Core	Core	Core	Core
8	River system (width of 200m)	Core	Core	Core	Core

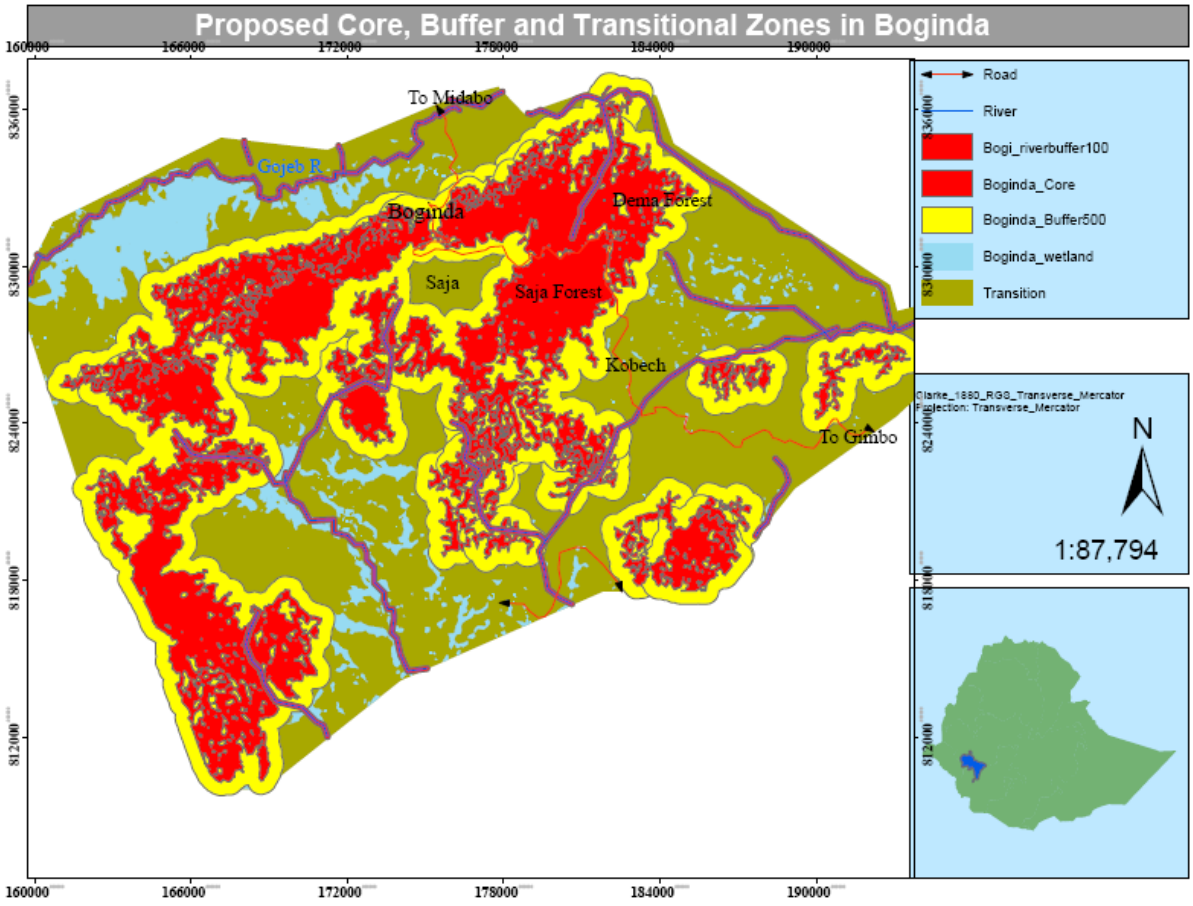
The result, as it is depicted on Map 4 and 5 below, is larger in size than the area proposed by Schmitt C. B., 2006 and Taestensen, F. et al., 2007. However, this zonation

is made entirely based on landcover, slope, river and altitude dtata. Therefore it is possible to refine the zonation later if socio-economic and fauna data are included.

Map 4 Proposed Core, Buffer and Transitional Area in Bonga and Mankira



Map 5. Proposed Core, Buffer and Transitional Areas of Boginda



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7. ANNEXES

Annex I. Definitions

Forest

"Forest is land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meter at maturity *in situ*", (FAO, 2002).

Tree

"Tree is a woody perennial with a single main stem, or in the case of coppicing with several stems, having a more or less definite crown. Includes: Bamboo, palms, and other woody plants meeting the above criterion", (FAO, 2002).

