1. INTRODUCTION

1.1. Definition of wetlands

Wetlands have been described as a "halfway world between terrestrial and aquatic ecosystems that exhibit some of the characteristics of each"(Maltby, 1986). They form part of a continuous gradient between uplands and open water. Wetlands are not easily defined because they have a considerable range of hydrologic conditions; they vary in size, location, and human influence (Davis, 1994). Wetlands tend to have seasonal and fluctuating conditions that make it difficult for one definition to adequately describe all wetland types (Dugan, 1990).

Wetlands have many distinguishing features, the most notable of which are the presence of water, unique wetland (hydric) soils, and vegetation adapted to, or tolerant of, saturated soils. Wetlands are environments subject to permanent or periodic inundation or prolonged saturation of their soils (Tiner, 1999). These conditions are suitable for the establishment of hydrophytes and/or the development of hydric soils or substrate (Tiner, 1999).

The Iternational Union for the Conservation of Nature and Natural Resources (IUCN), in the Convention on wetlands of international importance as waterfowl habitat (The Ramsar Convention Beureau, 1977), defined wetlands as:

> *"Areas of marsh, fens, peat land or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tides does not exceed six meters."*

The Ramsar Convention recognizes five major wetland systems (Ramsar Convention Bureau, 1997), while others identify up to seven main groupings (Dugan, 1990). The major Ramsar groupings are: marine (coastal wetlands); estuarine (deltas, tidal marshes, and mangroves), lacustrine (lakes and associated wetland); riverine (rivers, streams and associated wetlands), palustrine (marshes, swamps and bogs).

1.2. Distribution and classification of wetlands in Ethiopia

Wetlands are distributed all over the globe and estimated to cover about 6% of the earth's surface (Maltby, 1986). Although Africa is best known for its savannahs and hot deserts, 1% of its surface area (345,000 km^2) is covered by wetlands (Finlayson and Moser, 1991).

Because Ethiopia forms watershed between the Mediterranean and the Indian Ocean, it is often referred to as the "water tower of northeast Africa" (Leykun Abunie, 2003). Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems (Leykun Abunie, 2003). Ethiopia is well endowed with wetland resources consisting of lakes, marshlands, swamps, flood plains, rivers and river shores, ponds and dams. Most of these wetlands are found in highlands, above 1500 m a.s.l. mainly in Oromia, SNNP, and Amhara National Regional States (EWNHS, 1996).

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With the exception of coastal and marine related wetlands and extensive swamp forest complexes, all forms of wetland are represented in Ethiopia (EPA, 2006). Several attempts have been made to classify wetlands based on their distribution, habitat types and physical and biological characteristics.

Hillman (1993) listed 77 wetlands in Ethiopia and Eritrea, together with locations. He estimated that Ethiopian wetlands cover an area of 13,699 km^2 or 1.14% of the country's land surface. Ethiopian wetlands can be grouped into four major categories based on ecological zones, hydrological functions, geomorphologic formations and climatic conditions (EWNHS, 1996). These categories interlink to form four major biomes, which also describe climatic conditions in Ethiopia. These biomes are the Afro-tropical highlands, the Somalia-Masai, the Sudano-Guinea and the Sahelian Transition Zone groups (EWNHS, 1996).

Using the Directory of African wetlands as the basis, Ethiopian wetlands are classified into ten major groups, lakes being included (Hughs and Hughs, 1992). This classification system is based mainly on river and lake drainage systems. The classification scheme is not complete and needs revision. The classification scheme is, however, able to show the diversity of wetland types in the country. The classification excludes tidal and coastal wetlands because Ethiopia has no access to the sea. The ten groups of wetlands recognized following the classification system of Hughs and Hughs (1992) are:

(a). The lake Tana and associated wetlands (Tana, Fogera floodplains and Dombia floodplains).

(b). The Ashange and Hayk lakes.

(c). Wetlands of the Bale mountains (Numerrous alpine lakes including GabraGuracha swamps and floodplains.

(d). Wetlands of the western highlands (Keffa Zone wetlands, Ghibe and Gojeb and other wetlands in Illubabor).

