



**ADDIS ABABA UNIVERSITY**

**SCHOOL OF GRADUATE STUDIES**

**FLORISTIC COMPOSITION AND STRUCTURE IN  
BESCHILLO AND ABAY (BLUE NILE) RIVERINE  
VEGETATION**

**GETANEH BELACHEW**

**July 2006**

## **Acknowledgements**

I would like to express my deepest gratitude to my advisors Prof. Sebesebe Demissew and Prof. Zerihun Woldu for their inspiring guidance, advice, constructive criticism, comments and follow up from problem identification up to completion of this work. I am indebted to members of SES (Scientific Exploration Society) for their support in boat transportation and data collection. I thank the Graduate Studies of Addis Ababa University for its financial support. I am grateful to Department of Biology and National Herbarium of Addis Ababa University for providing materials and facilitating my work. I am sincerely acknowledging the unfailing co-operation of the local people who are living at villages near to Beschillo and Blue Nile rivers in Amhara Regional State, Oromya Regional State and Benishangul-Gumuz Regional State for their support and guidance during data collection. Finally, I wish to thank my family and all my friends for their support and encouragement.

<b>Table of contents</b>	<b>page</b>
Acknowledgement.....	I
Table of contents.....	II
List of tables.....	IV
List of figures .....	V
List appendices.....	V
Abstract .....	VI
1. Introduction. ....	1
1.1. Problem statements and justification.....	3
1.2. Objective of the study area.....	4
2.2.1. General objective.....	4
2.2.2. Specific objectives.....	4
2. Literature review.....	5
2.1. Wetlands, riparian areas and their functions.....	5
2.2. Species richness in riparian area.....	5
2.3. Riparian areas and rivers as a conservation biota.....	6
2.4. Movement of materials and colonization.....	7
2.3. Significance of disturbance.....	9
2.6. Diversity.....	10
2.7. Blue Nile.....	10
2.4. Comments on riparian, swamp and riverine vegetation.....	11

<b>Table of contents</b>	<b>Page</b>
3. Description of the study area.....	12
3.1. Climate.....	14
3.2. Geology. ....	16
4. Materials and methods.....	17
4.1. Statistical analysis.....	18
5. Results and discussion.....	20
5.1. Floristic composition.....	20
5.2. Tree species.....	20
5.2.1. Vegetation structure.....	21
5.2.1.1. Density and DBH.....	21
5.2.1.2. Basal area.....	22
5.2.1.3. Height and density.....	23
5.2.1.4. Frequency.....	24
5.2.1.5. Important Value Index.....	25
5.2.1.6. Species population structure.....	27
5.3. Plant communities.....	30
5.4. Species diversity.....	36
6. Conclusion and recommendation.....	38
7. References.....	42
8. Appendices.....	48

<b>List of tables</b>	<b>Page</b>
Table 1. Location of Metrological Stations and climatic records.....	14
Table 2 Mean monthly rainfall amount in mm.....	14
Table 3. Mean monthly temperature in <sup>0</sup> C.....	14
Table 4. Major phases of Nile River System.....	16
Table 5. Main archaeological phases of the River Nile.....	17
Table 6. Distribution of trees in different DBH classes.....	21
Table 7. Dominant trees with their percentage basal area.....	22
Table 8. Stem number ha <sup>-1</sup> , species number and ratio of individuals to species by storey...	23
Table 9. Frequency class trees.....	24
Table 10. Importance Value index of Tree species.....	26
Table 11. TWINSpan out put of vegetation.....	33
Table 12. Synoptic cover-abundance values.....	35
Table 13. Shannon-Weiner Diversity Index.....	36

<b>List of figures</b>	<b>Page</b>
------------------------	-------------

Fig.1. Map of the study area.....	13
Fig. 2. Climatic diagram from Filiklek.....	15
Fig.3 Climatic diagram from Mendi.....	15
Fig .4 Species population structure of six important tree species.....	29

<b>List of appendices</b>	<b>Page</b>
Appendix 1. List of plant species, family, and growth habit.....	48
Appendix 2. Tree species & families.....	55
Appendix 3. Stem number and height class of tree species.....	57
Appendix 4. DBH range of tree species.....	58
Appendix 5. Relative density and frequency.....	50
Appendix 6. Dominance and relative dominance.....	62
Appendix 7. Importance value of each tree species.....	63
Appendix 8. Basal area (BA) of trees.....	64

## **Abstract**

Riverine vegetation along Beschillo and Blue Nile rivers was studied with the aim of compiling floristic composition and describing its plant communities. The area studied occurred between altitudinal gradients of 1324 and 626m. Beschillo is a tributary of Blue Nile River from which the study was started at a point between Mekdela and Tach-Gayint 'woredas' in Amhara Regional State (11°25.232' N & 38° 42.331' E) up to the point at which it joins the Blue Nile River (11°02.121' N & 38°28.521' E) and then continued to Sirba Abay (10°07.492' N & 35°20.919' E), which is located in Benishangul-Gumuz Regional State. A total of 580 km was covered to study the riverine vegetation along the two rivers. The data was collected in October and November 2005. Along the rivers, nested belt transects were laid at 500 or 1000 m interval from the riverbank to the adjoining upland. A total of 74 releves were analyzed within 43 transects. The number of plots in each transect was determined by the size of riverine vegetation which laid from the stream edge to the adjoining upland. Cover abundance value for each species was estimated based on Braun-Blanquet approaches as modified by Van der Maarel (1979). The number, height, and diameter at breast height (DBH) >2.5cm were measured for all tree individuals. A total of 205 vascular plant species were recorded of which, 47.32% were herbs, 6.83 % climbers, 22.44% shrubs and 23.41% were trees. A total of 53 Families and 152 Genera were registered, of these 12% were Poaceae, 10% Fabaceae, 5.4% Acanthaceae, 4.9 % Malvaceae and 4.4% Tiliaceae. The output of cluster analysis revealed 6 distinct plant community types. Structural parameters such as Density, Frequency, Dominance, and Important Value Index were calculated. Shannon-Weiner Diversity Index was also computed. The density of tree species per ha was 115 whereas the total basal area (BA) of trees species m<sup>2</sup> / ha was 12.6. Most of the tree individuals distributed in middle diameter and height classes.

## **1. Introduction**

The vegetation of Ethiopia is complex. The complexity arises from the great variation in altitude employing equally great spatial difference in moisture regime as well as

temperature (Zerihun Woldu, 1999). Ethiopian Mapping Agency (1988) noted that riverine vegetation shows variation from region to region depending upon rainfall, altitude and adjacent vegetation through which rivers flows. According to Springuel (1990), a sequential zonation from the river edge to adjacent uplands is apparently controlled by topographic feature governing the surplus and shortage of water. The amount of soil water can determine plant type and distribution. Schimper (1903) divided plants in to the following three categories on the basis of their water requirement. *Hgdrophytes*: - plants growing in water or water rich substratum and require abundance of water to let their life cycle. *Mesophytes*: - plants growing in places of moderate water supply. These plans can't live for long time either in saturated or in moisture deficient media. *Xerophytes*: - Plants capable of growing on water deficient medium. With in a semi arid climate zone, rverine vegetation forms green "linear oasis" due to available of soil moisture near to the stream and decreasing the moisture content towards the adjoining uplands.

The characteristic woody plant species in riparian and swamp vegetation in general include *Celtis africana*, *Ficus sycomorus*, *Mimosops kumel*, *Tamarindus indica*, *Maytenus senegalensis*, *Acacia spp.*, *Kigelia aethiopicum*, *Syzygium guineense*, etc. The tree species are associated with a wide range of shrubs, herbs and grasses. Swamps are dominated by sedges, grasses, and herbs (Demel Teketay, 1999).

Beschillo is a perennial tributary of Abay (Blue Nile) and Blue Nile is one of the major rivers in Ethiopia, which originates from Lake Tana and flows to Sudan. Friis (1992) noted that not much is known about the riverine forest in the lower Abbay (Blue Nile) Gorge. He also recommended that more studies and collection of complex vegetation type are desirable. Pichi-Sermolli (1957) visited the riverine forest along upper part of Abbay and identified the characteristic woody species that include: *Apodytes dimidiata*, *Carissa edulis*, *Euclea racemosa* subsp. *schmiperi*, *Ficus vasta*, *Millettia feruginea*, *Mimosops Kummel*, *Phoenix reclinata*, and *Pittosporum viridiflorum*. However, *Syzygium guineense* subsp. *guineense* is the most characteristic species.

According to a report of EFAP (1994), the forest coverage in Ethiopia was reduced from 35% in the early 1950's to 3.6% by 1980's and 2.7% by 1989's. Friis (1992) remarked that the major causes of forest destruction in Ethiopia are: increasing intensive use of land for agriculture and livestock, tree cutting for fuel wood and construction materials, forest fire and human settlement. This problem is associated with population growth. Rood & Mahoney (1990) also noted that widespread decline in riverine forest in arid and semi-arid regions have been observed in association with water and land use practices and heavy cattle grazing. The same is true in Beschillo and most parts of Blue Nile riverine vegetation. The pressure from high population growth and use of land along the river is resulting in more rapid change on the vegetation composition and structure along Beschillo (in Amhara Regional State) and Blue Nile (in Benishangul-Gumuz Regional State). The valley and plains surrounding Beschillo are now intensively cultivated. Teff and sorghum are grown on flatter parts, while cattle and goats graze the slopes along the riverine vegetation. In many parts only a few trees remain owing to the huge demand for firewood and building materials. Unless the present trend of exploiting the remaining sparse forest resources and their conversion into agricultural land is changed, every piece of relict forest remaining will go in the very near future (Sebsebe Demissew, 1998).

Seasonal burning is largely determined by the availability of ignition source and seasonal variation in flammability (Waring & Schlesinger, 1985). Not only seasonal burning but also in some part of Beschillo and Blue Nile the local people deliberately burn the vegetation in order to stimulate new and fresh leaves, control ticks and snakes and prepare land for cultivation. Fire can lead to the extinction of unique community of plants and animals. According to Vickery (1984), the natural balance of soil is considerably altered by fire, which removes the humus from the surface of the topsoil, destroys microorganisms, and increases the concentration of salts. It also affects successions, disrupts the natural stability of the original climax community (Abrahmson, 1984). Trees with thick bark near the base such as *Sterculia africana* can withstand the effect of fire to some extent. The older the tree, the thicker the bark, and consequently the more resistant the tree to fire. Thus, some fire resistant species may remain in the area. Ewusie (1980) indicated that

next to climate and soil, fire has been the most important single factor affecting the extent, composition, and character of forest and other vegetation cover on wild land.

## **1.2. Problem statements and justification**

The uncontrolled exploitation of forest areas by anthropogenic factors and depletion of vegetation by natural factors like forest fire has led to the threat as well as the decline in number and area of many plant species (Tesfaye Bekele, 2002).

Misra (1974) noted that one of the essential and most important aspects of ecology investigation is the study of vegetation. Goldsmith & Harisson (1976) also stated that vegetation being an essential component of an ecosystem needs careful study and analysis since such study is used as a means of revealing useful information about vegetation of an area and ecosystem.

No study was made on riverine vegetation of Beschillo and lower part of Blue Nile gorge. No more systematic floristic study was also made along upper part of Blue Nile. Now a day, intensive use of land for agriculture, high demand of wood for different purposes is increasing, there by riverine vegetation is being affected in Ethiopia.

Based on this background and baseline, this study was undertaken aiming at describing and providing available floristic information about riverine vegetation of Beschillo and Blue Nile, including some impacts on the vegetation of the study area. The information is supposed to be important for further studies, taking conservation measurements, formulating and implementing relevant policies, Improving vegetation resources, etc.

## **1.2. Objectives**

### **1.2.1. General objective**

The main objective of this study is to document the floristic composition and community type in the Beschillo and Blue Nile riverine vegetation.

### **1.2.2. Specific objectives**

- A. To compile floristic composition
- B. To determine vegetation structure of the species
- C. To identify major plant communities
- D. To describe plant species diversity
- E. To find out the main impacts on Beschillo and Blue Nile riverine vegetation

## **2. Literature Rivew**

### **2.1. Wetlands, riparian areas and their functions**

According to Wolfson *et al.* (2002), *wetlands* including marshes, swamps, fens and bogs, are among the most biological productive natural ecosystems in the world. They are typically identified by the presence of water at or near the land surface sufficient to support predominance of aquatic life by the presence of saturated soil conditions (hydric soil) and by presence of plant typically adapted for living in saturated soil conditions (hydrophytes). Dugan (1989) mentioned that wetlands with their hydrophytes serve a wide variety of functions, including flood control, water purification, shoreline stabilization, supporting of wildlife and numerous people that depend on them for livelihood. They also function as microclimate stabilization, windbreak, storm protection, nutrient retention, erosion control, ground water recharge, ground water discharge, production of forest and wild resources. An area of land located immediately adjacent to rivers, lakes, or other surface water is known as *riparian area*. Some would describe it as the floodplain. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequent flooding, and unique assemblage of plant and animal communities. Though the interaction of their soils, hydrology, and biotic communities, riparian forests maintain many important physical, biological, and ecological functions and important social benefits (Klapproth, 2000). He also explained that riparian areas provide critical

habitat for many types of wildlife, because of their diverse and productive plant communities, complex structure, and close proximity to water.

## **2.2. Species richness in riparian area**

Patterns of richness and rarity are observed in riverine wetlands, and permit us to forecast community dynamics and thus guidelines for the conservation of this biodiversity (Nicolas, 1998). Similarly Pollock (1998) described Riparian Plant Communities have been shown to be species rich and highly variable in species composition in both temperate and tropical systems. Stream corridors are exceptionally diverse environmentally and normally support high species richness, sometimes the highest in the landscape (Compton *et al.*, 1988). Plant litter is important in determining species richness, whereas the vegetation canopy is more important in determining seed germination and seedling emergence. Hence, both litter and vegetation canopy are important in determining plant colonization and species richness in riparian zones, but that their relative importance changes along the hydrological gradient (Shaojum, *et al* 2003). A small difference in moisture may result in a significant difference in seed germination and this in floristic composition and diversity of a wetland community (Keddy & Ellis, 1985).

## **2.3. Riparian area and rivers as a conservation of biota**

Groombridge (1989) described some goals of conservation of biodiversity: the present and potential use of elements of biodiversity as biological resources; the maintenance of the biosphere in state supportive of human life; the maintenance of biological diversity. Re-establishing functional diversity (e.g. hydrologic and successional processes) across the active corridors could serve as the focus of river conservation initiative. Once functional processes have been reconstituted, habitat heterogeneity will increase, followed by corresponding increasing in species diversity of aquatic and riparian biota (Ward and Tockner, 2001). The authors also pointed out a broadened concept of biodiversity encompassing spatio-temporal heterogeneity functional processes and species diversity

could provide a unifying theme for river ecology. Surface water, subsurface water and riparian system and the ecotones between them (e.g. springs) as interacting components contributing to the total biodiversity, is crucial for developing a holistic frame work of river as ecosystems.

#### **2.4. Movement of materials and colonization**

Riverine wetlands experience a through flow of water importing materials (Smith, 1992). One obvious reason for movement relates to the flowing nature of the water in rivers and streams. The drag force of flow (especially during high flow rate events) can cause dislodgement and subsequent downstream transport of individuals (Ger, *et al.*, 2003). Further down stream the velocity decreases, and the stream deposit its load of sediment as silt, sand, or mud. At the flood time, a stream drops its load of sediment on surrounding level land, over which floodwater spread to form flood plane deposits. The area of land a stream or river drains its water shade. Each water shade is different, characterized by vegetative covered, geology, soils, topography, and land use (Smith, 1992). River seepage is usually rich in nutrients (Bornette & Amoros, 1991). Over flow of the river in to cut-off channels bring nutrient-rich, fine sediments and poropagules to the ecosystem. Sediments promote better recruitment of new individuals and/or species, and thus increase species richness (Godreau, 1998). Large river cut-off channels are currently considered as high source of productivity and diversity in fluvial hydrosystem (Drago, 1976). This diversity result from: (i) Ecological succession occurring in this slow following or stagnant water bodies (in contrast to the main river channel; and (ii) episodic connection with the river during floods, which carry and import animals, plant and suspended materials (Schneider & Sharitz, 1988).

The variation in mobility could even be viewed as one aspect of resource partitioning as species may differ in there to colonize disturbed or newly formed patches of reaches (Huston, 1994). The mobility of most lotic organisms underlies on other of the strong patterns in stream and rivers, that of the relatively rapid re-establishment of communities

and recolonization of disturbed areas (Misra, 1974). Water availability is important in affecting plant colonization and distribution in wetlands (Johansson & Nilsson 2002).

Riparian species with a limited terrestrial dispersal capacity may greatly extend their range by hydrochory (dispersal by water flow). That is, if large amount of (small) seeds are produced and provided that these can reach the water body. Buoyancy of seeds, the ability to release vegetative fragments and high frequency of occurrence in the establishment of vegetation promote this dispersal capacity as well (Ger, *et. al*, 2003).

Klosowiki and Tomaszewicz (1993) described the riverine zone can serve as a zone of transportation, accumulation and transformation of local and non-local materials. This may imply the development of unique vegetation types and supporting consumers at variety level making the wet riverine zone a zone of diversifications of different life forms. The balance between rejuvenation, erosive flooding and terrestrialization processes sustain a diversity of successional stage in riverine flood planes. The wide variety of water bodies and riparian vegetation stands characterizing natural rivers corridors is attributable, in part, to hydrarch and riparian successional stage contains distinct biotic communities and species richness is increased by successional diversity (Castella *et al.*, 1984).

Landscape position contributes to the complexity of the riparian plant communities. Because of their location between the uplands and the stream, there is regular movement of nutrients, sediment, organic matter, and living organisms across the three environments (Nilsson *et al.*, 1994).

## **2.5. Significance of disturbance**

Connel (1978) formulated the 'intermediate disturbance hypothesis', that is, the disturbance with intermediate frequency and magnitude permit the co-occurrence of fast growing and competitive rudral species, promoting the great richness and diversity of species. Such pattern has been observed in wetlands (Keddy, 1983) where intermediate frequency of disturbance, depending in some case on connectively between the wetland and river, favors the maintenance of rare species that are usually weakly competitive

(Wisheu & Amoros, 1991). Hedman and Van Lear (1995) described that the species composition of riparian forest underwent change through time in relation to shade tolerance and the adaptability of the species to disturbance.

River back flows maintain nutrient-rich and turbid water in the permanently connected down stream zone, impeding the recruitment of most propagules (Godreau, 1998). According to Scott and Pool (1989), the major disturbances of wetlands are human settlement, agricultural activities, pollution, woodcutting for domestic use, and degradation of water shade, soil erosion siltation, and overgrazing are the major disturbances. On the other hand, the periodic flooding of the estuary and draw down could therefore be considered as a natural disturbance influencing vegetation establishment and regeneration.

According to Bohlen and King (1996) the diverse plant community is also a function of regular disturbance. Disturbances, both chronic (predictable, occurring monthly to yearly) and episodic (not predictable, usually occurring decades or centuries apart), are common to the riparian area, due to floods, fire, wind, and pests. These disturbances can produce large-scale changes in the plant community, or smaller patchy clearings scattered about the floodplain. As a result, young growth and mature vegetation are often found growing close together.