Shrubs

"Shrubs refers to vegetation types where the dominant woody elements are shurubs, i.e., woody perennial plants, generally of more than 0.5 meter and less than 5 meter in height on maturity and without a definit crown", (FAO, 2002).

Core

"The ***core area*** needs to be legally established and give long-term protection to the landscape, ecosystem and species it contains. It should be sufficiently large to meet these conservation objectives. As nature is rarely uniform and because of historical land-use constraints, there may be several core areas in a single biosphere reserve to ensure a representative coverage of the mosaic of ecological systems. Normally, the core area is not subject to human activity, except for research and monitoring and, as the case may be, for traditional extractive uses by local communities", (UNESCO, 2006).

Buffer

"The ***buffer zone*** (or zones) is clearly delineated and surrounds or is contiguous to the core area. Activities are organized here so that they do not hinder the conservation objectives of the core area but rather help to protect it, hence the idea of "buffering". It can be an area for experimental research, for example to discover ways to manage natural vegetation, croplands, forests, fisheries; to enhance high quality production while conserving natural processes and biodiversity, including

soil resources, to the maximum extent possible. In a similar manner, experiments can be carried out in the buffer zone to explore how to rehabilitate degraded areas. It may accommodate education, training, tourism and recreation facilities", (UNESCO 2006)

Transition

"An outer ***transition area*** or area of co-operation extends outwards, which may contain a variety of agricultural activities, human settlements and other uses. It is here that the local communities, conservation agencies, scientists, civil associations, cultural groups, private enterprises and other stakeholders must agree to work together to manage and sustainably develop the area's resources for the benefit of the people who live there. Given the role that biosphere reserves should play in promoting the sustainable management of the natural resources of the region in which they lie, the transition area is of great economic and social significance for regional development," (UNESCO 2006)

Annex II. Tables

Table 14. Summary of woody species registered in Bonga, Boginda and Mankira

Scientific Name	Family	Habit
Acanthus eminens	*Acanthaceae*	*s*
Alangium chinense	*Alangiaceae*	*T*
Albizia gummifera	*Fabaceae.*	*T*
Allophyllus abyssinicus	*Sapindaceae*	*T*
Allophyllus macrobotrys	*Sapindaceae*	*s*
Apodytes dimidiata	*Icacinaceae*	*T*
Bersama abyssinica	*Melianthaceae*	*T*
Brucea antidysenterica	*Simaroubaceae*	*sT*
Buddleja polystachya	*Loganiaceae*	*T*
Canthium oligocarpum	*Rubiaceae*	*T*
Cassipourea malosana	*Rhizophoraceae*	*T*
Celtis africana	*Ulmaceae*	*T*
Celtis gomphophylla	*Ulmaceae*	*T*
Chionanthus mildbraedii	*Oleaceae*	*sT*
Cissampelos pareira	*Menispermaceae*	*wC*
Cissus petiolata	*Vitaceae*	*wC*
Clausena anisata	*Rutaceae*	*sT*
Clematis hirsuta	*Ranunculac*	*wC*
Clerdendrum myricoides	*Lamiaceae*	*s*
Coffea arabica	*Rubiaceae*	*sT*
Cordia africana	*Boraginiaceae*	*T*
Croton macrostachyus	*Euphorbiaceae*	*T*
Cyathea manniana	*Cyathaceae*	*sT*
Cyphomandra betacaea	*Solanaceae*	*s*
Dalbergia lactea	*Fabaceae*	*wC*
Deinbollia kilimandscharica Taub.	*Sapindaceae*	*sT*

Scientific Name	Family	Habit
Diospyros abyssinica (Hiern) F. White	*Ebenaceae*	*T*
Dombeya torrida	*Sterculiaceae*	*s*
Dracaena afromontana	*Agavaceae*	*sT*
Dracaena fragrans	*Agavaceae*	*sT*
Dracaena steudneri	*Agavaceae*	*sT*
Ehertia cymosa	*Boraginiaceae*	*sT*
Ekebergia capensis	*Meliaceae*	*T*
Embelia schimperi	*Myrsinac*	*wC*
Erythrina brucei	*Papilionoideae*	*T*
Erythrococca trichogyne	*Euphorbiaceae*	*s*
Eugenia bukobensis	*Myrtaceae*	*T*
Euphorbia ampliphylla	*Euphorbiaceae*	*T*
Fagaropsis angolensis	*Rutaceae*	*T*
Ficus ovata	*Moraceae*	*T*
Ficus palmata	*Moraceae*	*T*
Ficus sur	*Moraceae*	*T*
Ficus thonningii	*Moraceae*	*sT*
Flacortia indica	*Flacourtiac*	*T*
Galineiera saxifraga	*Rubiaceae*	*sT*
Grewia ferruginea	*Tiliaceae*	*s*
Hagenia abyssinica	*Rosaceae*	*T*
Hallea rubrostipulata	*Rubiaceae*	*T*
Hibiscus berberidifolius	*Malvaceae*	*s*
Hibiscus calyphyllus	*Malvaceae*	*s*
Hippocratea africana	*Celastraceae*	*wC*
Hypericum revoltum	*Hypericaceae*	*s/T*
Illex mitis	*Aquifoliaceae*	*T*
Justicia schimperiana	*Acanthaceae*	*s*
Landolphia buchananii	*Apocynaceae*	*wC*
Landolphia owerensis	*Apocynaceae*	*T*