(e). Lakes of Bishoftu (Zukala, Bishoftu lakes, etc.).

(f). Lakes and the associated wetlands of southwest rift valley (Lake Awassa, Ziway, Langano, Abijata, Shala, Abaya, Chamo, Chew bahir and Turkana).

(g). Lakes and swamps of the Awash River system (Lake Abe, Delta, the upper Awash valley-Dillu, Aba Samuel, etc.)

(h). Lakes of the Afar depression (Lake Afdera, Asale, Dallol depression).

(i). Western river floodplains (Baro, Akobo, Dabu swamp, Fincha swamp, etc.).

(j). Artificial impoundments and micro dams (Koka, Fincha, Melka-Wakena, Municipal and other reservoirs like dams, aquifers and wells).

1.3. Values and services of wetlands

Irrespective of the size and spatial distribution, wetlands contribute to the quality of life. The complex interactions between biotic (fauna and flora) and abiotic (soil, water, topography, etc.) components of wetland ecosystems make them among the earth's most productive systems (Dugan, 1990). They are described as "kidneys of the landscape" because of the functions they perform in hydrological and chemical cycles, and "biological supermarkets"

because of the extensive food webs and rich biodiversity that they support (Mitsch and Gossenlink, 1993). Dugan (1990) categorises the essential life support values and services provided by wetlands into three broad classes (i.e. functions, products and attributes). Table (1) summarizes the economic importance of wetlands and demonstrates that wetlands provide ecosystem services estimated to be worth at least $14, 785/ha/yr (Costanza *et al*., 1997).

Table 1: The economic value of ecosystems

Ecosystem	Area (million ha.)	Value US$/ha/yr	Global value USD Trillions/yr
Open ocean	33,200	252	8.4
Coastal	3,100	4,052	12.6
Tropical forests	1,900	2,007	3.8
Other forests	2,955	302	0.9
Grasslands	3,898	232	0.9
Wetlands	330	14,785	4.9
Lakes & rivers	200	8,498	1.7
Cropland	1,400	92	0.1

Source: Costanza *et al*., 1997

1.3.1. Functions of wetlands

These are indirect values of ecological functions, which maintain and protect nature and human system through services (Adamus *et al*, 1987).

1.3.1.1. Water purification

One of the most widely recognized functions of wetlands is their ability to reduce or remove nutrients from surface water or groundwater passing through the wetland (Illueca and Rast, 1996). A wide array of physical and biogeochemical processes in wetlands interact to provide a natural filtering mechanism in the watershed to maintain or enhance downstream water quality (Sather and Smith, 1984).

It is their unique combination of structural and functional attributes that sets wetlands apart from terrestrial and aquatic ecosystems in their ability to remove or sequester nutrients and toxic environmental contaminants (Sather and Smith, 1984). For example, wetlands provide

favorable conditions for settling of particulate matter (sediments): shallow water, low current velocity and the physical filtering action of plant stems and leaves (Kadlec and Kadlec, 1979). The resistance offered by vegetation and gradual slope of wetlands results in deposition of particles (Kadlec and Kadlec, 1979). Wetlands also provide physical support, or substrates, for a multitude of chemical and microbiological processes, promoting nutrient removal and storage within the micro-sites in the soil and vegetation cover (Adamus *et al*, 1987). The total surface area available for microbial activity in the soil and the overlying dead plant material (litter or detritus) is extremely high in wetlands (Lee *et al*., 1975). A considerable contact between water and sediments, because of the shallow nature of water column, leads to high level of sediment or soil and water exchanges (Hammer, 1992). The high plant productivity of many wetlands leads to high rate of mineral uptake by vegetation (Mitsch and Gosselink, 1986). Another important characteristic of wetlands is the presence of anaerobic (oxygen-depleted) soils during periods of flooding, which gives rise to an aerobic-anaerobic interface, or boundary, near the soil surface (Sather and Smith, 1984).