## **2.6. Diversity**

Species diversity has been identified as one of the key indices of sustainable land use practices and considerable resources are expended to identify and implement strategies that will reverse the current decline in biodiversity at local, regional and international scales (Shackelton, 2000). According to Groombridge (1999), *Biodiversity* is the number, variety and variability of living organisms. Rosenzweig, (1995) pointed out that diversity could be viewed in terms of *alpha*, *beta* and *gamma* diversity. *Alpha diversity* refers to the diversity or number of species within a particular habitat or community. *Beta diversity* is the rate and extent of change in species richness between communities across an

environmental gradient over a relatively small distance. It is often estimated by calculating species turn over. *Gamma diversity* is on the other hand the diversity of species or number of species across a very large area such as a biome or continent and is dependent on the alpha and beta diversities. Among the different coefficient widely used to compute diversity of a community are species richness, evenness and heterogeneity (Krebs, 1989). Hurlbert (1978) defined the following terms: *Species richness* is the simplest concept of species diversity implying the number of species in a community whereas *evenness* is a measure of equitability and it attempts to quantify the unequal representation of species in a community against a hypothetical community in which all species are equally common. *Heterogeneity* is the measure of the probability of which, two individuals randomly picked from a community belong to different species.

## **2.7. Blue Nile**

According to Colombian Electronic Encyclopedia (2000), Blue Nile River, a 1,600 km long, is the chief headstream of the Nile originates from Lake Tana, which is located in NW Ethiopia, at an altitude of 1,800 m. The Blue Nile generally flows towards south of Lake Tana and then west of Ethiopia and finally northwest into Sudan. Within 30 km of its source at Lake Tana, the river enters a gorge about 400 km long. This gorge is a tremendous obstacle for travel and communication from the north half of Ethiopia to the southern half. The power of the Blue Nile may best be appreciated at Tis Issat Falls, which are 45 m high, located about 40 km. The flow of the Blue Nile reaches maximum volume in the rainy season (from June to September), when it supplies about two thirds of the water of the Nile proper.

The Blue Nile is vital to the livelihood of Egypt. Almost 80-85% of the water that reaches Egypt originates from the Blue Nile branch of the great river. The river is also an important resource for Sudan, where the Roseires and Sennar dams produce 80% of the country's power. These dams also help irrigate the Gezira Plain, which is most famous for its high quality cotton. The region also produces wheat, and animal feed crops

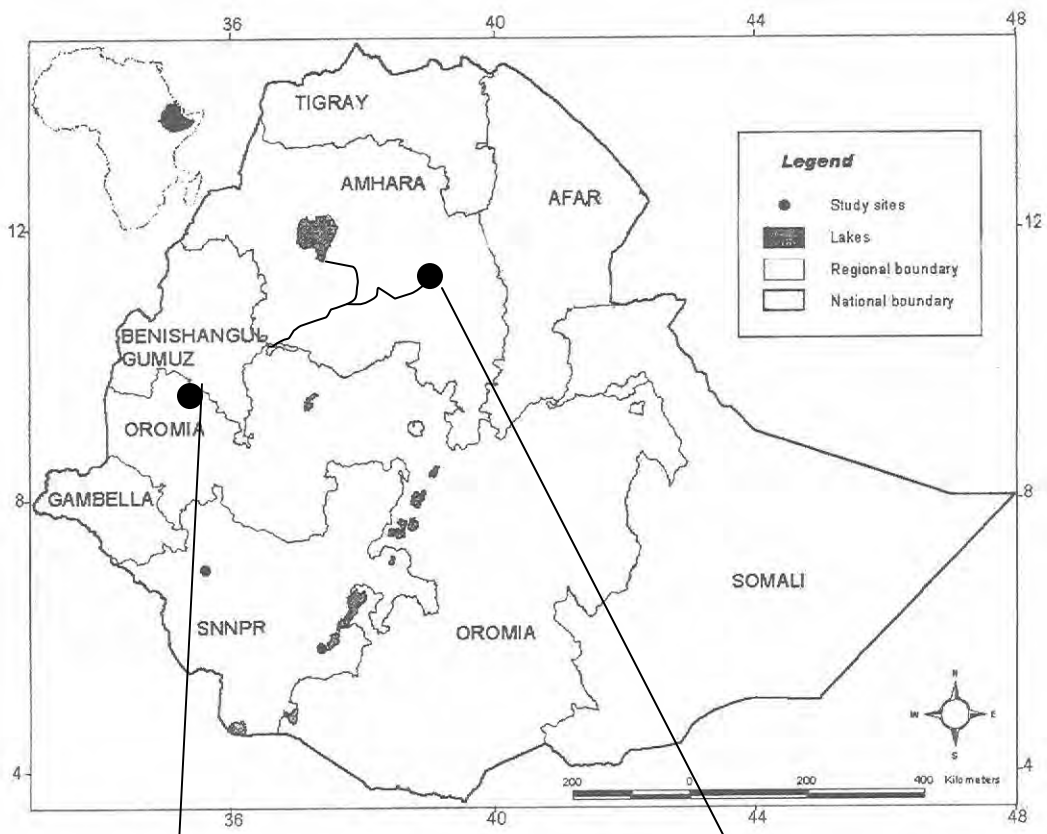
## **2.8. Few comments on riparian, swamp and riverine vegetation**

Carr (1998) described that detailed investigation of riverine vegetation in semi-arid Africa are poorly recognized in the literature. Riparian vegetation structural and functional alterations are now frequent in all parts of the world, especially through restoration programmes and anthropogenic uses. All these have come at a time when the species diversity of the riparian vegetation is not known, especially in Africa (Jude & Samuel, 2000). Ensermu Kelbessa *et al.* (1992) noted that the riparian & swamp vegetation in Ethiopia is not properly documented though there is a higher probability of finding endemic species.

## **3. Description of the study area**

The study covers the area along the Beschillo and Blue Nile rivers in the northern and western parts of Ethiopia. Beschillo, a tributary of Blue Nile, is located in Amhara Regional State, north Ethiopia. Its source starts at the foot of Magdala Selassie and Fala plateaus, 80 km NW of Dessie (11°25.232' N; 38°42.331' E) and joins the Blue Nile (11°02.121' N; 38°28.521' E) at about 143 km from the sources. Blue Nile originates from Lake Tana near Bahir Dar (11°38' N; 37°24' E). It generally flows south from Lake Tana and then west across Ethiopia and northwest into Sudan. Within 30 km of its source at Lake Tana, the river enters into a canyon of about 400 km long. This gorge makes the terrain difficulty for traveling. Along its course, Blue Nile forms the magnificent Tis Issat Falls at about 40 km from the origin at Lake Tana.

The Blue Nile covers a distance of 1,400 km from its source from Lake Tana to Khartoum, where it joins White Nile. Jamma, Muger, Dabus, Bolassa, Rahad and Dinder are other major tributaries of Blue Nile. Most of the water carried by the Nile originates from Ethiopia. The study area extends 437 km along Blue Nile starting from the place at where Bechillo adjoins the Blue Nile (11°02.121' N; 38°28.521' E) to Sirba Abay (10°07.492' N; 35°20.919' E) in Benishangul-Gumuz Rigional State. (See Fig. 1)



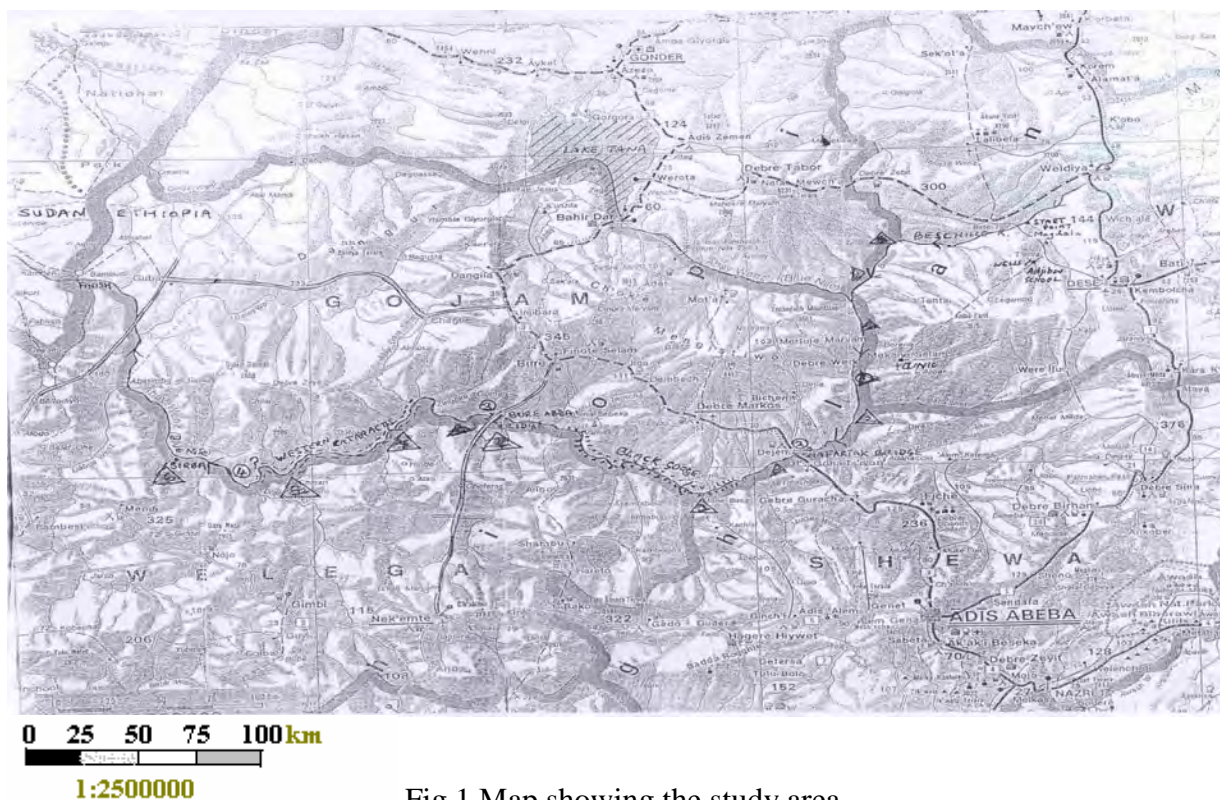


Fig 1 Map showing the study area

### 3.1. Climate

Three meteorological stations at different sites along the study area were selected. Tenta is the nearest station to Becshillo whereas Filiklek and Mendi are the nearest stations along the Blue Nile. The stations may not represent the actual study area but they may give some climatic clue, especially the mean monthly rainfall.

According to the National Meteorology of Ethiopia (NME, 2005) the following nearest stations to the study area have recorded the following climatic information. Temperature data has not been recorded at Tena yet. (See Table 1-3).

**Table1: List of stations, locations, altitude (m), mean annual rainfall (mm) and temperature ( $^{\circ}\text{C}$ )**

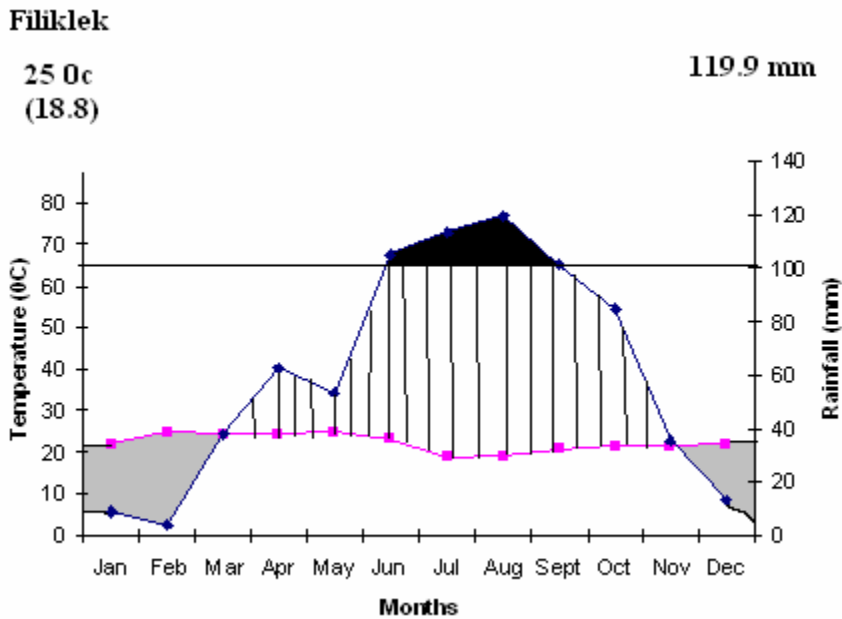
Stations	Long.	Lat.	Alt. (m)	Mean annual rainfall (mm)	Mean annual temperature ( $^{\circ}\text{C}$ )
Tenta	11 <sup>0</sup> 31'	38 <sup>0</sup> 18'	--	78.72	--
Filiklek	10 <sup>0</sup> 07'	38 <sup>0</sup> 08'	1790	91.93	21.1
Mendi	35 <sup>0</sup> 05'	09 <sup>0</sup> 47'	1650	253.46	21.5

**Table 2: Mean monthly rainfall amounts in mm**

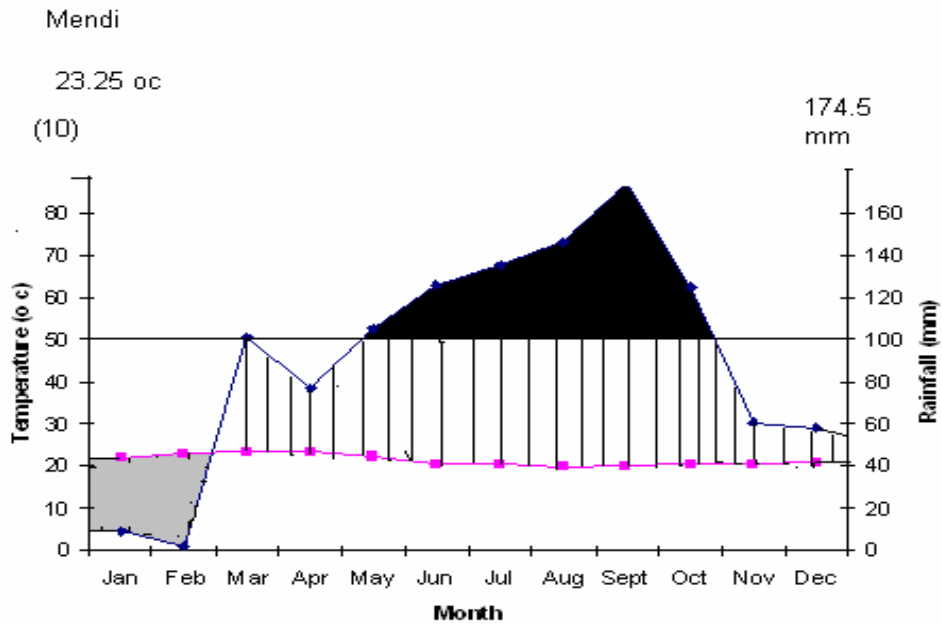
Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Tenta	11.2	20.0	68.6	49.2	42.7	13.8	340.2	320.1	43.9	9.8	12.8	12.3	1996-2005
Filiklek	8.8	3.7	37.7	63	52.3	153.9	236	299.5	112.3	85.1	37.7	13.2	1996-2005
Mendi	10.2	3.1	120.0	76.9	150.0	348.6	456.6	561.9	847.4	348.2	59.8	58.8	1996-2005

**Table 3: Mean monthly temperature in °C.**

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Filiklek	21.9	22.35	23.1	23	23.65	20.55	18.6	18.25	19.85	20.3	20.65	21.1	1996-2005
Mendi	22.1	21.9	23.6	24.25	22.35	21.5	20.0	20.1	20.2	20.45	20.6	20.7	1996-2005



**Fig.2. Climatic diagram of Filiklek**



**Fig. 3 Climatic diagram of Mendi**

Daniel Gemechu (1977) indicated that the highlands of Ethiopia where the rivers start are in general humid and rugged, while the low lands into which the rivers flow are in general arid and relatively flat.

### **3.2. Geology of the study area**

According to <http://www.aber.ac.uk/~quecwww/tana/geoloy.htm> underlying the Tertiary volcanics capping the Northwestern Plateau is a thick (>2 km) section of Mesozoic strata, including ca. 600 m of Late Jurassic-Early Cretaceous continental sediments. These are well exposed in Shewa Province in the Abay (Blue Nile) River Basin. The Lower Sandstone Unit of Blue Nile is primarily composed of sandstones with interbeds of siltstone, mudstone, and rare conglomerates that probably were deposited in a fluvial or deltaic environment. Throughout its history the Blue Nile, as with the whole Nile system has been greatly influenced by tectonic setting and relative sea level. Phases of the last 20,000 yrs of Nile history are summarized in table 4 & 5.

**Table 4: Major phases of Nile River System**

Period	Phase	Transgression/Regression	Climate	Main events
	Neo-Nile	—	wet-dry	—
Pleistocene	Pre-Nile	—	arid, cold	Sed sources switch to Ethiopia/Sudan
	Proto-Nile	—	cool/wet	Massive sediment input>>present time
L. Pliocene	Palaeonile	Transgression-Regression	warm/wet	
U. Miocene	Eonile	Regression	cooling	Erosion, Mediterranean shrinking and drying out

Source: <http://www.aber.ac.uk/~qecwww/tana/geology.htm>

*Table 5: Main archaeological phases of the River Nile*

Period	Age	Event
Diberia-Jer formation	20,750 BC	Rise of river. Fluival deposits are first true Nile sediments, 157m a.s.l. traces of drowned vegetation, U. Palaeolithic
Ballana Recession	17,200 BC	Local drought, wind erosion and dune formation. Sebilian industry. 133m a.s.l
Sahaba formation	12,550 BC	Rise to 20m above present flood plain, 147m a.s.l.
Recession	9000 BC	level drops to 129m a.s.l.
Arkin rise	7440 BC	Rise to 135m a.s.l. Arkin industry
Qadrus formation	3650BC	Neolithic. gradual fall of river level with fluctuations

Source: <http://www.aber.ac.uk/~qecwww/tana/geology.htm>

#### 4. Materials and methods

Reconnaissance survey of the Beschillo and Blue Nile riverine vegetation was conducted in the first two months of October 2005 in order to identify sampling sites along the two rivers. The initial site, which is located about 9 km down from the Beschillo Bridge, was selected as the highest altitude at 1324 m a.s.l and Sirba Abay as the lower altitude at 626

m a.s.l. The initial point is located at Beschillo River between Mekdela and Tach-Gayint 'woredas' in Amahara Regional State whereas Sirba Abay is located in Benishangul-Gumuz Regional State.