Scientific Name	Family	Habit
Lepidotrichilia volkensii	*Meliaceae*	*sT*
Macaranga capensis	*Euphorbiaceae*	*T*
Maesa lanceolata	*Myrsinaceae*	*sT*
Marsdenia spec	*Asclepiadaceae*	*wC*
Maytenus gracilipes	*Celastraceae*	*s*
Maytenus ovatus	*Celastraceae*	*T*
Milletia ferruginea	*Fabaceae*	*T*
Mimusops kummel	*Sapotaceae*	*T*
Myrsine melanophloeos/africana	*Myrsinaceae*	*s*
Ocotea kenyensis	*Lauraceae*	*T*
Olea welwitschii	*Oleaceae*	*T*
Oncinotis tenuiloba	*Apocynaceae*	*wC*
Oncoba routledgei Sprague	*Flacourtiaceae*	*T*
Oxyanthus speciosus	*Rubiaceae*	*sT*
Paullinia pinnata	*Sapindaceae*	*wC*
Pavetta abyssinica	*Rubiaceae*	*s*
Phonix reclinata	*Arecaceae*	*T*
Phytolacacca dodecandra	*Phytolaccac*	*?*
Pittosporum viridiflorum	*Pittosporaceae*	*sT*
Polyscias fulva	*Araliaceae*	*T*
Pouteria adolfi-friederici	*Sapotaceae*	*T*
Prunus africana	*Rosaceae*	*T*
Psychotria orophila	*Rubiaceae*	*sT*
Pterolobium stellatum	*Fabaceae*	*wC*
Rhamnus prinoides	*Rhamnaceae*	*s*
Ricinus communis	*Euphorbiaceae*	*s*
Ritchiera steudneri Gilg	*Capparidaceae*	*?*
Rothmannia urcelliformis	*Rubiaceae*	*sT*
Rubus apetalus	*Rosaceae*	*s*
Rytigynia neglecta	*Rubiaceae*	*s*

Scientific Name	Family	Habit
Salacia congolensis	*Celastraceae*	*L/s*
Sapium ellipticum	*Euphorbiaceae*	*T*
Schefflera abyssinica	*Araliaceae*	*T*
Schefflera myriantha	*Araliaceae*	*wC*
Schefflera volkensii	*Araliaceae*	*T*
Schrebera alata	*Oleaceae*	*sT*
Sericostachys scandens	*Amaranthac*	*wC*
Solanecio gigas	*Asteraceae*	*s*
Solanecio mannii	*Asteraceae*	*s*
Syzygium guineense	*Myrtaceae*	*T*
Teclea nobilis	*Rutaceae*	*sT*
Tiliacora troupinii	*Menispermaceae*	*wC*
Tinospora caffra	*Menispermaceae*	*wC*
Trichilia dregeana	*Meliaceae*	*T*
Trilepisium madagascariense	*Moraceae*	*T*
Urera hypselodendron	*Urticaceae*	*wC*
Vepris dainelli	*Rutaceae*	*sT*
Vernonia amygdalina	*Asteraceae*	*s*
Vernonia auriculifera	*Asteraceae*	*s*
Vernonia sp	*Asteraceae*	*s*
Yushania alpina K. Schum	*Bambusaceae*	*G (T)*