1.3.1.2. Ground water recharge and discharge

Ground water recharge occurs when water moves from the wetland into the underground aquifer. By the time it reaches the auifer, the water is usually cleaner than when it began to filter down from the wetland. Ground water discharge occurs when water that has been stored underground moves upward and becomes surface water. Some wetlands are sites of ground water discharge at one time of the year and they act as site of recharge at another time depening on the rise and fall of the local ground water table (Dugan, 1990). They act as 'banks' from where water may be drown and ground water replinshed (Dugan, 1990).

1.3.1.3. Flood and erosion control

Wetlands reduce flood damage by storing floodwater and slowly releasing it into downstream areas, thus lowering flood peaks (Dugan, 1990). The large surface area of wetlands allows precipitation and surface runoff to accumulate in a temporary holding basin.

1.3.1.4. Maintenance of biodiversity

They provide water and primary productivity upon which many species of plants and animals depend for survival. Thus, they play an important role in food web. They support high concentration of birds, mammals, reptiles, amphibians, fish, and invertebrate species. With their diverse and abundant vegetation, wetlands support many valuable species of fish and wildlife that thrive only in a wetland habitat (Maltby, 1986). When wetland plants die, specialized bacteria and fungi break down the plant tissues into minute fragments of nutrient rich detritus (Mitsch and Gosselink, 1986). The tide flushes out these bits of decaying material, making them available to finfish, shellfish, and invertebrates in the coastal and marine environments (Mitsch and Gosselink, 1986). These animals in turn can serve as food for larger wetland inhabitants such as herons and waterfowl. Still other species that do not inhabit wetlands feed upon fish and wildlife that originate in wetlands (Hammer, 1992). Many different types of wildlife use wetlands at some time during their life cycles (Maltby, 1986). Migratory birds use wetlands as stopovers (Hammer, 1992). Nesting waterfowl takes advantage of the cover provided by wetland vegetation. Many fish depend on wetlands for feeding and spawning, and as nursery areas for their young (Sather and Smith, 1984). Wetlands are home to a number of protected and endangered species (Kadlec and Kadlec, 1979). They are also important storehouses of plant genetic material (Dugan, 1990).

1.3.1.5. Contribution to biogeochemical cycling

Among the important biogeochemical functions provided by wetlands are sediment deposition, nitrogen and phosphorus removal and transformation of inorganic nutrients to organic forms. A wetland may function in the watershed as either a nutrient sink or source, providing net retention or release of nutrients to downstream waters (Preston and Bedford, 1988). Whether a wetland serves as sink or source depends on the biogeochemical characteristics, including soil and vegetation, within the wetland, as well as the rate of nutrient input from surface or groundwater sources (Preston and Bedford, 1988). Wetlands can also function as net transformers of nutrients from inorganic to organic forms (Sather and Smith, 1984). In many cases, nutrients entering wetlands are predominantly in dissolved inorganic form (e.g., nitrate, ammonium, phosphate) (Maltby, 1986). In contrast, nutrients

exported from wetlands are predominantly in organic form, a consequence of the copious production of dissolved and particulate organic matter within a wetland (Sather and Smith, 1984). The importance of wetlands as carbon and sulphur sinks appears to be of global significance (Hammer, 1992).

1.3.2. Attributes

These are the existence values, regardless of the present or future use possibilities. The attributes include diversity of species, aesthetic values in the landscape, cultural heritage, tourist attractions, bird watching, sailing, education and paleoecological study (Preston and Bedford, 1988). The natural beuty as well as the diversity of plant and animal life in many wetlands make them ideal locations for tourism (EPA, 2006). They are related to the religious activities, which constitute a source of aesthetic inspiration and form the basis of important local tradition (EPA, 2006).

1.3.3. Products

These are direct values and are sources of raw materials and products for consumption and sale. Wetlands in their natural state provide a range of products, which include domestic water from springs around the wetlands, water for washing clothes and reeds for thatching, crafts or floor covering, medicinal plants and cattle grazing during the dry season (Maltby, 1986). Wetlands produce fish, fuelwood, timber, fodder for domestic animals, and habitat for wetland dependent species.