Vegetation data were collected between 24 October and 29 November 2005. During sampling, riverine and non-riverine vegetation were visually observed. Closed transects were laid out from riverbank to adjoining upland at 500 or 1000 m intervals along the rivers. Sample plots of 20 m x 20 m were delimited in 43 transects giving a total of 74 quadrants (2.96 ha). The number of plots in each transect was limited by the size of the riverine vegetation from the edge of stream to the adjoining upland. All vascular plant species present in sampling unit were recorded and percentage aerial cover/abundance of each species was estimated based on 1-9 scale of Braun-Blanquet (as modified by Van der Maarel, 1979): 1 = rare generally only one individual; 2 = sporadic (few) which are less than 5% cover of the total area; 3 = abundant with less than 5% cover of the total area; 4 = very abundant and less than 5% cover of the total area; 5 = 5-12% cover of the total area; 6 = 12.5-25% cover of the total area; 7 = 25-50% cover of the total area; 8 = 50-75% cover of the total area; 9 = 75-100% cover of the total area. Floristic analysis of herbaceous species was made on the average value of 5m x 5m subplots laid within the largest plot where the vegetation assumed to be representative. The number, height, DBH (diameter at breast height) >2.5 cm were documented for each tree individuals in the plots. The latitude, longitude and altitude of each sample plot were measured using GPS.

Each of the collected plant specimens was identified at National Herbarium (ETH), Addis Ababa University. Species nomenclature follows Hedberg & Edwards (1989), Edwards, Mesfin Tadesse & Hedberg (1995), Hedberg & Edwards (1995), Edwards, Sebsebe Demissew & Hedberg (1997), Edwards, Mesfin Tadesse, Sebsebe Demissew & Hedberg (2002), Hedberg & Edwards (2003), Hedberg, Edwards & Sileshi Nemomissa (2003), Mesfin Tadesse (2004).

#### 4.1. Statistical analysis

TWINSPAN (Two Way Indicator Species Analysis) and Hierarchical agglomerative classification: SYNTAX PROGRAM PACKAGE FOR MULTIVARIATE NUMERICAL ANALYSIS (Padoni, 1988) was applied in the multivariate analysis for classification and ordination. The percentage cover/abundance of each species was converted into 1-9 Braun-Blanquet scale. The converted data was used for multivariate numerical analysis followed by polythetic agglomerative classification. Individuals with greatest average similarities were fused into large groups. This process is known as average linkage.

The average cover/abundance value of each species in each cluster identified was computed and then characteristic species and local plant community types of the cluster were recognized.

The diversity of each cluster was calculated using Shannon-Weiner diversity index based on cover/abundance value of the species as input source. The relative Equitability (evenness) of the species in each cluster was also calculated.

$$\text{Diversity: } H' = - \sum_{i=1}^s p_i \ln p_i$$

$$\text{Equitability (evenness): } J = \frac{H'}{H'_{\max}} = \frac{- \sum_{i=1}^s p_i \ln p_i}{\ln S}$$

where  $H'$  is Shannon Index

$S$  = the number of species

$P_i$  = the proportion of individuals abundance of the  $i^{\text{th}}$  species

$\ln$  = log base  $e$

The vegetation data of the tree species were calculated and summarized on Access and Excel spreadsheet using the following formula.

- Density =  $\frac{\text{Total number of stems of all trees}}{\text{Sample size in hectare}}$

Sample size in hectare

- Relative density =  $\frac{\text{Number of individuals of tree species} \times 100}{\text{Total number of individuals}}$

- Relative frequency =  $\frac{\text{Frequency of tree species} \times 100}{\text{Frequency of all species}}$

- Basal area =  $\pi (d/2)^2$  where d is diameter at breast-height

- Relative dominance =  $\frac{\text{Dominance}^* \text{ of tree species} \times 100}{\text{Dominance of all species}}$

Where Dominance\* is mean basal area per tree times the number of tree species.

- Importance value =  $\text{Relative density} + \text{Relative frequency} + \text{Relative dominance}$

## 5. Result and Discussion

### 5.1. Floristic composition

A total of 205 species of vascular plants were recorded which belong to 53 families and 152 genera (see Appendix 1). Out of 205 identified species, 47.32% were herbs, 6.83% climbers, 22.44% shrubs, and 23.41% were trees. Out of 53 identified families and 152 genera, 12% were Poaceae, 10% Fabaceae, 5.4 % Acanthaceae, 4.9% Malvaceae and 4.4%

Tiliaceae were few of the dominant families. Poaceae and Fabaceae are the two most dominant families.

## **5.2. Tree species**

A total of 48 species belonging to 22 families and 35 genera with  $\geq 2.5$  cm DBH of trees individuals were recorded from 74 sample plots (2.96 ha); with Fabaceae having the highest number of species (10) followed by Moraceae (4), Bignoniaceae, Combretaceae and Sapotaceae (3 each). 340 trees individual were encountered of which 14.2% were *Anogeissus leiocarpa*, with the highest number of all tree species (see Appendix 2). There were 47 *Anogeissus leiocarpa* trees within 2.96 m<sup>2</sup>/ha. Other species such as *Sterculia africana* was 34 in number (10.3%); *Diospyros abyssinica* 25 (7.55%); *Acacia polyacantha* 25 (7.55%); *Acacia tortilis* 22 (6.65%) were the dominant species within the sample plots. *Allophylus rubifolius*; *Combretum adenogonium*; *Grewia mollis*; *Vangueria madagascariensis* were some of the rare species in the study area. *Anogeissus leiocarpa*, *Sterculia africana* and *Diospyros abyssinica* were the most common tree species in many sample plots along Blue Nile.

### **5.2.1. Vegetation structure**

#### **5.2.1.1. Tree density and DBH (Diameter at Breast-Height)**

The number of individuals whose DBH  $\geq 2.5$  cm was 115 per ha (see Table 6). *Anogeissus leiocarpa* occupied 18% of the total density and followed by *Sterculia africana* (10%), *Acacia polyacantha* (7.3%) and *Diospyros abyssinica* (7.1%). These trees were the most dominant species. It is obvious that the tree density of Beschillo and Blue Nile has little coverage and widely scattered relative to the study area.

Table 6: Distribution of trees in different DBH classes

DBH (cm)	Density ha <sup>-1</sup>	Percentage
≤ 10	7	6.1
10 < 20	12	10.4
20 ≤ 30	33	28.7
30 < 40	31	27.0
≥ 40	32	27.8

Table 6 above shows that 6.1% of tree individuals were in ≤ 10 cm DBH class. About 55.7% were within 20 ≤ 40 cm DBH and 27.8% > 40 cm DBH. There is a considerable increase in number of individuals with increasing DBH. The Blue Nile and Beschillo riverine vegetation is composed of high proportion of middle sized trees. *Ficus vasta* was the maximum of all trees that has an average DBH 97.5 cm (See appendix 4.).

#### 5.2.1.2. Basal area (BA)

The total basal area (BA) of tree species m<sup>2</sup>/ha was 12.6 (see Appendix 8). *Anogeissus leiocarpa*, *Sterculia africana*, *Ficus vasta*, *Acacia polyacantha*, *Trichilia emetica* and *Acacia tortilis* covered 48.31% of the total basal area (See Table 7). *Ficus vasta* possesses low density but high BA due to its maximum average DBH value. Five trees of this species contributed a total of 0.86m<sup>2</sup>ha<sup>-1</sup> (5.76%). The normal value of basal area (BA) for virgin tropical rain forest in Africa is 23 - 37 m<sup>2</sup> ha<sup>-1</sup> (Dawkins, 1959 cited in Lamprecht, 1989). Even though riverine forest is different from virgin tropical rain forest, one could expect less BA coverage present in this study area.

This comparison may indicate that the Blue Nile and Beschillo riverine vegetation composed of relatively few, dispersed and smaller sized trees. Most area of the sample plots was occupied by herbs and shrubs which were adapted to low altitude, high temperature, high seasonal flooding caused by overflowing of river, siltation and erosion.

Table 7: Dominant trees with their percentage basal area of Beshillo and Blue Nile vegetation

Species	Density	Average DBH (cm)	BA ha <sup>-1</sup>	Percentage
---------	---------	------------------	---------------------	------------

<i>Anogeissus leiocarpus</i>	47	36	2.56	20.2
<i>Sterculia africana</i>	34	46.8	1.52	6.79
<i>Ficus vasta</i>	5	97.5	0.86	5.76
			0.73	5.5
<i>Acacia polyacantha</i>	25	38		
<i>Trichilia emetica</i>	10	37.6	0.69	5.06
<i>Acacia tortilis</i>	22	40.5	0.64	5

### 5.2.1.3. Height and density

*Acacia robusta* was the tallest tree with maximum height attaining 26 m followed by 21 m, belonging to *Anogeissus leiocarpa* and *Acacia polyacantha*. The upper storey of the Beschilo and Blue Nile riverin tree individuals is 18 – 26 m, the middle storey 10 –15 m and the lower storey < 8 m. Table 8 shows stem number per hectare of species, number of species and ratio of individuals to species by storey (see Appendix 3).

Table 8: Stem number ha<sup>-1</sup>, species number and ratio of individuals to species by storey.

Storey	Stem No.per 2.96 ha <sup>-1</sup>	%	Species No.	%	Ratio of stem No. ha <sup>-1</sup> : Species No.
Upper	35	10	5	8	7: 1
Middle	231	68	30	47	8:1
Lower	74	22	29	45	2:1

The middle storey attains highest species compared to the lower and upper storeys. The upper storey has less species number. Some of the species were limited to the middle and the lower strata. Only four species (8%) reached the upper strata (the highest upper most canopy). These were *Acacia robusta*, *Acacia polyacantha*, *Anogeissus leiocarpa*, *Diospyros abyssinica*, and *Trichilia emetica*. The middle storey was 3 times denser than the lower storey. This indicates that over browsing, expansion of riverbank farm and seasonal flood may have destroyed many of the seedlings and young trees as well. The highest upper most canopy was formed by five species: *Acacia robusta*, *Anogeissus leiocarpa*, *Acacia polyacantha*, *Diospyros abyssinica*, and *Trichilia emetica*.

Some riverine vegetation of Blue Nile is conserved well where human activity is limited due to ragged topography, unfavorable temperature, malaria, robbers, remoteness from the main roads and villages, biting animals, (snake, crocodile, etc.), high flood during overflow, worshipping the river by some peoples.

The tree density of Beshillo and Blue Nile per ha was 115, which reveals that less density due to scattered tree coverage relative to shrubs and herbs. The problem was associated with expansion of farmland on the riverbank, over grazing & over browsing, seasonal flooding, fire, selective cutting for firewood and building material.

#### 5.2.1.4. Frequency

The five most frequent tree species in Blue Nile and Beschillo riverine vegetation were *Sterculia africana*, (13.5%), *Anogeissa leiocarpa* (12.7%), *Acacia tortilis* (5.71%), *Acacia polyacantha* (5.31%) and *Diospyros abyssinica* (5.31%) (See Appendix 5). About 5.33 % of tree species were not frequent occurring and thus they had clumped distribution. Few of these were *Allophylus rubifolius*, *Cordia sinensis*, *Erythrina abyssinica* and *Vitellia paradoxa*.

Frequency indicates an approximate homogeneity and heterogeneity of species. Lampright (1989) pointed out that high value in higher frequency and low value in lower frequency classes indicate constant or similar species composition whereas high value in lower frequency classes and low values in higher frequency indicate high degree of floristic heterogeneity. For convenience, the Beschillo and Blue Nile gallery trees has been classified into four frequency classes (see Table 9).

Table 9: Species frequency class of Beschillo and Blue Nile riverine trees.

	A	B	C	D
Frequency class	31-40	20-30	11-20	1-10
Sp. Frequency	2	0	4	42

The proportion of higher frequency value is  $A/C = (50\%)$  and the lower frequency value is  $C/D=(9.5\%)$ . Thus 50 % of the species were found in higher frequency class indicates that the gallery forest has homogenous species composition.

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

Curtis and McIntosh (1951) pointed out Important Value Index gives a more realistic figure of dominance from the structure standpoints. Lamprecht, (1989) also noted that The IVI is useful to compare the ecological significance of species. The five most dominant tree species of Beschillo and Blue Nile occupied 48% of the total important value index (see Appendix 7 & Table 10). Those dominant species were *Anogeissus leiocarpa*, *Sterculia africana*, *Acacia polyacantha*, *Acacia tortilis*, and *Diospyros abyssinica*. This figure shows that much of IVI was attributed by few species. These tree individuals were thought to be tolerant species that resist high pressure of flood caused by overflow of the rivers during raining seasons because they had very extensive root system and they were not readily removed by the flood. About 62.5% of tree species has IVI value less than 4 indicates that the requirement of conservation management. In terms of abundance, distribution and basal area, the contribution of *Anogeissus leiocarpa* and *Sterculia africana* were the highest of all tree species and accounted by 29%. These two species were the most frequent (26.2%) and they had highest BA ( $4.07\text{m}^2 \text{ha}^{-1}$ ) out of the total BA ( $12.62 \text{m}^2 \text{ha}^{-1}$ ). *Ficus vasta* had low relative frequency and density but high IVI value due to its highest BA. *Anogeissus leiocarpa* was 3 times more important than *Diospyros abyssinica*. Similarly *Sterculia africana* was 2 times more important than *Acacia tortilis* and so on.

Table10: Importance Value index of Tree species of Beschillo and Blue Nile Riverine Vegetation

Botanical Name	IVI
<i>Anogeissus leiocarpa</i> (A. Dc.) Guill. & Perr	52.3
<i>Sterculia africana</i> (Lour.) L.	35.53
<i>Acacia polyacantha</i> Wild	19.8
<i>Acacia tortilis</i> (Forssk.) Hay.	18.75

Botanical Name	IVI
<i>Diospyros abyssinica</i> (Hiern) F. White	16.72
<i>Maytenus senegalensis</i> (Lam.) Exell	12.25
<i>Acacia mearnsii</i> De Wild	11.31
<i>Trichilia emetica</i> Vahl	11.31
<i>Acacia etbaica</i> Schweinf.	10.12
<i>Pterocarpus lucens</i> Guill. & Perr	10.05
<i>Ficus vasta</i> Forssk	9.904
<i>Boswellia papyrifera</i> (Del.) Hochst.	9.001
<i>Kigelia africana</i> (Lam.) Benth.	8.478
<i>Zyziphus spina-christi</i> (L) Desef.	6.599
<i>Ficus glumosa</i> Del.	5.806
<i>Tamrindus indica</i> L.	5.153
<i>Boscia salicifolia</i> Olive.	5.052
<i>Zyziphus mucronata</i> Wild	3.584
<i>Acokanthera schimperi</i> (A. DC.) Schweinf.	2.888
<i>Lonchocarpus laxiflorus</i> Guill. & Perr.	2.887
<i>Bridelia scleroneura</i> Muell. Arg.	2.833
<i>Ficus sycomorus</i> L.	2.687
<i>Commiphora africana</i> Engl. ex Wild	2.645
<i>Acacia seyal</i> Del.	2.543
<i>Acacia persiciflora</i> Pax	2.422
<i>Diospyros mespiliformis</i> Hochst. ex A. DC.	2.397
<i>Pouteria altissima</i> (A. Chev.) Aubrev. & Pellgr.	2.39
<i>Celtis africana</i> Burm. f.	2.256
<i>Piliostigma thonningi</i> (Schum.) Milne-Redh	2.062
<i>Combretum adenogonium</i> Steud. ex A.Rich.	1.801
<i>Cordia africana</i> Lam.	1.674
<i>Combretum collinum</i> Fresen.	1.625
<i>Lannea fruticosa</i> (Hochst ex A. Rich) Engl.	1.456
<i>Dalbergia melanoxylon</i> Guill. & Perr.	1.451
<i>Gardenia ternipholia</i> Sch. & Thonn	1.451
<i>Malacantha alnifolia</i> (Bak.) Pierre.	1.439
<i>Ficus gnaphalocarpa</i> (Miq.) A. Rich.	1.006
<i>Stereospermum kunthianum</i> Cham.	0.819
<i>Lepidotrichilia volkensii</i> (Gurke) Leroy	0.779
<i>Allophylus rubifolius</i> (A. Rich) Engl.	0.77
<i>Cassia</i> sp.	0.77
<i>Erythrina abyssinica</i> Lam. ex DC.	0.77
<i>Moringa stenopetala</i> (Bark. f.) Cufod.	0.77
<i>Ritchiea albersii</i> Gilg	0.77

Botanical Name	IVI
<i>Vangueria madagascariensis</i> Gmel.	0.756
<i>Cordia sinensis</i> Lam.	0.733
<i>Grewia mollis</i> A. Juss.	0.723
<i>Vitellaria paradoxa</i> Gaerth.	0.71

### 5.2. 1.6. Species population structure

Different patterns of species population structure can indicate variation in population dynamics. The patterns are based on various size classes (DBH) and density. The variation, on the other hand, could arise from inherent characters, interventions of human, and livestock.

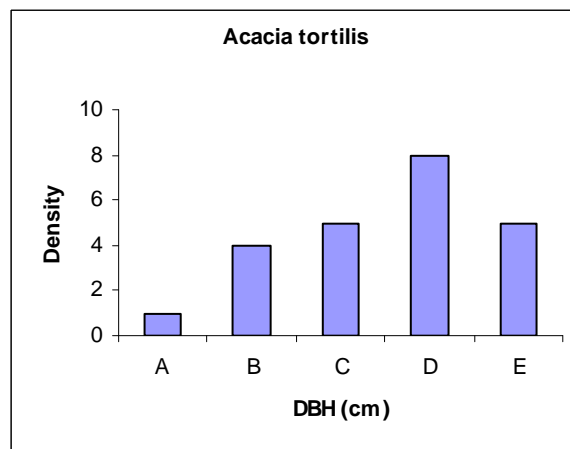
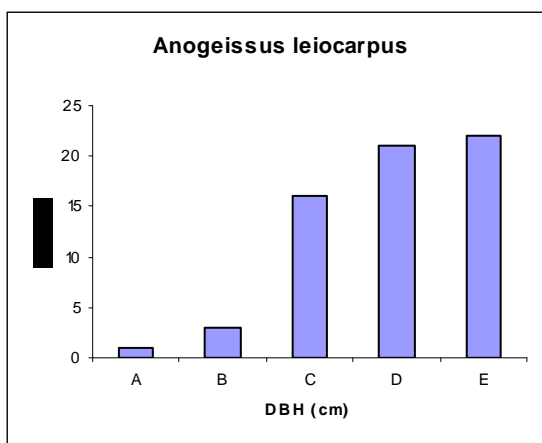
The six most important values of tree species representing 20 species in Beschillo and Blue Nile riverine vegetation whose IVI value > 12 are illustrated in Fig.4. The population structure of *Angeissus leiocarpa* shows a J- curve distribution. This species was found in all DBH classes and very common along the two rivers. It has poor regeneration and there are big individuals that have no potential to reproduce. The density increases as the DBH increase. *Acacia persiciflora*, *Kigelia africana*, *Celtis africana*, *Boscia salicifolia*, *Tamrindus indica* and *Pterocarpus lucens* and *Zyziphus spina-christ* also have J- curve population structure.