Table 15. Ground layer vegetation including climbers

No.	Scientific name	Family	Habit
1	*Achyranthes aspera*	Amaranthaceae	H
2	*Aframomum corrorima*	Zingiberaceae	H
3	*Aframomum sanguineum*	Zingiberaceae	H
4	*Asplenium sp*	Aspleniaceae	Fern
5	*Brillantaisia grotanellii*	Acanthaceae	H
6	*Carduus leptacanthus*	Asteraceae	H
7	*Centalla asiatica*	Apiaceae	H
8	*Clematis spp*	Ranunculaceae	Wc
9	*Crassocephalum macropappum*	Asteraceae	H
10	*Cyclosorus dentatus*	Thelypteridaceae	Fern
11	*Cynoglossum amplifolium*	Boraginiaceae	H
12	*Cyperus sp*	Cyperaceae	H
13	*Datura stromonium*	Solanaceae	H
14	*Dichondra repens*	Convolvulaceae	H
15	*Dichrocephala integrifolia*	Asteraceae	H
16	*Dicliptera laxata*	Acanthaceae	H
17	*Didymochlaena truncatula*	Aspidiaceae	Fern
18	*Dorstenia brownie*	Moraceae	H
19	*Dregea rubicund*	Asclepiadaceae	H
20	*Elatostema monticola*	Ulmaceae	H
21	*Euphorbia schimperiana*	Euphorbiaceae	H
22	*Galinsoga parviflora*	Asteraceae	H
23	*Gloriosa superba*	Colchicaceae	H
24	*Habenaria petitiana*	Orchidaceae	H
25	*Hydrocotyle mannii*	Apiaceae	H
26	*Hypoestes forskaolii*	Acanthaceae	H
27	*Impatiens tinctoria*	Balsaminaceae	H
28	*Ipomoea cairica*	Convolvulaceae	H
29	*Isoglossa puncata*	Acanthaceae	H

No.	Scientific name	Family	Habit
30	*Isoglossa somalensis*	Acanthaceae	H
31	*Laggera pterodonta*	Asterac*eae*	H
32	*Lantana trifolia*	Lamiac*eae*	H
33	*Malaxis weberbaueriana*	Orchidaceae	H
34	*Microglossa pyrifolia*	Asterac*eae*	hC
35	*Mictactis bojeri*	Asterac*eae*	H
36	*Momordica foetida*	Cucurbitaceae	H
37	*Nervilia bicarinata*	Orchidaceae	H
38	*Ocimum sp*	Lamiac*eae*	H
39	*Ocimum urticifolium*	Lamiac*eae*	H
40	*Paullina pinnata*	Sapindaceae	wC
41	*Pavonia schimperiana*	Malvaceae	H
42	*Pavonia spp*	Malvaceae	H
43	*Pavonia urens*	Malvaceae	H
44	*Pentas lanceolata*	Rubiac*eae*	H
45	*Peperomia abyssinica*	Piperac*eae*	H
46	*Peperomia molleri*	Piperaceae	H
47	*Peponium vogelii*	Cucurbitac*eae*	hC
48	*Persicaria glabra*	Polygonaceae	H
49	*Pilea johnstonii*	Ulmaceae	H
50	*Piper capense*	Piperac*eae*	H
51	*Pteridium aquilinum*	Dennstaedtiaceae	F
52	*Pteris cretica*	Pteridaceae	Fern
53	*Rumex nepalnsis*	Polygonaceae	H
54	*Rungia grandis*	Acanthaceae	H
55	*Salacia congolensis*	Celastraceae	H
56	*Satureja paradoxa*	Lamiac*eae*	H
57	*Sida rhombifolia*	Malvaceae	H
58	*Solanecio/ Hydrocotyle manii*	Rubiac*eae*	H
59	*Stephania abyssinica*	Menispermaceae	hC

No.	Scientific name	Family	Habit
60	*Tiliacora troupinii*	Menispermaceae	wC
61	*Tristemma maurtianum J.F. Gmel*	Melastomataceae	H
62	*Triumfetta brachyceras*	Tiliaceae	H
63	*Vernonia hochstetteri*	Asterac*eae*	H
64	*Vernonia tewoldei*	Asterac*eae*	H
65	*Zehneria scabra*	Cucurbitac*eae*	hC

Table 16. Major grass species encountered in the forest

No.	Scientific Name	Family
1	*Oplismenus undulatifolius*	Poaceae
2	*Olyra latifolia*	Poaceae
3	*Cynodon spp*	Poaceae
4	*Carex chlorosaccus*	Cyperaceae
5	*Poecilostachys oplismenoides*	Poaceae
6	*Tectaria cf. gemmifera*	Poaceae
7	*Setaria megaphylla*	Poaceae
8	*Cyperus rotundus*	Cyperaceae
9	*Leptaspis zeylanica*	Poaceae
10	*Panicum spp*	Poaceae
11	*Pseudechinolaena polystachya*	Poaceae
12	*Oplismenus hirtellus*	Poaceae