1.4. Vaues of wetlands in Ethiopia

Though the functions, products and attributes of wetland ecosystems have not been valued as such (due to lack of awareness), there is no exception that these features cannot be operational in Ethiopia. With the majority of Ethiopia's population living in rural areas, the country's wetlands are vital sources of food, water supply, forage and grazing, irrigation during the dry season and reeds for thatching and making mats thereby sustaining the rural livelihoods and improving food security (Yilma Dellelegn, 2003). In some cases, the

livlihoods of low-income households, particularly those without land, depend on the incomes they earn from sale of sedges (Yilma Dellelegn, 2003). Sedges in Ethiopia are traditionally used as floor spread on holidays, specific cultural events and during the popular coffee ceremony.

The Ethiopian Wetland Research program has for three years been studying small valley-head and mid-valley wetlands in Illubabor Zone, which are being used for varying degrees for agriculture. Wetlands in most of southwestern Ethiopia have been subjected to drainage for dry season maize cultivation. In Illubabor, the rich can afford the alternative Tin roof , so the rest of the community is forced to search for roofing materials in wetlands. The reed cutting and selling is an important activity which poor men use to supplement inadequate food production or to meet cash needs. Collecting raw materials from wetlands for craft activities is also taken by poorer women who process the palm fronds and for basket and mat weaving. The wetlands in Illubabor are natural reservoirs of some of the regions major rivers, and contribute towards the maintenance of its biological diversity (Zerihun Woldu and Kumlachew Yeshitela, 2003). Other uses of wetlands include establishing coffee and tree nurseries on wetland fringes, clay collection for making pottery and use of bark from wetland trees for making ropes. Amongest other things, wetland ecosystem provide shelter to different categories of bird species of Ethiopia. These include: endemic, globally endangered, vulnerable, near threatened and data deficient species.

1.5. Threats and causes of wetland loss

Historically, wetlands were considered as wastelands that should be drained and changed to other forms to control disease and for agricultural activities (Maltby, 1986; Lean *et al.,* 1990; Beazley, 1993; Mitsch and Gossenlink, 1993). Destruction of these habitats was an accepted and encouraged act.

At its Regional Pan-African Meeting in 1998, Contracting Parties to the Ramsar Convention recognized that “in many cases, the greatest threat to wetlands is land use which does not take water conservation objectives into account, since the shortage of land makes wetlands a

target for gaining land through drainage" (Leykun Abunie, 2003). Wetland loss is evident whenever major developments such as dams, irrigation scheme and conversion projects are present in the developing world (WCED, 1987). While most of the threats that wetlands face result from their misuse, many are related to unsustainable resource extraction (Yilma Delelegn, 2003). Another important reason for their vulnerability is the fact that they are dynamic systems undergoing continual change (Barbier *et al*., 1996).

Dugan (1990) claims that 65% of wetland disturbances are of human origin, while the remainder has natural origins. Out of these, 73% of disturbances are believed to come from indirect sources (Table 2).

Table 2: Causes of wetland loss

Human actions		**Natural causes**
Direct	**Indirect**	Subsidence
Drainage	Sediment diversion	Sea level rise
Dredging	Subsidence	Drought
Filling		Hurricanes & storms
Conversion		Erosion
Construction		Biotic effects
Discharge		
Mining		

Source: Dugan, 1990

1.5.1. Threats and causes of wetland loss in Ethiopia

Wetlands are a very important aspect of the environmental resource base of Ethiopia. They produce a range of ecological and socioeconomic benefits in their natural state, which contribute to the well being of rural communities and the environmental security of the country (EPA, 2006). However, wetlands, such as, swamps, marshes floodplains and ponds, are often seen as wastelands that are unhealthy areas where various water borne diseases multiply (Leykun Abunie, 2003). They are converted by drainage to allow agriculture or grazing (Leykun Abunie, 2003). Such conversion may create some new benefits such as increased food production and grazing but will generally cause the loss of many other benefits. The causes of wetland degradation in Ethiopia include the conversion of wetlands for irrigation, agriculture, the expansion of human settlement, industrial pollution, pesticides and fertilizers and water diversion for drainage and the construction of dams (Yilma Dellelegn, 2003).