*Acacia polyacantha* and *Acacia tortilis* depict gauss type structure. The pattern indicates poor regeneration and recruitment due to environmental factors, human and livestock interventions; seasonal flooding caused overflowing of rivers, delta formation and erosion. Big trees whose DBH >30 cm were cut by the local people for construction as well as charcoal preparation. This problem was more exaggerated where the local people settled and areas near bridges of the main road. Similarly *Diospyros abyssinica* shows gauss-shape population structure with poor regeneration and good recruitment. This species inhabited riverbank nearest to the stream of Blue Nile. It has a good resistance to overflow

of the river flood during raining seasons. The local people selected and cut the trees for construction because of its hard wood. Other gausss shape includes *Acacia robusta* and *Ziziphus mucronata*.

*Sterculia africana* also shows gausss shaped population structure with poor regeneration. This species was common in both riverine area and adjoining upland along Beschillo and Blue Nile. It can resist draught and fire, and it is not used for construction material as such. Therefore, high density of this tree is found in the DBH class > 30 cm.

*Maytenus senegalensis* shows inverted J-curve population with good regeneration. This successful regeneration might be associated with its environmental adaptation. The density of this species increases with increasing diameter. The same structure is true for *Acacia etbaica*, *Acacia seyal*, *Acokanthera schimperi*, *Celtis africana*, *Boswellia papyrifera*, *Dalbergia melanoxylon* *Acacia robusta* and *Ficus glumosa*.



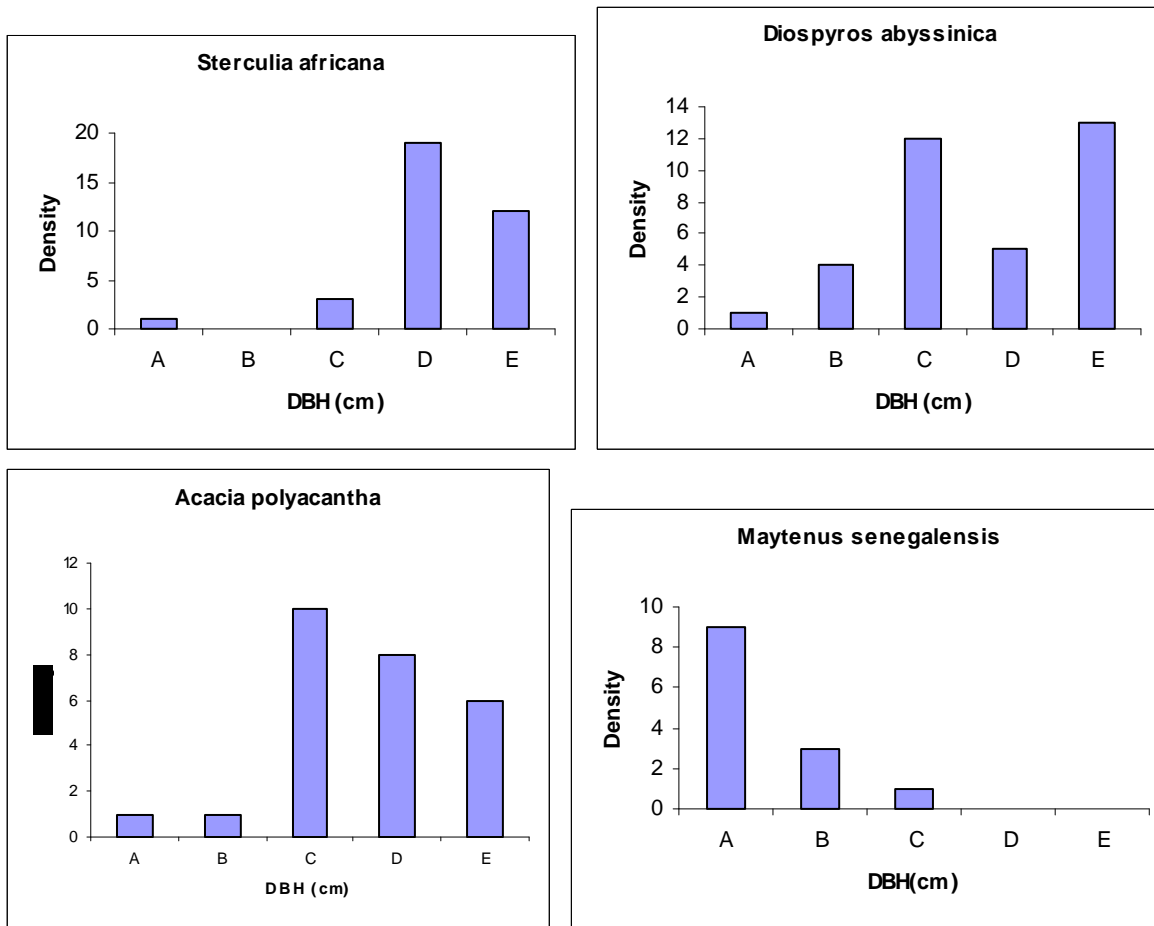


Fig 4. Species population structure of six important tree species in Beschillo and Blue Nile riverine vegetation; A = 2.5 – 10 cm; B = 10.1 – 20 cm; C = 20.1 – 30 cm; D = 30.1 – 40 cm; E = > 40 cm

### 5.3. Identification of Plant communities

Six clusters were identified from the output of TWINSpan (Two-Way Indicator Species Analysis), which represent the plant communities in Beschillo and Blue Nile riverine vegetation (see Table 11). The following plant communities have been named by two dominant species based on highest mean cover/abundance value that appears within a cluster. Priority is usually given to trees and shrubs. Description of the plant community types with their altitudinal distribution is written below.

#### I. *Acacia polyacantha* – *Pterocarpus lucens* community type

The dominant species of this type are *Acacia polyacantha* Wild and *Pterocarpus lucens* Guill. & Perr. *Pouteria altissima*, *Cordia africana*, *Malacantha alnifolia*, *Oxytenanthera abyssinica* and *Sesbenia sesban* are characteristic species in this type.

This community consists of 11 releves (0.44 ha) and 29 species. It is distributed between 718 m & 702 m a.s.l. *Pterocarpa lucens*, *Anogeissus leiocarpus*, *Ficus vasta*, *Malacantha alnifolia*, and *Aningeria altissima* are important trees layers. *Hyparrhenia dichroa*, *Achyranthes aspera*, *Setaria megaphylla* are dominant herbs in this community.

## II. *Anogeissus leiocarpa* - *Diospyros abyssinica* community type

This community type is distributed between 1079 m and 627 m. a.s.l. *Anogeissus leiocarpa* (A. DC.) Guill. & Perr and *Diospyros abyssinica* (Hiern) F. White are the dominant species in the tree layers. This community type contains 29 releves (1.16 ha) and 60 species. *Tamrindus indica*, *Zyziphus mucronata*, *Ricinus communis* and *Barleria grandis* are characteristic species in this type as shown in table 11. *Tamrix aphylla* and *Grewia bicolor* are shrub layers. *Xanthium stromarium*, *Hyparrhenia dichroa* and *Hyparrhenia dissolute* are the dominant herbs. *Tamrindus indica*, *Sterculia africana*, *Ficus glumosa* are trees abundant in this type. *Boswellia papyrifera*, *Grewia villosa*, and *Kigelia africana* are well represented in this type. *Luffa cylindrica* is one of the lianas in this community type.

## III. *Sterculia africana* - *Grewia bicolor* community type

This community is distributed in the altitudinal range between 1153 m & 775 m.a.s.l. It contains 18 releves (0.72 ha) and 50 species. *Sterculia africana* (Lour.) L. and- *Grewia bicolor* Juss. are the dominant species. *Acacia persiciflora*, *Acanthospermum hispidum* and *Capparis tomentosa* are characteristic species in this community type as shown in table 11. *Acacia etbaica*, *Acacia persiciflora*, *Boswellia papyrifera*, *Maytenus senegalensis*, are frequent trees. *Grewia bicolor*, *Barleria prionitis*, *Dichrostachys cinerea*, *Cadaba farinosa* are the most abundant shrubs whereas *Hypoestes forskali*, *Peristrophe paniculata*,

*Chloris gayana* & *Leucas marticensis* are dominant herb layers. *Cissus quadrangularis* is dominant liana in this type.

#### IV. *Acacia tortilis* - *Dichrostachys cinerea* community type

This type is distributed between 1124 m & 626 m.a.s.l. The dominant species are *Acacia tortilis* (Forssk.) Hay and *Dichrostachys cinerea* (L.) Wight & Arn. This community type consists of 10 plots (0.4 ha) and 48 species. *Dalbergia melanoxylon* is characteristic species. *Ziziphus spina-christi* and *Sterculia africana* are most frequent tree layers. *Grewia bicolor*, *Dichrostachys cinerea*, *Grewia villosa*, and *Barleria prionitis* are the dominant shrubs whereas *Nicandra physaloides*, *Commelina latifolia*, *Chloris gayana* and *Xanthium strumarium* are the most dominant herbs.

#### V. *Setaria megaphylla* – *Perisophe paniculata* community type

This community is distributed between 1328m & 1137m a.s.l. It consists of 3 relevés (0.12 ha) and 7 species only. *Setaria megaphylla* (Steud.) Th. Dur. & Schinz and *perisophe paniculata* (Forssk.) Brummitt are the dominant species in this type. *Biden pilosa* is common herb in this community type. *Grewia bicolor* is the only shrub found in very less frequent and there is no tree in this community type.

#### VI. *Sorghum arundinaceum*– *Cenchrus ciliaris* community type

This community is distributed between 1328m & 1137m.a.s.l. It is represented by 3 relevés (0.12 ha) and 11 species. The dominant species are *Sorghum arundinaceum* (Desv.) Stapf. and *Cenchrus ciliaris* L. Neither in this community type are characteristic. Other species such as *Ximenesia americana*, *Sida Alba*, *Maerua oblongifolia* are shrub layers in very less frequent in this type.

Table 11: TWINSpan output of Beschillo and Blue Nile riverine vegetation

	I	II	III	IV	V	VI	
	55556665555	26666633344223344444455667777	442222213121133311	0000010137	011	002	
	23980124567	27345948901380645678901680123	234567957408912367	1246819254	703	351	
6 Acac poly	32-2-3333-3	--33-----3-----2--	-----3-----	-----	---	---	000000
14 Anin alti	--22--2----	-----	-----	-----	---	---	000000
41 Cord afri	--232-----	-----	-----	-----	---	---	000000
68 Mala alni	-----223-	-----	-----	-----	---	---	000000
73 Oxyt abys	-----211-	-----	-----	-----	---	---	000000
78 Phra kark	----2---44	--333-----	-----	-----	---	---	000000
80 Ptro luce	--32333---	-----	-----	-----	---	---	000000
84 Sesb sesb	-----222-	-----	-----	-----	---	---	000000
85 Seta mega	---3422---	-----3-----	-----	-----	---	---	000000
96 Tric emet	---32---33	-----3-----23--	-----	-----	---	---	000000
52 Ficu vast	-----33--	-----3-3-----	-----	-----	---	---	000001
74 Pava tasp	-----21	-----2-----	-----	-----	---	---	000001
86 Seta vert	--4-----	-----24---	-----	2-----	---	---	000001
58 Hypa dich	---322344--	--2--34233--233332444-3-44-	-----23-----	-----3-	---	---	000010
65 Luff cyli	2-----	-----1111	-----	-----	---	---	000010
13 Ampe schi	-----	-1--1-----1---	-----	-----	---	---	000011
15 Anog leio	--3--3---23	3333-3-3233-333333333333233	-----3-----	-----	---	---	000011
16 Arun dona	-----	-----1-----12-----	-----	-----	---	---	000011
21 Barl gran	-----	-----111	-----	-----	---	---	000011
26 Brid scle	-----	-----222-----	-----	-----	---	---	000011
31 Celt afri	-----	-----222-----	-----	-----	---	---	000011
34 Ciss peti	-----	-----111-----	-----	-----	---	---	000011
36 Cler capi	-----	-----111-----	-----	-----	---	---	000011
47 Dios bulb	-----	3-222-----	-----	-----	---	---	000011
49 Dios mesp	-----1-	--3-----3-----	-----	-----	---	---	000011
62 Kige afri	-----	-----3-----2---333-	-----	-----	---	---	000011
79 Pseu flav	-----	--111-----	-----	-----	---	---	000011
81 Rici comm	-----	--2-21-----	-----	-----	---	---	000011
93 Taca veno	-----1	---2-----2-----	-----	-----	---	---	000011
94 Tamr indi	-----	-333-33-----	-----	-----	---	---	000011

99	Zizm mucr	-----3-----333-----	-----	-----	-----	000011
97	Xant stro	-----1- -23-33---23-3-3333-1113-----	-----3-----2-----	-----322-----	-----1-	00010
19	Balp made	-----1--2-----	-----1-----	-----	-----	000110
43	Cycr macr	-----1--2-----	-----1-----	-----	-----	000110
48	Dios abys	-----3---33-33-3-33-3-----	-----3---22-----2-----	-----	-----	000110
2	Abut bide	-----121-----	-----2-----	-----	-----	000111
12	Amar grae	-----21--1-----	-----	-----2-----	-----	000111
18	Asys tadi	-----11-----	-----1-----	-----	-----	000111
51	Ficu glum	-----3-3-3--3-----	-----3-----	-----3-----	-----	000111
57	Hibi sura	-----1-----	-----1-----	-----1-----	-----	000111
59	Hypa diss	-----21--1211---121---11-1--13	43-----21--1-----	-----	-----	000111
60	Hypo fors	332-----2-----3-----	-----2-----3-3-3-1-----	-----	-----	000111
82	Sens abys	-----11-----	-----1-----	-----	-----	000111
88	Sorg arun	-----1-----22-----	-----12-----	-----4-----	-----	000111
90	Sper chae	-----1-1-----	-----1-----	-----	-----	000111
95	Tamx aphy	-----1-----1---2---3---	-----32-----	-----	-----	000111
9	Achi aspe	2-12--111--	-----2-----21-----21---	-----3-2--2-3---	-----	001000
20	Barl acan	-----2-----	-----1-----	-----2-----	-----	001000
10	Acok schi	-----2-----	-----11-2-----	-----	-----	001001
25	Bosw papy	-----22-2-----	-----2-2--3222--3-----	-----	-----	001001
38	Comb aden	-----2-----3-----	-----4-----	-----	-----	001001
91	Ster afri	-----2-----3-3-33---23-33-32-33323	32--2-223-2223322	-----3---232-----	-----	001001
3	Acac etba	-----3-----3---2-----	-----233333-3-----	-----	-----	001010
4	Acac robu	-----333-----	-----33--33343-----	-----	-----	001010
5	Acac pers	-----	-----32--3-----	-----	-----	001010
27	Cada fari	-----1-----	-----2--222--31--2	-----2-----	-----	001010
28	Calo proc	-----22-----	-----2--2-----112-----	-----	-----	001010
30	Capp tome	-----	-----2-2-1---22-----	-----	-----	001010
35	Ciss quad	-----2--2-1-----	-----3-32-3-222--1-	-----	-----	001010
37	Clim euph	-----	-----2-----2--1---	-----	-----	001010
50	Dreg abys	-----	-----2-3-----	-----	-----	001010
55	Grew vill	-----222-----2-----	-----1--222-----	-----2-22-32---	-----	001010
64	Leuc mart	-----2---1---2---	-----1-2-22--1	-----12--1---	-----	001010
69	Mayt sene	-----222--	-----21-2--12-12--2	-----	-----	001010
71	Osim amer	-----	-----3-2-----	-----2---	-----	001010
72	Osim urti	-----	-----22---	-----1-----	-----	001010
7	Acac seya	-----	-----3-2-----	-----3---	-----	001011
8	Acac tort	-----	-----3-3-----3--32	333333333-	-----	001011
11	Aera lant	-----	-----1-2-----	-----1-1-1---	-----	001011
22	Barl prio	-----1-----	-----2--2-2--12-2	-----2-11-2--1---	-----	001011
24	Bosc sali	-----	-----3-----2-	-----3-2-----	-----	001011
29	Cami afri	-----	-----22---	-----2-2-----	-----	001011
32	Cham nigr	-----	-----22---	-----2-----	-----	001011
33	Chlo gaya	-----3-----	-----3-233---32	-----3143--2---	-----	001011
39	Comm imbe	-----	-----2--22---	-----	-----	001011
40	Comm lati	-----	-----2-31-22---	-----	-----	001011
42	Cucu dips	-----1-----	-----21---1-	-----122---	-----	001011
44	Dalb mela	-----	-----	-----111-----	-----	001011

I II III IV V VI

45	Datu stra	-----1-----	-----	-----11-----	-----	001011
46	Dich cine	-----2-----	-----22--1--1---	-----23-33-3-3-	-----	001011
54	Grew flav	1-----	-----1-----	-----122---	-----2-2-2---	001011
56	Heli subu	-----	-----	-----122---	-----	001011
61	Just cord	-----	-----	-----1--12---	-----2---	001011
63	Lanc laxi	-----	-----3-----	-----22---	-----	001011
66	Lycu escu	-----	-----	-----111---	-----	001011
70	Nica phys	-----	-----	-----23111-1---	-----	001011
100	Zizs spin	-----	-----	-----3-3323-	-----	001011
53	Grew bico	22-----	-----2--32-222222---	23223-332---3-222	-----22222--2--	0011
23	Bide pilo	-----	-----2-----	-----1-----3-----	3-23332---	111 0100
1	Abel escu	-----	-----	-----1-11-----	-----1-	01010
17	Aspi cili	-----	-----	-----1-11-----	-----1--	01010
67	Maer obli	-----	-----	-----111-----	-----1--	01010
75	Penn pedi	-----	-----	-----111-----	-----1--	01010
76	Penn poly	-----	-----	-----112-----	-----1--	01010
87	Sida alba	-----	-----	-----111-----	-----1--	01010
98	Xime amer	-----	-----	-----11-----	-----1--	01011
77	Peri pani	-----22---1-1-1---	-----22---	-----2---2--32-2--	2-1223---	1 011
83	Seta mega	-----	-----	-----	323 ---	1
89	Sorg arun	-----	-----	-----	33- 444	1
92	cenc cili	-----	-----	-----11-----	11 221	1

```

00000000000 0000000000000000000000000000000 000000000000000000 0000000000 111 111
00000000000 0000000000000000000000000000000 1111111111111111111 1111111111 000 111
00000000000 111111111111111111111111111111111 0000000000000000000 11111111111
00111111111 0000001111111111111111111111111 000000000111111111 0000000001
000001111 0011110000000000000000001111 001111111001111111 000000001
01111 00000111111111111111100001 0000011 0000011 00000011

```

I, II, III, IV, V & VI represent Community types

Table 12: Synoptic cover-abundance value for species reaching a value of > 0.67 in atleast one community type; value in bold refers to characteristic species