Table 17. Common, Occasional and Rare species in Bonga, Mankira and Boginda

	Bonga	Mankira	Boginda	selected species (Schmitt C. B. 2006)
Common	*Draceaena steudneri*	*Croton macrostachyus*	*Milletia ferruginea*	*Common species*
	Schefflera volkensii	*Phonix reclinata*	*Chionanthus mildbraedii*	*Elaeodendron buchananii*
		Vepris dainelli	*Macaranga capensis*	*Bersama abyssinica*
		Sapium ellepticum	*Vepris dainelli*	*Milletia ferruginea*
		Pouteria adolfi-friedericii	*Psychotria orophila*	*Albizia gummifera*
		Chionanthus mildbraedii		*Phoenix reclinata*
				Trilepisium madagascariense
Occasional	*Allophyllus macrobotrys*	*Draceaena steudneri*	*Cyathea manniana*	*Canthium oligocarpum*
	Milletia ferruginea	*Milletia ferruginea*	*Allophyllus abyssinicus*	*Allophylus abyssinicus*
	Maesa lanceolata	*Landolphia owerensis*	*Draceaena steudneri*	*Syzygium guineense*
	Phonix reclinata	*Maesa lanceolata*	*Syzygium guineense*	*Ocotea kenyensis*
	Allophyllus abyssinicus	*Celtis africana*	*Sapium ellepticum*	*Olea welwitschii length*
	Syzygium guineense	*Ehertia cymosa*	*Croton macrostachyus*	*Occasional species*
	Ficus ovata	*Cordia africana*	*Landolphia owerensis*	*Pouteria adolfi-friederici*
	Landolphia owerensis	*Trichilia dregeana*	*Rothmannia urcelliformis*	*Schefflera abyssinica*
	Vepris dainelli	*Olea welwitschii*	*Dracaena afromontana*	*Apodytes dimidiata*
	Galineiera saxifraga	*Ficus ovata*	*Galineiera saxifraga*	*Flacourtia indica*
	Schefflera abyssinica	*Cachno*	*Ehertia cymosa*	*Macaranga capensis*
	Rothmannia uricelliformis	*Diospyrose abyssinica*	*Oxyanthus specious*	*Trichilia dregeana*
	Sapium ellipticum	*Albizia gummifera*	*Allophyllus macrobotrys*	*Sapium ellipticum*
	Olea welwitschii	*Prunus africana*	*Pouteria adolfi-friederici*	*Albizia schimperiana*
	Macaranga capensis	*Psychotria orophila*	*Justica schimperiana*	*Ekebergia capensis*
	Croton macrostachyus	*Allophyllus abyssinicus*	*Olea welwitschii*	*Polyscias fulva*
	Albizia gummifera	*Schefflera abyssinica*	*Ficus palmata*	*Ilex mitis*
	Polyscias fulva	*Isoglosa somalensis*	*Dracaena fragrans*	*Ficus sur tiny high*
	Dracaeana afromontana	*Macaranga capensis*	*Ficus ovata*	*Prunus africana*
	Apodytes dimidiata	*Apodytes dimidiata*	*Polyscias fulva*	*Euphorbia ampliphylla*
	Bersama abyssinica	*Pittosporum viridiflorum*	*Salacia congolensis*	*Fagaropsis angolensis*
	Teclea nobilis	*Cissampelos pareira*	*Stephania abyssinica*	*Rare species*
	Illex mitis	*Galineiera saxifraga*	*Albizia gummifera*	*Alangium chinense*
	Psychotria orophila	*Vernonia amaygadlina*	*Cassipourea malosana*	*Cassipourea malosana*
	Vernonia amygdalina	*Polyscias fulva*	*Bersama abyssinica*	*Celtis africana*
	Eugenia bukobensis	*Flacortia indica*	*Schefflera abyssinica*	*Croton macrostachys*
	Cordia africana	*Rothmannia uricelliformis*	*Prunus africana*	*Cordia africana present*
	Chionanthus mildbraedii	*Bersama abyssinica*	*Sericostachys scandens*	*Ficus ovata tiny*
	Hagenia abyssinica	*Cyathea manniana*	*Maytenus gracilipes*	*Hallea rubrostipulata*
	Rytigynia neglecta	*Syzygium guineense*	*Erythrococca trichogyne*	*Albizia grandibracteata*
	Pouteria adolfi-friederici	*Cassipourea malosana*		*Ficus vasta tiny*
	Erythrina abyssinica			*Vangueria apiculata*
	Myrsine melanophloeos			
	Dracaena fragrance			
	Albizia gummifera			
	Canthium oligocarpum			
	Cassipourea malosana			
	Pterolobium stellatum			