<b>Species</b>	<b>C-1</b>	<b>C-2</b>	<b>C-3</b>	<b>C-4</b>	<b>C-5</b>	<b>C-6</b>
<i>Malacantha alnifolia</i>	1.5	0	0	0	0	0
<i>Ficus vasta</i>	1.27	0.48	0	0	0	0
<i>Luffa cylindrica</i>	0.36	0.24	0	0	0	0
<i>Amaranthus graecizans</i>	1.64	0.59	0	2.3	0	0
<i>Phragmites karka</i>	2	0.66	0	0	0	0
<i>Acacia polyachanta</i>	<b>4.55</b>	0.79	0.33	0	0	0
<i>Pterocarpus lucens</i>	2.64	0	0	0	0	0
<i>Trichila emetica</i>	2.36	0.59	0	0	0	0
<i>Setaria megaphylla</i>	2.27	0.21	0	0	0	0
<i>Anogeissus leiocarpa</i>	2.27	<b>5.76</b>	0.39	0	0	0
<i>Hyparrhenia dichroa</i>	3.73	4.52	0.67	0.7	0	0
<i>Xanthium strumarium</i>	0.18	2.76	0.61	1.5	0	0
<i>Diospyros abyssinica</i>	0	1.97	1.17	0	0	0
<i>Tamrindus indica</i>	0	1.1	0	0	0	0
<i>Kigelia africana</i>	0	1.03	0	0	0	0
<i>Ficus glumosa</i>	0	0.93	0.39	0.7	0	0

<i>Barleria prionitis</i>	0	0.07	1.39	1.4	0	0
<i>Acacia etbaica</i>	0	0.62	2.39	0	0	0
<i>Acacia robusta</i>	0	0.62	2.94	0	0	0
<i>Sterculia africana</i>	0.45	3.07	<b>3.83</b>	2.3	0	0
<i>Grewia bicolor</i>	0.82	1.76	3.78	2.5	1.67	0
<i>Boswellia papyrifera</i>	0	0.86	1.56	0	0	0
<i>Cissus quadrangularis</i>	0	0.34	2.22	0	0	0
<i>Hyparrhenia dissoluta</i>	0	1.38	1.44	0	0	0
<i>Cadaba farinosa</i>	0.1	0	2	0.5	0	0
<i>Hypoestes forskali</i>	1.73	0.55	1.22	0	0	0
<i>Acacia tortilis</i>	0	0	1.83	<b>6.4</b>	0	0
<i>Achyranthes aspera</i>	1.64	0.59	0	2.3	0	0
<i>Chloris gayana</i>	0	0.21	2	3.1	0	0
<i>Dichrostachys cinerea</i>	0	0.17	0.83	3.6	0	0
<i>Grewia flavescens</i>	0.18	0.07	0.67	1.4	0	0
<i>Grewia villosa</i>	0	0.59	0.89	2.4	0	0
<i>Ziziphus spina-christi</i>	0	0	0	3.3	0	0
<i>Peristrophe paniculata</i>	0	0.83	1.06	2.1	5.67	0.7
<i>Setaria megaphylla</i>	0	0	0	0	<b>6.33</b>	0
<i>Biden pilosa</i>	0	0.1	0.56	3.2	0.67	2
<i>Ximania americana</i>	0	0	0	0.3	0.7	0
<i>Sorghum arundinacium</i>	0	0	0	0	4.67	<b>9</b>
<i>Pennisetum polystachyon</i>	0	0	0	0.6	0	0.7
<i>Cenchrus ciliaris</i>	0	0	0	0.3	1.33	3.2
<i>Abelmoschus esculentus</i>	0	0	0	0.6	0	0.7
<i>Maerua oblingifolia</i>	0	0	0	0.4	0	1
<i>Pennisetum polystachyon</i>	0	0	0	0.4	0	1

#### 5.4. Species diversity

Table 13: Shannon-Weiner Diversity Index (H') and evenness (J) for the six community types of Beshillo and Blue Nile Riverine Vegetation

SHANNON-WEINER DIVERSITY INDEX OF SPECIES				
Community type	No. of spp.		H'	Evenness (J)
I	29		2.962	0.880
II	60		3.475	0.849
III	50		3.553	0.908
IV	48		3.503	0.905
V	7		1.566	0.805
VI	11		1.706	0.712

Where I = *Acacia polyacantha* - *Peterocarpus lucens* type  
 II = *Anogeissus leiocarpa* - *Diospyros abyssinica* type

III = *Sterculia africana* - *Grewia bicolor* type

IV = *Acacia tortilis* - *Dichrostachys cinerea* type

V = *Setaria megaphylla*- *perisrophe paniculata* type

VI= *Sorghum arundinacium* –*Cenchrus ciliaris* type

The Shannon-Wiener Diversity computed for six different communities (Table 12) shows that community type III is the most diverse and has even distribution of species indicating that the vegetation is expected to be natural with less human intervention. Community type II has the highest number of species with less diversity index value compare to community type II and IV. Community type VI has the least even diversity due to the dominance of *Sorghum arundinacium*. Magurran (1988) stated that the term diversity actually consists of species richness and relative abundance (evenness or unevenness). Therefore, community type II is the highest in species richness whereas community type IV is the least one. According to Kent and Coker (1992), the Shannon Weiner index is the most frequently used for the combination of species richness and relative abundance. A value of the index of Shannon-Weiner usually lies between 1.5 and 3.5 although in exceptional case, the value can exceed 4.5 (Pielou, 1969). Thus, the value of Shannon - Wiener Diversity Index of this study area occurs between 1.503 and 3.553. The higher the value of J, the more even the species is in their distribution. Thus, community type III has the highest even distribution whereas community type VI has the least even distribution.

## 6. Conclusion

The analysis of floristic data on Beschillo and Blue Nile riverine vegetation between altitudinal gradients of 1324 and 626m indicated the presence of higher species diversity. A total of 205 species belonging to 152 genera and 53 families were recorded, of which 47.32% were herbs, 6.83% climbers, 22.44 % shrubs and 23.41% were trees. The stream corridors of Beschillo and Blue Nile are exceptionally diverse environmentally and normally support high species richness. *Anogeissus leiocarpa*, *Diospyros abyssinica*, *Xanthium strumarium*, *Tamrix aphylla*, *Peristrophe paniculata*, *Ficus sycomorus*, *Acacia polyacantha*, *Hyparrhenia dichroa*, *Chloris gayana* were some of plant species, which successfully inhabit in the study area.

The total density of tree stems per hectare was 115 indicating that the vegetation of Beschillo and Blue Nile has been found to possess scattered tree individuals that dominated by grasses and shrubs. *Anogeissus leiocarpa*, *Sterculia africana*, *Acacia tortilis*,

*Acacia polyacantha*, *Diospyros abyssinica* were the most frequent and dominant tree species.

The total BA (Basal Area) of trees whose DBH >2.5 cm was 12.6 m<sup>2</sup> ha<sup>-1</sup>. This value is supposed to be low basal area coverage in Beschillo and Blue Nile riverine vegetation. 48% of IVI was attributed by *Anogeissus leiocarpus*, *Sterculia africana*, *Acacia polyacantha*, *Acacia tortilis*, and *Diospyros abyssinica*. These species were also important in ecological significance since they had highest IVI (Important Value Index). About 62.5% of tree species have IVI value less than 4 indicating that they require proper conservation and management. *Lepidotrachia volkensis*, *Allophylus rubifolius*, *Erythrina abyssinica*, *Moringa stenopetala*, *Ritchiea albersii*, *Vangueria madagascariensis*, *Cordia sinensis*, *Grewia mollis* and *Vitelaria paradoxa* are the most significance species in this case.

The tolerant species established on the flood plains and riverbank resist seasonal flooding and water logging have extensive root system. *Diospyros abyssinica*, *Anogeissus leiocarpa*, *Tamrix aphylla*, *Ficus glumosa* were significant examples of tolerant species on riverbank along Beschillo and Blue Nile riverine vegetation. *Xanthium strumarium* and *Ricinus communis*, on the other hand, were common opportunistic species. These opportunistic species are usually affected and readily eliminated by flood disturbance during raining seasons.

Structural description indicates the dominance of medium sized and limited occurrence of small trees & largest tree individuals. *Acacia robusta* was the tallest of tree with maximum height attained 26m. From the viewpoint of population structure analysis most tree species were in poor regeneration and recruitment level. The main causative agent was anthropological activities.

Cluster analysis resulted in six plant community types at altitude between 1324 and 626 m): *Acacia polyacantha* - *Pterocarpus lucens* type; (II) *Anogeissus leiocarpus* - *Diospyros abyssinica* type; (III) *Sterculia africana* - *Grewia bicolor* type; (IV) *Acacia tortilis* -

*Dichrostachys cinerea* type; (V) *Setaria megaphylla* – *Perisprope paniculata* type and (VI) *Sorghum arundinaceum*– *Cenchrus ciliaris* type. Community type III is the most diverse whereas community type V is the least diverse of plant species. On the other hand, community type III has highest even distribution whereas community type VI has the least even distribution of species. Highest species richness was recorded in community type II. Least diversity and even distribution was recorded in cultivated riverbank represented by community type V and VI

Clearing forest for cultivation, fire, overgrazing and over browsing by domestic stocks are the most common impacts that result in change on the vegetation composition and structure along Beschillo (in Amhara Regional State) and Blue Nile (in Benishangul Gumuz Regional State). The valley and plains surrounding Beschillo are now intensively cultivated. Teff and sorghum are grown while cattle and goats graze the slopes along riverine vegetation. Only a few trees remain owing to the huge demand for firewood and building materials.

The Blue Nile riverine vegetation is well conserved in parts where there are no human settlements due to natural barriers (topography, temperature, remoteness, malaria, etc.). Gumuz people have intensively and moderately cultivated the remaining portions of the riverbank. Cotton, sesames and maize are the main cultivated crops when the size of the river flow decreases seasonally.

### *6.1. Recommendations*

Analysis of Important Value Index and species structure shows that some important tree species including *Acacia species* and *Diospyros abyssinica* are in poor regeneration and recruitment conditions due to over browsing, fire, expansion of farmland, selective cutting owing to high demand for firewood and building materials. This indicates that the need of proper conservation measures by the relevant authorities.

Many local farmers confidentially explain that the time requirement for seed germination, regeneration and recruitment of many plant species in the study area. They also have good idea about the ecological importance of vegetation. This indigenous knowledge should be integrated with modern studies such as Ecology.

As one goes down the Blue Nile stream the topography becomes flattened and flattened. At the same time the amount of water in the river increases (even 47m depth) indicating that the presence of high irrigation potential. Irrigation in relevant area can minimizes the farm activities on riverbank, thereby the riverine vegetation will get a chance of rehabilitations and protections if the local people aware and actively participated in irrigation program.

Blue Nile has significant Eco-tourism potential. The pressure of anthropogenic activities on the riverine vegetation can be minimized to some extent if the local people are benefited from eco-tourism income. For example, traveling by boat, the landscape, wild animals, the green vegetation, the local people and their culture are very attractive to tourists. Vervet monkeys, baboons, wild dogs, lesser kudus, warthogs, and variety of birds are common in the corridors of riverine vegetation. On the other hand, Hippopotamus, Crocodiles and varieties of fishes are also common in the river. *Ficus species* and *Diospyros abyssinica* are keystones for baboons, monkeys and birds.

Blue Nile has been found to possess scattered trees dominated by grass and shrubs. This floristic composition is supposed to be susceptible to fire. During dry season, the local people deliberately burn the vegetation every year for their own benefits as mentioned in the introduction. Thus the local people should be aware about protection and sustainable way of utilization of the riverine vegetation supported by rule and regulation.

Finally, further studies are required to fill the gap of this work such as analysis of soil sampling.

## 7. References

- Abrahamson, N.G. (1984). Species response to fire on Florida Lake Wales Ridge. *American Journal of Botany* 71: 35-45.
- Bohlen, C.C. and King, D.M. (1996). Ecological principles of riparian buffer functions. Center for Environmental and Estuarine pages. Studies. Technical Contribution UMCEES-CBL-96-161. University Maryland, College Park, Md. 24
- Bornette, G. and Amoros, C. (1991). Aquatic vegetation and hydrology of a braided river flood plain. *Journal of Vegetation Science* 2: 407-412.
- Carr, C. J. (1998). Patterns of vegetation along the Omo River in southeast Ethiopia. *Plant Ecology* 135: 135-163.
- Castella, E., Richardotcoulet, M., & Rschoux, P. (1984). Macroinvertebrates as 'describers' of morphological and hydrological types aquatic ecosystem abandoned by the Rhone River. *Hydrobiologia* 119: 219-225.
- Compton, B.B., Mackie, R.J. and Dusek, G.L. (1988). Factors influencing distribution of white-tailed deer in riparian habitats. *Journal of Wildlife Management* 52:544-548.
- Colombian Electronic Encyclopedia (2000). Six edition. Houghton Mifflin Publishing Company. (<http://www.answer.com>).
- Connell, J.H. (1978). Diversity in tropical rain forest and coral reefs. *Science* 199:1302-1310.
- Curtis, J.T., and McIntosh, R.P. (1951). An upland forest continuum in the Prairie- forest border region of Wisconsin. *Ecology* 32: 476-496.
- Daniel Gemechu (1977). Aspects of Climate and Water Budget in Ethiopia. Addis Ababa University Press. pp 71.
- Demel Teketay (1999). Achievement and constraints in Forest Genetic Resource conservation. In: Edwards, S., Abebe Demisse, Taye Bekele and Haase, G. (eds). Forest Genetic Resource Conservation. IBCR & GTZ, Addis Ababa.
- Drago, E.C. (1996). Origin y classification de ambientes leniticosen llanuras aluviales. Revista Asociacione Ciencias. *Naturales Literacias* 7: 123-137.

- Dugan, P.J. (Ed.) 1989. Wetland conservation: a review of current issue and required action. IUCN, Gland, Switzerland.
- Edwards, S. Sebsebe Demessew & Hedberg, I. (eds.) (1997). Flora of Ethiopia and Eritrea, Vol. 6. Hydrocharitaceae to Arecaceae. Addis Ababa, Ethiopia and Uppsala, Sweden.
- Edwards, S., Mesfin Tadsse & Hedberg, I. (eds.) (1995). Flora of Ethiopia and Eritrea, Vol.2, 2. Canellaceae to Euphrbiaceae. Addis Ababa, Ethiopia & Uppsal, Sweden.
- Edwards, S., Mesfin Tadesse, Sebsebe Demissew and Hedberg, I. (eds.) (2000). Flora of Ethiopia and Eritrea. Vol. 2, 1. Magnoliaceae to Flacourtiaceae. Addis Ababa, Ethiopia and Uppsela, Sweden.
- Ethiopian Forest Action Program (1994). Volume I, II, III and IV. Final report, MoNRDEP, EFAP Secretariat, Addis Ababa.
- Ethiopian Mapping Agency (1988). *National Atlas of Ethiopia*, Ethiopian Mapping Agency, Addis Ababa pp 76.
- Ensermu Kelbssa, Sebsebe Demissew, ZerihunWoldu & Edwards, S. (1992). Some threatened endemic plant of Ethiopia. MONOGRAPH SERIES 2: 35-65.
- Ewusie, J.Y. (1980). Element of Tropical Ecology. With Reference to African, Asian, Pacific and New World Tropics. Heimemann Educational Book, Ltd, London. 346 pp.
- Friis, I. (1992). Forest and Forest Trees of Northeast Tropical Africa: Their Natural Habitats and Distribution Patterns in Ethiopia, Djibouti, and Somalia. *Kew Bulletin, Additional Series XV*: HMSO, UK, pp 40-41.
- Ger, B., Jan, P.B., Renee M., Jan, M., Van, G. and Martin, S. (2003). Plant dispersal in low land stream in relation to occurrence and three specific life-history traits of the species in the species pool. *Journal of Ecology*, 91: 855-866.
- Giller P. and Malmquist B. (1998). The Biology of Stream and Rivers. Oxford University Press, New York, pp 296.
- Godreau, V. (1998). Biodiversity in the flood plane of stone: A global approach. *Biodiversity and conservation* 8: 648:839.
- Goldsmith, F.B. and Harisson, C.H. (1976). Description and Analyssis of Vegetation. In: *Methods in Plant Ecology* (Champman, S.B. ed.) pp 85 – 155. Blackwell Scintific Publications, London.
- Groombridge, B. (1999). Global Biodiversity: Status of Earth's Living Resource. Conservation Monitory Center, London, 585 pp.

- Hedberg, I. & Edwards, S. (eds.) (1989). Flora of Ethiopia, Vol. 3. Pittosporaceae to Araliaceae. Addis Ababa and Asmara, Ethiopia & Uppsala, Sweden.
- Hedberg, I. and Edwards S. (eds.) (1995). Flora of Ethiopia and Eritrea, Vol. 7. Poaceae. Addis Ababa, Ethiopia & Uppsal, Sweden.
- Hedberg, I., Edwards, S. and Sileshi Nemomissa (eds.) (2003). Flora of Ethiopia and Eritrea. Vol. 4, 1. Apiaceae to Dipsacaceae. Addis ababa, Ethiopia, Uppsala, Sweden.
- Hedman, C.W. and. Van Lear, D.H. (1995). Vegetative structure and composition of Southern Appalachian riparian forests. *Bulletin Torrey Botanical Club*,122: 134-144.
- Hurlbert, S.H. (1978). The None- Concept of Species Diversity: A critique and Alternative Parameters. *Ecology* 52:577-586.
- Huston, M.A. (1994). Biological Diversity: the coexistence of species on changing landscape. Cambridge University Press, New York.
- Hynes, H.B. (1975). The stream and its valley. *Verch. Verein. Limnol* .19: 115-121.
- <http://www.aber.ac.uk/~qecwww/tana/geology.htm>. The Tana Project (2003).
- Johansson, M.E. and Nilsson, C. (2002). Response of riparian plants to water level in free flowering and regulated boreal rivers: an experimental study. *Journal of Applied Ecology*, 39:971-986.
- Keddy, P.A. & Ellis, T.H. (1985). Seedling, recruitment of 11 wetland plant species along water level gradient: shared or distinct responses? *Canadian Journal of Botany* 63: 1876-1879.
- Keddy, P.A. (1983). Shoreline vegetation in Axe Lake Ontario, effect of exposure on zonation pattern. *Ecology* 64:331-344.
- Kent, M. and Coker, P.(1992). Vegetation Description and Analysis. Belhaven Press, London 363 pp.
- Klapporth, J. C. (2000). Understanding the Science behind Riparian Forest Buffers: Effect on Plant and Animal Communities, Virginia Cooperative Extension, pp 420-452.
- Klosowski, S. & Tomaszewicz, H. (1993). Analysis of distribution, structure and habitat condition of riparian vegetation in the river lake system of the upper Szeszupa (Suwalki Landscape Park-North-Eastern Poland). *Ekologia Polska*, 41: 1-2; 123-156
- Krebs, C. J. (1978). Ecological Methodology. Harpes Collins Publishers, New York.
- Lamprecht, H. (1989). Silviculture in the Tropics-Tropical Forest Ecosystem and their Tree Species-Possibilities and Methods for their Long term Utilization T<sub>2</sub>- Verlagsyeseells chaft mbH, Pustach 1164, D6101, Federal Republic of Germany.

- Magurran, A. (1988) Ecological diversity and measurement. Croom Helm, London.
- Mesfin Tadesse (2004). Flora of Ethiopia and Eritrea. Vol. 4, 2. Asteraceae (compositae). Addis Ababa, Ethiopia and Uppsala, Sweden.
- Misra, K. C. (1974). Manual of plant ecology. Oxford & IBH publishing Co. New Delhi. 368 pp.
- Nicolas, L. (1998). Aquatic plant diversity in riverine wetlands: the role of connectivity. *Fresh water Biology* 39:267-275.
- Nilsson, C., Grellson, G., Johansson, M.E. & Sperens, U. (1994). Patterns of plant species richness along riverbank. *Ecology* 70: 77-84.
- Pichi-Sermolli, R.E.G. (1950). Sulla sistematica e nomenclatura di alcune piante dell' Abissinia. *Webbia* 7: 325-335.
- Pielou, E.C. (1969). An introduction to Mathematical Ecology. Wiley, New York.
- Padoni, J (1988). Syntax 3: Users manual. *Abstracta Botanica* 12, Supplement 1.
- Pollock, M.M. (1998). Plant species richness in riparian wetlands-a test of biodiversity theory. *Ecology* 79: 94-105.
- Rood, S.B. & Mahoney, J.M. (1996). Collapse of riparian population downstream from dams in western Prairies: probable case and prospect for mitigation. *Environmental Management*, 14: 451- 464.
- Rosenzweig, H.C. (1995). Species Diversity in Space and Time. Cambridge University press.
- Shaojun, X., Mats, E.J., Francis, M.R., Adrian, H., Keith, S.R. & Christer, N. (2003). Interactive effect of soil moisture, vegetation canopy, plant litter and seed addition on plant diversity in wet land community. *Journal of Ecology* 91:976-986.
- Schneider, R.L. and Sharith, R.R. (1988). Hydrochry and regeneration in a bald Cypress-water tupelo swamp forest. *Ecology*, 69: 1055-1063.
- Scott, D.A. and Poole, C.M. (1989). A status overview of Asian Wetlands. No.53. AWB, Kuala Lumpur.
- Sebe Demissew (1998). A study of the vegetation and floristic composition of southern Wollo, Ethiopia, *J. Ethiop. Studies* .32: 159-192.
- Shackelton, C. M. (2000). Comparison of Plant Diversity in Protected and Communal Lands in Bushbuck ridge Lower Savana, South Africa. *Biological Conservation* 94: 273 – 285.

- Shaojun, X., Mats, E.J., Francis, M.R., Adrian, H., Keith, S.R. & Christer, N. (2003). Interactive effect of soil moisture, vegetation canopy, plant litter and seed addition on plant diversity in wet land community. *Journal of Ecology* 91: 976-986.
- Schimper, A.F.W. (1903). Plant geography upon a physiological basis. Cerandon Press, Oxford.
- Smith, R.L. (1992). Element of Ecology. 3<sup>rd</sup> ed., Harper Collins publisher. Western University 667 pp.
- Springuel, I. (1990). Riverine Vegetation in the Nile Valley in Upper Egypt. *Journal of Vegetation Science* 1: 595 – 598.
- Tesfaye Bekele (2002). Plant Population Dynamics of *Dodonea angustifolia* and *Olea europea* Sub sp .*cuspidata* in dry Afromountain Forest of Ethiopia. Acta Universtitatis upsaliens Upsala, Sweden.
- Van der Maarele, E. (1979). Transformation of cover/abundance value in Phytosociology and its effect on community similarity. *Vegetation* 39:97-114.
- Vickery, L.M. (1984). Ecology of Tropical Plants. John Wiley and Sons Ltd., Great Britain.
- Ward and Tockner (2001). Biodiversity: towards a unifying theme for river ecology. *Freshwater Biology* 46: 807-813.
- Waring, H.R. and Schlesinger, H.W. (1985). Forest Ecosystem Concept and Management. Academic Press. Inc. London.
- Wisheu, I.C. and Amoros, P.A. (1991). Seed bank of a rare wetland plant community, distribution pattern and effect of human-induced disturbance. *Journal of Vegetation Science* 2: 181-188.
- Wolfson, L., Mokma, D. Schultink, C. and Dersch, E. (2002). Development and use of wetlands information system for assessing wetland functions. Lakes and Reservoir. *Research and Management* 7: 207.
- Xiong, S. & Nilson, C. (1977). Dynamics of leaf litter accumulation and its effect on riparian vegetation: a review. *Botanical Review* 63:240-264.
- Zerihun Woldu (1999). Forest in the vegetation type of Ethiopia and this status in the Geographical context. In: Edwards, S., Abebe Demisse, Taye Bekele and Haase, G. (eds). Forest Genetic Resource Conservation. IBCR & GTZ, Addis Ababa.

## 8. Appendices

**Appendix 1.** List of plant species, family and growth habit recorded from Beschillo and Blue Nile riverine Vegetation.

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
1.	<i>Abelmoschus esculentus</i> (L.) Moench.	Malvaceae	Herb
2.	<i>Abutilon bidentatum</i> (Hochst.) A. Rich.	Malvaceae	Shrub
3.	<i>Abutilon fruticosum</i> Guill. & Perr.	Malvaceae	Shrub
4.	<i>Acacia etbaica</i> Schweinf.	Fabaceae	Tree
5.	<i>Acacia robusta</i> Burch.	Fabaceae	Tree
6.	<i>Acacia persiciflora</i> Pax	Fabaceae	Tree
7.	<i>Acacia polyacantha</i> Wild	Fabaceae	Tree
8.	<i>Acacia seyal</i> Del.	Fabaceae	Tree
9.	<i>Acacia tortilis</i> (Forssk.) Hay.	Fabaceae	Tree
10.	<i>Acalypha</i> sp.	Euphorbiaceae	Shrub
11.	<i>Acanthospermum hispidum</i> DC.	Asteraceae	Herb
12.	<i>Achyranthes aspera</i> L.	Amaranthaceae	Herb

Code No.	Botanical name	Family	Habit
13.	<i>Acmella caulirhiza</i> Del.	Asteraceae	Herb
14.	<i>Acokanthera schimperi</i> (A. DC.) Schweinf.	Apocynaceae	Tree
15.	<i>Adiantum philippense</i> L.	Adiantaceae	Herb
16.	<i>Aerva javanica</i> (Burm. f.) Merr.	Amaranthaceae	Herb
17.	<i>Aerva lantana</i> (L.) Juss. ex Schultes	Amaranthaceae	Herb
18.	<i>Agave sisalana</i> Perrine ex Engel.	Agavaceae	Herb
19.	<i>Allophylus rubifolius</i> (A. Rich) Engl.	Sapindaceae	Tree
20.	<i>Amaranthus dubius</i> Thell.	Amaranthaceae	Herb
21.	<i>Amaranthus graecizans</i> L.	Amaranthaceae	Herb
22.	<i>Ampelocissus schimperi</i> (Hochst.) ex A. Rich.	Vitaceae	Herb
23.	<i>Aningeria altissima</i> (A. Chev.) Aubrev. & Pellgr.	Sapotaceae	Tree
24.	<i>Anogeissus leiocarpa</i> (A. DC.) Guill. & Perr	Combretaceae	Tree
25.	<i>Aristida</i> Sp.	Poaceae	Herb
26.	<i>Arundo donax</i> L.	Poaceae	Herb
27.	<i>Asparagus flagellaris</i> (Kunth.) Baker	Asparagaceae	C/Shrub
28.	<i>Asparagus setaceus</i> (Kunth.) Jessop	Asparagaceae	Shrub
29.	<i>Aspilia helianthoides</i> (Schum.) Oliv. & Hiern.	Asteraceae	Herb
30.	<i>Astripomoea malvcea</i> (Klotzsch.) Meeuse	Convolvulaceae	Herb
31.	<i>Asystasia riparia</i>	Acanthaceae	Shrub
32.	<i>Barleria acanthoides</i> Vahl	Acanthaceae	Shrub
33.	<i>Barleria eranthemoides</i> R. Br. ex C.B. Clarke	Asteraceae	Shrub
34.	<i>Barleria grandis</i> Hochst. ex Nees	Acanthaceae	Shrub
35.	<i>Barleria prionitis</i> L.	Acanthaceae	Herb
36.	<i>Biden pilosa</i> L.	Asteraceae	Herb
37.	<i>Blepharis edulis</i> (Forssk.) Pers.	Acanthaceae	Herb
38.	<i>Blepharis maderaspatensis</i> (L.) Roth.	Acanthaceae	Herb
39.	<i>Boerhavia diffusa</i> L .ex Desc.	Nictaginaceae	Herb

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
40	<i>Boscia salicifolia</i> Olive.	Capparidaceae	Tree
41.	<i>Boswellia papyrifera</i> (Del.) Hochst.	Burseraceae	Tree
42.	<i>Bridelia scleroneura</i> Muell. Arg.	Euphorbiaceae	Tree
43.	<i>Cadaba farinosa</i> Forssk.	Capparidaceae	Shrub
44.	<i>Calotropis procera</i> (Ait.) Ait. f.	Asclepiadaceae	Shrub
45.	<i>Capparis tomentosa</i> Lam.	Capparidaceae	Shrub
46.	<i>Cardiospermum halicacabum</i> L.	Sapindaceae	Climber
47.	<i>Carphalea glaucescens</i> (Hiern) Verdc.	Rubiaceae	Shrub
48.	<i>Cassia</i> sp.	Fabaceae	Tree
49.	<i>Celosia argentea</i> L.	Amaranthaceae	Herb
50.	<i>Celosia trigyna</i> L.	Amaranthaceae	Herb
51.	<i>Celtis africana</i> Burm.f.	Ulmaceae	Tree
52.	<i>Cenchrus ciliaris</i> L.	Poaceae	Herb
53.	<i>Chamaecrista nigricans</i> (Vahl) Greene	Fabaceae	Herb
54.	<i>Chloris gayana</i> Kunth	Poaceae	Herb
55.	<i>Cissus petiolata</i> Hook.f.	Vitaceae	Climber
56.	<i>Cissus quadrangularis</i> L.	Vitaceae	Climber
57.	<i>Clerodendrum capitatum</i> (Wild.) Schumach & Thorn	Verbenaceae	Herb
58	<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	Climber
59.	<i>Combretum adenogonium</i> Stud. ex A.Rich.	Combretaceae	Tree
60.	<i>Combretum collinum</i> Fresen.	Combretaceae	Tree
61.	<i>Commelina imberbis</i> Ehrenb. ex Hassk	Commelinaceae	Herb
62.	<i>Commelina latifolia</i> Hochst. ex A. Rich.	Commelinaceae	Herb
63.	<i>Commicarpus</i> sp.	Nictaginaceae	Herb
64.	<i>Commiphora africana</i> Engl. ex Wild	Burseraceae	Tree
65.	<i>Convolvulus glomeratus</i> Choisy	Convolvulaceae	Herb
66.	<i>Corchorus fascicularis</i> Lam.	Tiliaceae	Herb
67.	<i>Cordia africana</i> Lam.	Boraginaceae	Tree

Code No.	Botanical name	Family	Habit
68.	<i>Cordia sinensis</i> Lam.	Boraginaceae	Tree
69.	<i>Crotalaria pycnostachya</i> Benth.	Fabaceae	Herb
70.	<i>Crotalaria</i> sp.	Fabaceae	Herb
71.	<i>Cucumis dipsaceus</i> Ehrenb.	Cucurbitaceae	Climber
72.	<i>Cuscuta campestris</i> Yuncker	Cuscutaceae	Herb
73.	<i>Cynodon</i> sp.	Poaceae	Herb
74.	<i>Cynoglossum johnstonii</i> Barker	Hyacinthaceae	Herb
75.	<i>Cyperus macrostachyos</i> (Lam.) Raynal.	Cyperaceae	Herb
76.	<i>Cyprus schimperianus</i> Steud.	Cyperaceae	Herb
77.	<i>Dalbergia melanoxylon</i> Guill. & Perr.	Fabaceae	Tree
78.	<i>Datura stramonium</i> L.	Solanaceae	Herb
79.	<i>Diaphanante schimperiana</i> (A. Rich.) Sum.	Orchidaceae	Herb(epi.)
80.	<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Fabaceae	Shrub
81.	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	Climber
82.	<i>Diospyros abyssinica</i> (Hiern) F. Whiite	Ebenaceae	Tree
83.	<i>Diospyros mespiliformis</i> Hochst ex A. DC.	Ebenaceae	Tree
84.	<i>Dregea abyssinica</i> (Hochst.) K. Schum.	Asclepiadaceae	Climber
85.	<i>Ornithogalum donaldsonii</i>	Hyacinthaceae	Herb
86.	<i>Eragrostis aspera</i> (Jacq.) Nees	Poaceae	Herb
87.	<i>Eragrostis lepida</i> (A. Rich.) Hochst. ex Steud.	Poaceae	Herb
88.	<i>Eragrostis teff</i> (Zucc.) Totter	Poaceae	Herb
89.	<i>Eragrostis tremula</i> Hochst. ex Steud.	Poaceae	Herb
90.	<i>Erythrina abyssinica</i> Lam. ex DC.	Fabaceae	Tree
91.	<i>Euphorbia platyphyllos</i> L.	Euphorbiaceae	Herb
92.	<i>Euphorbia polyacantha</i> Boiss.	Euphorbiaceae	Shrub
93.	<i>Euphorbia</i> sp.	Euphorbiaceae	Climber
94.	<i>Ficus capreaefolia</i> Del.	Moraceae	Shrub
95.	<i>Ficus glumosa</i> Del.	Moraceae	Tree

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
96.	<i>Ficus gnaphalocarpa</i> (Miq.) A. Rich.	Moraceae	Tree
97.	<i>Ficus sycomorus</i> L.	Moraceae	Tree
98.	<i>Ficus vasta</i> Forssk.	Moraceae	Tree
99.	<i>Fimbristylis bisumbellata</i> (Forsk.) Bub.	Cyperaceae	Herb
100.	<i>Flaveria trinervia</i> C. Mohr	Amaranthaceae	Herb
101.	<i>Gardenia ternipflia</i> Sch. & Thonn.	Rubiaceae	Tree
102.	<i>Gladiolus abyssinicus</i> (Brongn.ex Lemarie) Goldblatt & de Vos	Iridiaceae	Herb
103.	<i>Gossipium hirsutum</i> L.	Malvaceae	Shrub
104.	<i>Grewia bicolor</i> Juss.	Tiliaceae	Shrub
105.	<i>Grewia flavescens</i> Juss.	Tiliaceae	Shrub
106.	<i>Grewia mollis</i> A. Juss.	Tiliaceae	Tree
107.	<i>Grewia villosa</i> Willd.	Tiliaceae	Shrub
108.	<i>Gynandropsis gynandra</i> (L.) Briq.	Capparidaceae	Herb
109.	<i>Heliotropium subulatum</i> (Dc.) Martei	Boraginaceae	Herb
110.	<i>Hibiscus cinnabarinus</i> L.	Malvaceae	Shrub
111.	<i>Hibiscus micranthus</i> L.f.	Malvaceae	Shrub
112.	<i>Hibiscus noldeau</i> Bark. f.	Malvaceae	Shrub
113.	<i>Hibiscus panduriformis</i> Burm f.	Malvaceae	Shrub
114.	<i>Hibiscus surattensis</i> L.	Malvaceae	Shrub
115.	<i>Hippocratea</i> sp.	Celastraceae	Climber
116.	<i>Hyparrhenia dichroa</i> (Steud.) Stapf	Poaceae	Herb
117.	<i>Hyparrhenia dissoluta</i> (Steud.) C.E. Hubb.	Poaceae	Herb
118.	<i>Hypoestes forskaoli</i> (Vahl) R.Br.	Acanthaceae	Herb
119.	<i>Impomoea ficifolia</i> Linda	Convolvulaceae	Herb
120.	<i>Justicia cordata</i> (Hochst. ex Nees) T. Andress.	Acanthaceae	Shrub
121.	<i>Cadaba farinosa</i> Forsk	Tiliaceae	Shrub
122.	<i>Kalanchoe lanceolata</i> (Forssk.) Pers.	Krassulaceae	Herb

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
123.	<i>Kanahia laniflora</i> (Forssk.) R. Br.	Asclepiadaceae	Shrub
124.	<i>Kedrostis foetidissima</i> (Jacq.) Cogn.	Cucurbitaceae	Climber
125.	<i>Kigelia africana</i> (Lam.) Benth.	Bignonaceae	Tree
126.	<i>Laggera pterodonata</i> (DC.) Benth.	Asteraceae	Herb
127.	<i>Lonchocarpus laxiflorus</i> Guill. & Perr.	Fabaceae	Tree
128.	<i>Lnnea fruticosa</i> (Hochst ex A. Rich) Engl.	Anacardiaceae	Tree
129.	<i>Lepidagathis aristata</i> (Vahl) Nees.	Acanthaceae	Shrub
130.	<i>Lepidotrichilia volkensis</i> (Gurke) Leroy	Meliaceae	Tree
131.	<i>Leptadenia arborea</i> (Forssk.) Decne	Asclepeadiaceae	Herb
132.	<i>Leucas martinicensis</i> (Jacq.) R. Br.	Lamiaceae	Herb
133.	<i>Loudetia arundinacera</i> (Hochst. ex A. Rich.) Steud.	Poaceae	Herb
134.	<i>Luffa cylindrica</i> (L.) M.J. Roem.	Cucurbitaceae	Climber
135.	<i>Lycopersicum esculentum</i> Mill.	Solonaceae	Herb
136.	<i>Maerua edulis</i> (Gilg. & Bened.) De Wolf.	Capparidaceae	Shrub
137.	<i>Maerua oblongifolia</i> (Forssk.) A. Rich.	Capparidaceae	Shrub
138.	<i>Maerua pseudopetalosa</i> (Gilg & Bened) De Wolf	Capparidaceae	Shrub
139.	<i>Malacantha alnifolia</i> (Bak.) Pierre.	Sapotaceae	Tree
140.	<i>Maytenus senegalensis</i> (Lam.) Exell	Celastraceae	Tree
141.	<i>Meineckia phyllantoides</i> Baill.	Euphorbiaceae	Shrub
142.	<i>Merremia aegyptia</i> (L.) Urb.	Convolvulaceae	Herb
143.	<i>Mimosa pigra</i> L.	Fabaceae	Shrub
144.	<i>Momordica</i> sp.	Cucurbitaceae	Climber
145.	<i>Moringa stenopetala</i> (Bark. f.) Cufod.	Moringaceae	Tree
146.	<i>Nicandra physaloides</i> (L.) Gaertn	Solonaceae	Herb
147.	<i>Crinum abyssinicum</i> Hochst ex A. Ruch.	Amaryllidaceae	Herb
148.	<i>Oplismenus burmannii</i> (Retz.) P. Beauv.	Poaceae	Herb
149.	<i>Oriza longistaminata</i> A. Chev. & Roehr.	Poaceae	Herb
150.	<i>Ocimum americanum</i> L.	Lamiaceae	Herb