Table 18. Species found within one of the study area only

Mankira	Boginda	Bonga
Cissampelos pareira	*Alangium chinense*	*Brucea antidysenterica*
Diospyrose abyssinica	*Fagarobsis angolensis*	*Celtis gomphophylla*
Ficus sur	*Ficus thonningii*	*Coffea arabica*
Flacortia indica	*Hibiscus calyphyllus*	*Dalbergia lactea*
Grewia ferruginea	*Justica schimperiana*	*Deinbollia kilimandscharica*
Isoglosa somalensis	*Ocotea kenyensis*	*Dombeya torrida*
Trichilia dregeana	*Salacia congolensis*	*Ekebergia capensis*
	Sericostachys scandens	*Erythrina abyssinica*
	Stephania abyssinica	*Eugenia bukobensis*
	Tiliacora troupinnicuf	*Euphorbia ampliphylla*
	Trilepisium madagascariense	*Hagenia abyssinica*
		Hallea rubrostipulata
		Hibiscus berberidifolius
		Hypericum revoltum
		Mimusops kummel
		Myrsine melanophloeos
		Oncoba routledgei
		Paullinia pinnata
		Pavetta abyssinica
		Pterolobium stellatum
		Schefflera volkensii
		Schrebera alata
		Teclea nobilis
		Tinospora caffra
		Vernonia sp
		Weramo
		Yushania alpina

Annex III. Pictures

Photo 1 Impact of Agriculture (Cultivation) on forest

Photo: Sisay Nune, 2008

Photo 2 .Deforested Hagenia forest for Agriculture and remnants of the species

Photo: Sisay Nune, 2008

Photo 3. Forest conversion for agriculture, Boka *Kebele*

Photo by Sisay Nune, 2008.

Photo 4. Dense Bamboo Forest

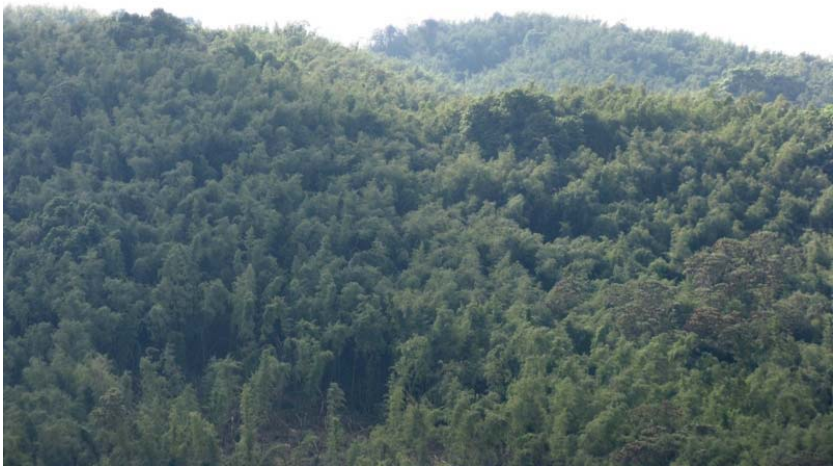

Photo by Sisay Nune, 2008.

Annex IV. CITES Annex I & II plant species

Species Name	Family
Rhipsalis baccifera (J.S.Mueller) Stearn ssp. mauritiana (De Candolle) Barthlott	CACTACEAE
Alsophila manniana (Hook.) R.M.Tryon	CYATHEACEAE
Cyathea dregei Kunze 1834 var. dregei	CYATHEACEAE
Cyathea manniana Hook. 1865	CYATHEACEAE
Disperis anthoceros Reichb.f. var. anthoceros	ORCHIDACEAE
Habenaria armatissima Reichb.f.	ORCHIDACEAE
Habenaria cirrhata (Lindley) Reichb. f.	ORCHIDACEAE
Habenaria keayi Summerh.	ORCHIDACEAE
Holothrix tridentata (Hook.f.) Reichb.f.	ORCHIDACEAE
Microcoelia guyoniana (Reichb.f.) Summerh.	ORCHIDACEAE
Prunus africana (Hook. f.) Kalkm.	ROSACEAE

Annex V. Transect Location

Figure 20. Distribution of Transect Lines