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
151.	<i>Ocimum spicatum</i> Def.	Lamiaceae	Herb
152.	<i>Ocimum urticifolium</i> Roth	Lamiaceae	Herb
153.	<i>Oxytenanthera abyssinica</i> (A.Rich.) Munro	Poaceae	Herb
154.	<i>Panicum maximum</i> Jacq.	Poaceae	Herb
155.	<i>Pavetta</i> sp.	Rubiaceae	Shrub
156.	<i>Pennisetum pedicellatum</i> Trin	Poaceae	Herb
157.	<i>Pennisetum polystachyon</i> (L.) Schult.	Poaceae	Herb
158.	<i>Peristrophe paniculata</i> (Forssk.) Brummitt	Acanthaceae	Herb
159.	<i>Phragmites karka</i> (Retz.) Steud.	Poaceae	Herb
160.	<i>Piliostigma thonningi</i> (Schum.) Milne-Rdeh	Caesalpinaceae	Tree
161.	<i>Polygonium nepalinse</i> Meisn	Polygonaceae	Herb
162.	<i>Pseudomussaenda flava</i> Verdc.	Rubiaceae	Shrub
163.	<i>Pterocarpus lucens</i> Guill. & Perr	Fabaceae	Tree
164.	<i>Puapalia lappaceae</i> Juss	Amaranthaceae	Herb
165.	<i>Ricinus communis</i> L.	Euphorbiaceae	Herb
166.	<i>Ritchiea albersii</i> Gilg	Capparidaceae	Tree
167.	<i>Saccharum spontaneum</i> L.	Poaceae	Herb
168.	<i>Senna obtusifolia</i> (L.) Irwin & Barneby	Fabaceae	Herb
169.	<i>Senna septemtrionalis</i> (Viv.) Iwan & Barneby	Fabaceae	Shrub
170.	<i>Sensevieria abyssinica</i> N.E. Br.	Agavaceae	Herb
171.	<i>Sesamus indicum</i> L.	Pedaliaceae	Herb
172.	<i>Sesbenia sesban</i> (L.) Merr.	Fabaceae	Shrub
173.	<i>Setaria megaphylla</i> (Steud.) Th. Dur. & Schinz	Poaceae	Herb
174.	<i>Setaria verticillata</i> (L.) P. Beauv.	Poaceae	Herb
175.	<i>Sicyos polyacanthus</i> Cogn.	Cucurbitaceae	Climber
176.	<i>Sida alba</i> L.	Malvaceae	Herb
177.	<i>Solanum marginatum</i> L.	Solanaceae	Shrub
178.	<i>Solanum nigrum</i> L.	Solanaceae	Herb

<b>Code No.</b>	<b>Botanical name</b>	<b>Family</b>	<b>Habit</b>
179.	<i>Sorghum arundinaceum</i> (Desv.) Stapf.	Poaceae	Herb
180.	<i>Sorghum bicolor</i> (L.) Moench.	Poaceae	Herb
181.	<i>Spermacoce chaetocephala</i> Dc.	Rubiaceae	Herb
182.	<i>Spermania sp.</i>	Tiliaceae	Shrub
183.	<i>Sterculia africana</i> (Lour.) L.	Sterculiaceae	Tree
184.	<i>Streospermum kunthianum</i> Cham.	Bignonaceae	Tree
185.	<i>Striga hermonthica</i> (Del.) Benth.	Scrophulariaceae	Herb
186.	<i>Tacazzea venosa</i> Decne	Asclepidaceae	Shrub
187.	<i>Tamrindus indica</i> L.	Caesalpiniaceae	Tree
188.	<i>Tamrix aphylla</i> (L.) Karst.	Tamaricaceae	Tree/shrub
189.	<i>Tapinostemma acaciae</i> (Zuc.) Tieghem	Loranthaceae	Herb
190.	<i>Tephrosia linearis</i> (Willd.) Pers	Fabaceae	Herb
191.	<i>Tephrosia uniflora</i> Pers.	Fbaceae	Herb
192.	<i>Trichilia emetica</i> Vahl	Meliaceae	Tree
193.	<i>Triumfetta flavescens</i> Hochst ex A. Rich	Tiliaceae	Shrub
194.	<i>Triumfetta pilosa</i> Roth	Tiliaceae	Shrub
195.	<i>Vangueria madagascariensis</i> Gmel.	Rubiaceae	Tree
196.	<i>Vernonia adoensis</i> Sch.Bip. ex Walp	Asteraceae	Tree/shrub
197.	<i>Vernonia cyliderica</i> Sch. Bip. ex Walp.	Asteraceae	Tree/shrub
198.	<i>Vigna vexillata</i> (L.) A.Rich.	Fabaceae	Herb
199.	<i>Vitelaria paradoxa</i> Gaerth. F.	Sapotaceae	Tree
200.	<i>Xanthium strumarium</i> L.	Asteraceae	Herb
201.	<i>Xenostegia tridentata</i> Austin and Staples	Convolvulaceae	Herb
202.	<i>Ximenia americana</i> L.	Olacaceae	Shrub
203.	<i>Ziziphus abyssinica</i> Hochst. ex A. Rich	Rhamnaceae	Shrub
204.	<i>Ziziphus mucronata</i> Wild	Rhmnaceae	Tree
205.	<i>Ziziphus spina-christi</i> (L.) Desf.	Rhamnaceae	Tree

**Appendix 2.** Tree species, Families and density of Beschillo and Blue Nile Riverine Vegetation

<b>S No.</b>	<b>Tree species</b>	<b>Family</b>	<b>Density ha<sup>-1</sup> %</b>
1	<i>Acacia etbaica</i> Schweinf.	Fabaceae	3.5
2	<i>Acacia robusta</i> Burch	Fabaceae	4.4
3	<i>Acacia persiciflora</i> Pax	Fabaceae	0.9
4	<i>Acacia polyacantha</i> Wild	Fabaceae	7.3
5	<i>Acacia seyal</i> Del.	Fabaceae	0.9
6	<i>Acacia tortilis</i> (Forssk.) Hay.	Fabaceae	6.5
7	<i>Acokanthera schimperi</i> (DC) Benth	Apocynaceae	1.2
8	<i>Allophylus rubifolius</i> (A. Rich) Engl.	Sapindaceae	0.3
9	<i>Aningeria altissima</i> Aubrev. & Pellgr.	Sapotaceae	0.6
10	<i>Anogeissus leiocarpa</i> (A. Dc.) Guill. & Perr	Comberetaceae	18
11	<i>Boscia salicifolia</i> Olive.	Capparidaceae	1.5
12	<i>Boswellia papyrifera</i> (Del.) Hochst.	Burseraceae	3.5
13	<i>Bridelia scleroneura</i> Muell. Arg.	Euphorbiaceae	0.6
14	<i>Commiphora africana</i> Engl. ex Wild	Bursceraceae	0.9
15	<i>Cassia</i> sp.	Fabaceae	0.3
16	<i>Celtis africana</i> Burm. f.	Ulmaceae	0.6
17	<i>Combretum adenogonium</i> Steud. Ex A.Rich.	Combretaceae	0.3
18	<i>Combretum collinum</i> Fresen	Combretaceae	0.9
19	<i>Cordia africana</i> Lam.	Boraginaceae	0.6
20	<i>Cordia sinensis</i> Lam.	Boraginaceae	0.3
21	<i>Dalbergia melanoxyton</i> Guill. & Perr.	Fabaceae	0.6
22	<i>Diospyros abyssinica</i> (Hiern) f. White	Ebenaceae	7.1
23	<i>Diospyros mespiliformis</i> A. DC.	Ebenaceae	0.9
24	<i>Erythrina abyssinica</i> Lam. ex DC.	Fabaceae	0.3
25	<i>Ficus glumosa</i> Del.	Moraceae	1.5
26	<i>Ficus gnaphalocarpa</i> (Miq.)A.Rich	Moraceae	0.3
27	<i>Ficus sycomorus</i> L.	Moraceae	0.6
28	<i>Ficus vasta</i> Forsk	Moraceae	1.5
29	<i>Gardenia ternifolia</i> Sch. & Thonn.	Rubiaceae	0.6
30	<i>Grewia mollis</i> A. Juss	Tiliaceae	0.3
31	<i>Kigelia africana</i> (Lam.) Benth.	Bignonaceae	3.2
32	<i>Lonchocarpus laxiflorus</i> Guill. & Perr.	Fabaceae	1.2

S No.	Tree species	Family	Density ha <sup>-1</sup> %
33	<i>Lannea fruticosa</i> (Hochst ex A. Rich) Engl	Anacardiaceae	0.6
34	<i>Lepidotrichilia volkensii</i> (Gurke) Leroy	Meliaceae	0.3
35	<i>Malacantha alnifolia</i> (Bak.) Pierre.	Sapotaceae	0.6
36	<i>Maytenus senegalensis</i> (Lam.) Exell	Celastraceae	3.5
37	<i>Moringa stenopetala</i> (Bark. F.) Cufod.	Moringaceae	0.3
38	<i>Piliostigma thonningi</i> (Schum.) Milne-Redh	Caesalpinaceae	0.6
39	<i>Pterocarpus lucens</i> Guill. & Perr	Fabaceae	2.9
40	<i>Ritchiea albersii</i> Gilg	Capparidaceae	0.3
41	<i>Sterculia africana</i> (Lour.) L.	Sterculiaceae	10
42	<i>Sterospermum kuntheanum</i> Cham.	Bignonaceae	0.3
43	<i>Tamrindus indica</i> L.	Caesalpiniaceae	1.5
44	<i>Trichilia emetica</i> Vahl	Meliaceae	2.9
45	<i>Vangueria madagascariensis</i> Gmel.	Rubiaceae	0.3
46	<i>Vitellia paradoxa</i> Gaerth. F.	Sapotaceae	0.6
47	<i>Ziziphus mucronata</i> Wild	Rhamnaceae	1.2
48	<i>Ziziphus spina-chrisiti</i> (L.) Desf	Rhamnaceae	3.2

### Appendix 3. Stem number and height class of tree species of Beschillo and Blue Nile Riverine Vegetation

	Tree species	No. of stems	HEIGHT			
			≤ 8m	8.1≤18m	18<26	26m
1	<i>Acacia etbaica</i>	12	1	10	0	0
2	<i>Acacia robusta</i>	15	0	13	1	1
3	<i>Acacia persiciflora</i>	3	0	3	0	0
4	<i>Acacia polyacantha</i>	25	4	16	5	0
5	<i>Acacia seyal</i>	3	1	2	0	0
6	<i>Acacia tortilis</i>	22	5	17	0	0
7	<i>Acokanthera schimperi</i>	4	4	0	0	0
8	<i>Allophylus rubifolius</i>	1	1	0	0	0
9	<i>Aningeria altissima</i>	2	1	1	0	0
10	<i>Anogeissus leiocarpa</i>	62	2	39	21	0
11	<i>Boscia salicifolia</i>	5	0	5	0	0

	Tree species	No.of stems	HEIGHT			
			≤ 8m	8.1≤18m	18<26	26m
12	<i>Boswellia papyrifera</i>	12	5	7	0	0
13	<i>Bridelia scleroneura</i>	2	2	0	0	0
14	<i>Commiphora africana</i>	3	3	0	0	0
15	<i>Cassia sp.</i>	1	0	1	0	0
16	<i>Celtis africana</i>	2	1	1	0	0
17	<i>Combretum adenogonium</i>	1	1	0	0	0
18	<i>Combretum collinum</i>	3	0	3	0	0
19	<i>Cordia africana</i>	2	0	2	0	0
20	<i>Cordia sinensis</i>	1	1	0	0	0
21	<i>Dalbergia melanoxylo</i>	2	2	0	0	0
22	<i>Diospyros abyssinica</i>	24	6	11	7	0
23	<i>Diospyros mespiliformis</i>	3	0	3	0	0
24	<i>Erythrina abyssinica</i>	1	1	0	0	0
25	<i>Ficus glumosa</i>	5	0	5	0	0
26	<i>Ficus gnaphalocarpa</i>	1	1	0	0	0
27	<i>Ficus sycomorus</i>	2	0	0	0	0
28	<i>Ficus vasta</i>	5	0	5	0	0
29	<i>Gardenia ternifolia</i>	2	2	0	0	
30	<i>Grewia mollis</i>	1	1	0	0	0
31	<i>Kigelia africana</i>	11	0	14	0	0
32	<i>Lonchocarpus laxiflorus</i>	4	0	4	0	0
33	<i>Lannea fruticosa</i>	2	2	0	0	0
34	<i>Lepidotrichilia volkensii</i>	1	1	0	0	0
35	<i>Malacantha alnifolia</i>	2	2	0	0	0
36	<i>Maytenus senegalensis</i>	12	12	0	0	0
37	<i>Moringa stenopetala</i>	1	0	1	0	0
38	<i>Piliostigma thonningi</i>	2	0	2	0	0
39	<i>Pterocarpus lucens</i>	10	0	10	0	0
40	<i>Ritchiea albersii</i>	1	0	1	0	0
41	<i>Sterculia africana</i>	34	1	33	0	0
42	<i>Sterospermum kuntheanum</i>	1	0	1	0	0
43	<i>Tamrindus indica</i>	5	0	5	0	0
44	<i>Trichilia emetica</i>	10	0	8	2	0
45	<i>Vangueria madagascariensis</i>	1	1	0	0	0

	Tree species	No. of stems	HEIGHT			
			≤ 8m	8.1≤18m	18<26	26m
46	<i>Vitellia paradoxa</i>	2	2	0	0	0
47	<i>Ziziphus mucronata</i>	4	1	3	0	0
48	<i>Ziziphus spina-chrisiti</i>	11	7	4	0	0
	Total	<b>340</b>	<b>74</b>	<b>229</b>	<b>36</b>	<b>1</b>

#### Appendix 4. DBH range of tree species of Beschillo and Blue Nile Riverine Vegetation

##### DBH (Diameter at Breast-Height)

	Tree species	1-10cm	11-20cm	21-30cm	31-40cm	>40cm
1	<i>Acacia etbaica</i>	0	0	8	4	0
2	<i>Acacia robusta</i>	0	1	8	5	1
3	<i>Acacia persiciflora</i>	0	0	1	2	0
4	<i>Acacia polyacantha</i>	1	1	9	8	6
5	<i>Acacia seyal</i>	0	0	2	1	0
6	<i>Acacia tortilis</i>	1	3	5	8	5
7	<i>Acokanthera schimperi</i>	3	1	0	0	0
8	<i>Allophylus rubifolius</i>	0	1	0	0	0
9	<i>Aningeria altissima</i>	0	0	0	0	2
10	<i>Anogeissus leiocarpa</i>	1	2	16	24	19
11	<i>Boscia salicifolia</i>	0	0	0	2	3
12	<i>Boswellia papyrifera</i>	0	0	12	0	0
13	<i>Bridelia scleroneura</i>	2	0	0	0	0
14	<i>Commiphora africana</i>	0	3	0	0	0
15	<i>Cassia sp.</i>	0	0	0	1	0
16	<i>Celtis africana</i>	0	0	0	2	0
17	<i>Combretum adenogonium</i>	0	0	0	0	1
18	<i>Combretum collinum</i>	0	0	3	0	0
19	<i>Cordia africana</i>	0	1	0	1	0
20	<i>Cordia sinensis</i>	0	1	0	0	0
21	<i>Dalbergia melanoxylon</i>	1	1	0	0	0
22	<i>Diospyros abyssinica</i>	1	3	12	5	3
23	<i>Diospyros mespiliformis</i>	0	1	2	0	0
24	<i>Erythrina abyssinica</i>	1	0	0	0	0
25	<i>Ficus glumosa</i>	0	0	0	3	2

	<b>Tree species</b>	1-10cm	11-20cm	21-30cm	31-40cm	>40cm
26	<i>Ficus gnaphalocarpa</i>	0	0	0	1	0
27	<i>Ficus sycomorus</i>	0	0	0	0	2
28	<i>Ficus vasta</i>	0	0	0	0	5
29	<i>Gardenia ternifolia</i>	1	1	0	0	0
30	<i>Grewia mollis</i>	0	1	0	0	0
31	<i>Kigelia africana</i>	0	0	3	0	8
32	<i>Lonchocarpus laxiflorus</i>	0	0	4	0	0
33	<i>Lannea fruticosa</i>	1	1	0	0	0
34	<i>Lepidotrichilia volkensii</i>	0	1	0	0	0
35	<i>Malacantha alnifolia</i>	2	0	0	0	0
36	<i>Maytenus senegalensis</i>	9	3	0	0	0
37	<i>Moringa stenopetala</i>	0	1	0	0	0
38	<i>Piliostigma thonningi</i>	0	0	0	1	1
39	<i>Pterocarpus lucens</i>	0	0	0	0	10
40	<i>Ritchiea albersii</i>	0	1	0	0	0
41	<i>Sterculia africana</i>	1	0	2	19	12
42	<i>Sterospermum kuntheanum</i>	0	0	1	0	0
43	<i>Tamrindus indica</i>	0	0	0	1	4
44	<i>Trichilia emetica</i>	0	0	0	1	9
45	<i>Vangueria madagascariensis</i>	0	1	0	0	0
46	<i>Vitellia paradoxa</i>	0	0	0	0	0
47	<i>Ziziphus mucronata</i>	0	0	2	1	1
48	<i>Ziziphus spina-chrisiti</i>	0	3	7	1	0
	<i>Sum.</i>	<b>26</b>	<b>32</b>	<b>97</b>	<b>91</b>	<b>94</b>

**Appendix 5.** Percentage relative density and frequency of tree species of Beschillo and Blue Nile Riverine Vegetation

	<b>Tree species</b>	<b>Family</b>	<b>No.</b>	<b>Pi</b>	<b>r.dens. (%)</b>	<b>frq.</b>	<b>r.frq.(%)</b>
1	<i>Acacia etbaica</i>	Fabaceae	12	0.04	3.53	10	4.081633
2	<i>Acacia robusta</i>	Fabaceae	15	0.04	4.41	10	4.081633
3	<i>Acacia persiciflora</i>	Fabaceae	3	0.01	0.88	3	1.22449
4	<i>Acacia polyacantha</i>	Fabaceae	25	0.07	7.35	13	5.306122
5	<i>Acacia seyal</i>	Fabaceae	3	0.01	0.88	3	1.22449

	<b>Tree species</b>	<b>Family</b>	<b>No.</b>	<b>Pi</b>	<b>r.dens. (%)</b>	<b>frq.</b>	<b>r.frq.(%)</b>
6	<i>Acacia tortilis</i>	Fabaceae	22	0.06	6.47	14	5.714286
7	<i>Acokanthera schimperi</i>	Apocynaceae	4	0.01	1.18	4	1.632653
8	<i>Allophylus rubifolius</i>	Sapindaceae	1	0	0.29	1	0.408163
9	<i>Aningeria altissima</i>	Sapotaceae	2	0.01	0.59	2	0.816327
10	<i>Anogeissus leiocarpa</i>	Comberetaceae	62	0.18	18.2	31	12.65306
11	<i>Boscia salicifolia</i>	Capparidaceae	5	0.01	1.47	4	1.632653
12	<i>Boswellia papyrifera</i>	Burseraceae	12	0.04	3.53	10	4.081633
13	<i>Bridelia scleroneura</i>	Euphorbiaceae	2	0.01	0.59	2	0.816327
14	<i>Commiphora africana</i>	Burseraceae	3	0.01	0.88	4	1.632653
15	<i>Cassia sp.</i>	Fabaceae	1	0	0.29	1	0.408163
16	<i>Celtis africana</i>	Ulmaceae	2	0.01	0.59	2	0.816327
17	<i>Combretum adenogonium</i>	Combretaceae	1	0	0.29	2	0.816327
18	<i>Combretum collinum</i>	Combretaceae	3	0.01	0.88	1	0.408163
19	<i>Cordia africana</i>	Boraginaceae	2	0.01	0.59	2	0.816327
20	<i>Cordia sinensis</i>	Boraginaceae	1	0	0.29	1	0.408163
21	<i>Dalbergia melanoxylon</i>	Fabaceae	2	0.01	0.59	2	0.816327
22	<i>Diospyros abyssinica</i>	Ebenaceae	24	0.07	7.06	13	5.306122
23	<i>Diospyros mespiliformis</i>	Ebenaceae	3	0.01	0.88	3	1.22449
24	<i>Erythrina abyssinica</i>	Fabaceae	1	0	0.29	1	0.408163
25	<i>Ficus glumosa</i>	Moraceae	5	0.01	1.47	6	2.44898
26	<i>Ficus gnaphalocarpa</i>	Moraceae	1	0	0.29	1	0.408163
27	<i>Ficus sycomorus</i>	Moraceae	2	0.01	0.59	2	0.816327
28	<i>Ficus vasta</i>	Moraceae	5	0.01	1.47	4	1.632653
29	<i>Gardenia ternifolia</i>	Rubiaceae	2	0.01	0.59	2	0.816327
30	<i>Grewia mollis</i>	Tiliaceae	1	0	0.29	1	0.408163
31	<i>Kigelia africana</i>	Bignoniaceae	11	0.03	3.24	5	2.040816
32	<i>Lonchocarpus laxiflorus</i>	Fabaceae	4	0.01	1.18	3	1.22449
33	<i>Lannea fruticosa</i>	Anacardiaceae	2	0.01	0.59	2	0.816327

	<b>Tree species</b>	<b>Family</b>	<b>No.</b>	<b>Pi</b>	<b>r.dens. (%)</b>	<b>frq.</b>	<b>r.frq.(%)</b>
34	<i>Lepidotrichilia volkensii</i>	Meliaceae	1	0	0.29	1	0.408163
35	<i>Malacantha alnifolia</i>	Sapotaceae	2	0.01	0.59	2	0.816327
36	<i>Maytenus senegalensis</i>	Celastraceae	12	0.04	3.53	11	4.489796
37	<i>Moringa stenopetala</i>	Moringaceae	1	0	0.29	1	0.408163
38	<i>Piliostigma thonningi</i>	Caesalpinaceae	2	0.01	0.59	2	0.816327
39	<i>Pterocarpus lucens</i>	Fabaceae	10	0.03	2.94	5	2.040816
40	<i>Ritchiea albersii</i>	Capparidaceae	1	0	0.29	1	0.408163
41	<i>Sterculia africana</i>	Sterculiaceae	34	0.1	10	33	13.46939
42	<i>Sterospermum kuntheanum</i>	Bignonaceae	1	0	0.29	1	0.408163
43	<i>Tamrindus indica</i>	Caesalpinaceae	5	0.01	1.47	5	2.040816
44	<i>Trichilia emetica</i>	Meliaceae	10	0.03	2.94	7	2.857143
45	<i>Vangueria madagascariensis</i>	Rubiaceae	1	0	0.29	1	0.408163
46	<i>Vitellia paradoxa</i>	Sapotaceae	1	0	0.29	1	0.408163
47	<i>Ziziphus mucronata</i>	Rhamnaceae	4	0.01	1.18	4	1.632653
48	<i>Ziziphus spina-chrisiti</i>	Rhamnaceae	11	0.03	3.24	5	2.040816
	<b>Total</b>		<b>340</b>	<b>1</b>	<b>100</b>	<b>245</b>	<b>100</b>

**Appendix 6.** Mean basal area, Dominance and relative dominance of tree species of Beschillo and Blue Nile Riverine Vegetation

	<b>Tree species</b>	<b>Family</b>	Mean BA	No.	Dominance	r. domi(%).
1	<i>Acacia etbaica</i>	Fabaceae	0.077827	12	0.93393	2.50445
2	<i>Acacia robusta</i>	Fabaceae	0.070138	15	1.05207	2.82126
3	<i>Acacia persiciflora</i>	Fabaceae	0.039172	3	0.11751	0.31513

4	<i>Acacia polyacantha</i>	Fabaceae	0.106556	25	2.66389	7.14354
5	<i>Acacia seyal</i>	Fabaceae	0.054165	3	0.1625	0.43575
6	<i>Acacia tortilis</i>	Fabaceae	0.111228	22	2.44702	6.56199
7	<i>Acokanthera schimperi</i>	Apocynaceae	0.007342	4	0.02937	0.07876
8	<i>Allophylus rubifolius</i>	Sapindaceae	0.025434	1	0.02543	0.0682
9	<i>Aningeria altissima</i>	Sapotaceae	0.18369	2	0.36738	0.98518
10	<i>Anogeissus leiocarpa</i>	Comberetaceae	0.128803	62	7.98581	21.4149
11	<i>Boscia salicifolia</i>	Capparidaceae	0.145324	5	0.72662	1.94852
12	<i>Boswellia papyrifera</i>	Burseraceae	0.043184	12	0.51821	1.38965
13	<i>Bridelia scleroneura</i>	Euphorbiaceae	0.266429	2	0.53286	1.42892
14	<i>Commiphora africana</i>	Burseraceae	0.016112	3	0.04834	0.12962
15	<i>Cassia sp.</i>	Fabaceae	0.025434	1	0.02543	0.0682
16	<i>Celtis africana</i>	Ulmaceae	0.158766	2	0.31753	0.8515
17	<i>Combretum adenogonium</i>	Combretaceae	0.257676	1	0.25768	0.69099
18	<i>Combretum collinum</i>	Combretaceae	0.041587	3	0.12476	0.33457
19	<i>Cordia africana</i>	Boraginaceae	0.05024	2	0.10048	0.26945
20	<i>Cordia sinensis</i>	Boraginaceae	0.011304	1	0.0113	0.03031
21	<i>Dalbergia melanoxylon</i>	Fabaceae	0.008674	2	0.01735	0.04652
22	<i>Diospyros abyssinica</i>	Ebenaceae	0.06767	24	1.62408	4.35517
23	<i>Diospyros mespiliformis</i>	Ebenaceae	0.036069	3	0.10821	0.29017
24	<i>Erythrina abyssinica</i>	Fabaceae	0.025434	1	0.02543	0.0682
25	<i>Ficus glumosa</i>	Moraceae	0.140705	5	0.70352	1.88659
26	<i>Ficus gnaphalocarpa</i>	Moraceae	0.113354	1	0.11335	0.30397
27	<i>Ficus sycomorus</i>	Moraceae	0.239122	2	0.47824	1.28247
28	<i>Ficus vasta</i>	Moraceae	0.507191	5	2.53595	6.80048
29	<i>Gardenia ternifolia</i>	Rubiaceae	0.008674	2	0.01735	0.04652
30	<i>Grewia mollis</i>	Tiliaceae	0.00785	1	0.00785	0.02105
31	<i>Kigelia africana</i>	Bignonaceae	0.108559	11	1.19414	3.20225
32	<i>Lonchocarpus laxiflorus</i>	Bignonaceae	0.045295	4	0.18118	0.48586
33	<i>Lannea fruticosa</i>	Anacardiaceae	0.009577	2	0.01915	0.05136
34	<i>Lepidotrichilia volkensii</i>	Meliaceae	0.028638	1	0.02864	0.0768
35	<i>Malacantha alnifolia</i>	Sapotaceae	0.006437	2	0.01287	0.03452
36	<i>Maytenus senegalensis</i>	Celastraceae	0.131466	12	1.57759	4.2305
37	<i>Moringa stenopetala</i>	Moringaceae	0.025434	1	0.02543	0.0682
38	<i>Piliostigma thonningi</i>	Caesalpinaceae	0.122656	2	0.24531	0.65784
39	<i>Pterocarpus lucens</i>	Fabaceae	0.188972	10	1.88972	5.06751
40	<i>Ritchiea albersii</i>	Capparidaceae	0.025434	1	0.02543	0.0682
41	<i>Sterculia africana</i>	Sterculiaceae	0.132245	34	4.49634	12.0575
42	<i>Sterospermum kuntheanum</i>	Bignonaceae	0.043536	1	0.04354	0.11675
43	<i>Tamrindus indica</i>	Caesalpinaceae	0.122452	5	0.61226	1.64185
44	<i>Trichilia emetica</i>	Meliaceae	0.205453	10	2.05453	5.50949

45	<i>Vangueria madagascariensis</i>	Rubiaceae	0.020096	1	0.0201	0.05389
46	<i>Vitellia paradoxa</i>	Sapotaceae	0.002826	1	0.00283	0.00758
47	<i>Ziziphus mucronata</i>	Rhamnaceae	0.072272	4	0.28909	0.77522
48	<i>Ziziphus spina-chrisiti</i>	Rhamnaceae	0.044837	11	0.49321	1.3226

**340 37.2908 100**

**Appendix 7.** Importance value Index (IVI) of each tree species of Beschillo and Blue Nile Riverine Vegetation resulted from the sum of relative density, relative frequency and relative dominance.

Tree species	Family	r.dens.(%)	r.frq.(%)	r. domi(%)	IVI
<i>Acacia etbaica</i>	Fabaceae	3.529412	4.081633	2.504448	10.1
<i>Acacia robusta</i>	Fabaceae	4.411765	4.081633	2.821258	11.3
<i>Acacia persiciflora</i>	Fabaceae	0.882353	1.22449	0.31513	2.42
<i>Acacia polyacantha</i>	Fabaceae	7.352941	5.306122	7.143545	19.8
<i>Acacia seyal</i>	Fabaceae	0.882353	1.22449	0.435751	2.54
<i>Acacia tortilis</i>	Fabaceae	6.470588	5.714286	6.561993	18.7
<i>Acokanthera schimperi</i>	Apocynaceae	1.176471	1.632653	0.078757	2.89
<i>Allophylus rubifolius</i>	Sapindaceae	0.294118	0.408163	0.068204	0.77
<i>Aningeria altissima</i>	Sapotaceae	0.588235	0.816327	0.985175	2.39
<i>Anogeissus leiocarpa</i>	Comberetaceae	18.23529	12.65306	21.41493	52.3
<i>Boscia salicifolia</i>	Capparidaceae	1.470588	1.632653	1.948525	5.05
<i>Boswellia papyrifera</i>	Burseraceae	3.529412	4.081633	1.389648	9
<i>Bridelia scleroneura</i>	Euphorbiaceae	0.588235	0.816327	1.428925	2.83
<i>Commiphora africana</i>	Burseraceae	0.882353	1.632653	0.12962	2.64
<i>Cassia sp.</i>	Fabaceae	0.294118	0.408163	0.068204	0.77
<i>Celtis africana</i>	Ulmaceae	0.588235	0.816327	0.851503	2.26
<i>Combretum adenogonium</i>	Combretaceae	0.294118	0.816327	0.690991	1.8
<i>Combretum collinum</i>	Combretaceae	0.882353	0.408163	0.334566	1.63
<i>Cordia africana</i>	Boraginaceae	0.588235	0.816327	0.26945	1.67
<i>Cordia sinensis</i>	Boraginaceae	0.294118	0.408163	0.030313	0.73
<i>Dalbergia melanoxylon</i>	Fabaceae	0.588235	0.816327	0.046522	1.45
<i>Diospyros abyssinica</i>	Ebenaceae	7.058824	5.306122	4.355171	16.7
<i>Diospyros mespiliformis</i>	Ebenaceae	0.882353	1.22449	0.290172	2.4
<i>Erythrina abyssinica</i>	Fabaceae	0.294118	0.408163	0.068204	0.77
<i>Ficus glumosa</i>	Moraceae	1.470588	2.44898	1.886587	5.81
<i>Ficus gnaphalocarpa</i>	Moraceae	0.294118	0.408163	0.303973	1.01
<i>Ficus sycomorus</i>	Moraceae	0.588235	0.816327	1.282473	2.69

<i>Ficus vasta</i>	Moraceae	1.470588	1.632653	6.800476	9.9
<i>Gardenia ternifolia</i>	Rubiaceae	0.588235	0.816327	0.046522	1.45
<i>Grewia mollis</i>	Tiliaceae	0.294118	0.408163	0.021051	0.72
<i>Kigelia africana</i>	Bignonaceae	3.235294	2.040816	3.202246	8.48
<i>Lonchocarpus laxiflorus</i>	Fabaceae	1.176471	1.22449	0.48586	2.89
<i>Lannea fruticosa</i>	Anacardiaceae	0.588235	0.816327	0.051364	1.46
<i>Lepidotrichilia volkensii</i>	Meliaceae	0.294118	0.408163	0.076795	0.78
<i>Malacantha alnifolia</i>	Sapotaceae	0.588235	0.816327	0.034523	1.44
<i>Maytenus senegalensis</i>	Celastraceae	3.529412	4.489796	4.230497	12.2
<i>Moringa stenopetala</i>	Moringaceae	0.294118	0.408163	0.068204	0.77
<i>Piliostigma thonningi</i>	Caesalpinaceae	0.588235	0.816327	0.657836	2.06
<i>Pterocarpus lucens</i>	Fabaceae	2.941176	2.040816	5.067511	10
<i>Ritchiea albersii</i>	Capparidaceae	0.294118	0.408163	0.068204	0.77
<i>Sterculia africana</i>	Sterculiaceae	10	13.46939	12.05749	35.5
<i>Sterospermum kuntheanum</i>	Bignonaceae	0.294118	0.408163	0.116748	0.82
<i>Tamrindus indica</i>	Caesalpinaceae	1.470588	2.040816	1.641854	5.15
<i>Trichilia emetica</i>	Meliaceae	2.941176	2.857143	5.509488	11.3
<i>Vangueria madagascariensis</i>	Rubiaceae	0.294118	0.408163	0.05389	0.76
<i>Vitellia paradoxa</i>	Sapotaceae	0.294118	0.408163	0.007578	0.71
<i>Ziziphus mucronata</i>	Rhamnaceae	1.176471	1.632653	0.775221	3.58
<i>Ziziphus spina-chrisiti</i>	Rhamnaceae	3.235294	2.040816	1.3226	6.6

**Appendix 8.** Basal area (BA), BA/ha and percentage BA of trees individuals of Beschillo and Blue Nile Riverin Vegetation

	<b>Tree species</b>	<b>BA</b>	<b>BA/2.96</b>	<b>BA%</b>
1	<i>Acacia etbaica</i>	1.867859	0.63103	4.999216
2	<i>Acacia robusta</i>	1.053095	0.35578	2.818547
3	<i>Acacia persiciflora</i>	0.117515	0.0397	0.314521
4	<i>Acacia polyacantha</i>	2.151148	0.72674	5.757424
5	<i>Acacia seyal</i>	0.162495	0.0549	0.434908
6	<i>Acacia tortilis</i>	1.890881	0.63881	5.060833
7	<i>Acokanthera schimperi</i>	0.029369	0.00992	0.078605
8	<i>Allophylus rubifolius</i>	0.025434	0.00859	0.068073

	<b>Tree species</b>	<b>BA</b>	<b>BA/2.96</b>	<b>BA%</b>
9	<i>Aningeria altissima</i>	0.36738	0.12411	0.983271
10	<i>Anogeissus leiocarpa</i>	7.564913	2.55571	20.24705
11	<i>Boscia salicifolia</i>	0.726621	0.24548	1.94476
12	<i>Boswellia papyrifera</i>	0.518211	0.17507	1.386963
13	<i>Bridelia scleroneura</i>	0.532858	0.18002	1.426164
14	<i>Commiphora africana</i>	0.064449	0.02177	0.172493
15	<i>Cassia sp.</i>	0.025434	0.00859	0.068073
16	<i>Celtis africana</i>	0.317533	0.10727	0.849857
17	<i>Combretum adenogonium</i>	0.515353	0.17411	1.379311
18	<i>Combretum collinum</i>	0.124762	0.04215	0.333919
19	<i>Cordia africana</i>	0.10048	0.03395	0.268929
20	<i>Cordia sinensis</i>	0.011304	0.00382	0.030255
21	<i>Dalbergia melanoxylon</i>	0.017349	0.00586	0.046432
22	<i>Diospyros abyssinica</i>	1.692472	0.57178	4.529803
23	<i>Diospyros mespiliformis</i>	0.108208	0.03656	0.289611
24	<i>Erythrina abyssinica</i>	0.025434	0.00859	0.068073
25	<i>Ficus glumosa</i>	0.703524	0.23768	1.882942
26	<i>Ficus gnaphalocarpa</i>	0.113354	0.0383	0.303385
27	<i>Ficus sycomorus</i>	0.478245	0.16157	1.279995
28	<i>Ficus vasta</i>	2.535954	0.85674	6.787336
29	<i>Gardenia ternifolia</i>	0.017349	0.00586	0.046432
30	<i>Grewia mollis</i>	0.00785	0.00265	0.02101
31	<i>Kigelia africana</i>	1.354921	0.45774	3.626368
32	<i>Lonchocarpus laxiflorus</i>	0.181181	0.06121	0.484921
33	<i>Lannea fruticosa</i>	0.019154	0.00647	0.051265
34	<i>Lepidotrichilia volkensii</i>	0.028638	0.00967	0.076647
35	<i>Malacantha alnifolia</i>	0.012874	0.00435	0.034457
36	<i>Maytenus senegalensis</i>	1.53176	0.51749	4.099666
37	<i>Moringa stenopetala</i>	0.025434	0.00859	0.068073
38	<i>Piliostigma thonningi</i>	0.245313	0.08288	0.656565
39	<i>Pterocarpus lucens</i>	1.889717	0.63842	5.057719
40	<i>Ritchiea albersii</i>	0.025434	0.00859	0.068073
41	<i>Sterculia africana</i>	4.49634	1.51903	12.0342
42	<i>Sterospermum kuntheanum</i>	0.043536	0.01471	0.116522
43	<i>Tamrindus indica</i>	0.73145	0.24711	1.957685

	<b>Tree species</b>	<i>BA</i>	<i>BA/2.96</i>	<b>BA%</b>
44	<i>Trichilia emetica</i>	2.054534	0.6941	5.498842
45	<i>Vangueria madagascariensis</i>	0.020096	0.00679	0.053786
46	<i>Vitellia paradoxa</i>	0.002826	0.00095	0.007564
47	<i>Ziziphus mucronata</i>	0.339786	0.11479	0.909419
48	<i>Ziziphus spina-chrisiti</i>	0.493208	0.16662	1.320044
	Total	<b>37.36303</b>	<b>12.6226</b>	<b>100</b>