1.6. Vegetation resource of Ethiopia

Ethiopia has the fifth largest flora in Africa (Anonymous, 1997). The flora is very heterogeneous and has rich endemic elements owing to the diversity in climate, vegetation and terrain (Tewolde B.G. Egziabher, 1991). It is estimated to contain between 5,500-6,000 species of higher plants, of which about 10% are endemic (Tewolde B.G. Egziabher, 1991).

Despite these realities, the vegetation resources are disappearing at a very alarming rate in Ethiopia (Teshome Sormessa *et al*., 2004). If this trend continues, there is a great danger of serious decline or loss of biodiversity. Since the population is growing at a rate of about 3% per year, the need for more arable land to cultivate crops becomes inevitable, further aggravating the rate of devegetation and associated land degradation (Teshome Sormessa *et al*., 2004). It is therefore, urgent and important to study and document the vegetation resources of the country.

Based on the results of most of the vegetation resource studies (mainly that of Pichi-Sermolli, 1957), the various vegetation types of Ethiopia have been grouped into nine general categories for the purpose of developing the conservation strategy of Ethiopia. The nine vegetation types are: (1) Afro-Alpine and Sub-Afroalpine vegetation; (2) Dry-evergreen montane forest and montane grassland; (3) Montane evergreen thicket which is further divided into (a) Montane evergreen thicket and (b) Montane evergreen Scrub; (4) *Acacia-Commiphora* or small leaved deciduous woodland; (5) Moist evergreen forest; (6) Lowland Semi-evergreen forest; (7) *Combretum-Terminalia* or broad leaved deciduous woodland; (8) Desert and Semi-desert scrub land; and (9) Riparian and Swamp vegetation.

The vegetation sources of Ethiopia, including forest, woodlands and bushlands, have been studied by several authors Some of these are Tamrat Bekele (1993 and 1994b), Hedberg (1957), Gilbert (1970), Friis *et al*. (1982), Zerihun Woldu (1985), Friis (1986 and 1992), Sebsebe Demissew (1988), Zerihun Woldu *et al.* (1989), Zerihun Woldu and Mesfin (1990), Tamrat Bekele (1993 and 1994b), etc.

Studies on the vegetation of some wetlands of Ethiopia have been made taking different factors into consideration (Mitiku Tikisa *et al.,* 2003; Zerihun Woldu and Kumilachew Yeshitela, 2003; Yoseph Assefa and Melaku Wondafrash, 2004). Ensermu Kelbesa *et al*. (1992) noted that the riparian and swamp vegetation of Ethiopia is not properly studied and collected though there is a higher probability of finding endemic species. A study conducted by Zerihun Woldu and Kumlachew Yeshitela (2003) in eight wetlands of Illubabor suggests that there are many headwater wetlands in the area with *Cyperus latifolius* and *Aeschynomene abyssinica* as the original pristine community type.

A careful analysis of vegetation is a means of revealing important information about other components of an ecosystem (Goldsmith *et al*., 1986). Vegetation study may also aid in the selection and implementation of appropriate conservation and management plans for suitable use of ecosystems (Kershaw, 1973). Floristic data are relevant for establishing the present situation for environmental impact assessment and monitoring changes in ecosystem quality in terms of changing species composition (Groem *et al.,* 1994). Information on vegetation may be required to solve an ecological problem such as inputs to environmental impact assessments to monitor management practices or to provide the basis for prediction of possible future change (Kent and Coker, 1992).

Emergent conservation issues have highlighted the need for more information about the floristic composition of wetlands (Kershaw, 1961). A description of the plant communities around a wetland provides very useful information with respect to classifying the wetland and identifying important elements of plant biodiversity (Mitsch and Gosselink, 1986). In addition, assessment of the condition of wetland vegetation is an important tool for monitoring wetland health (Adamus *et al*., 1987). The dominance of particular species of vegetation in the landscape may provide an indication of hydrological or water quality changes that have taken place (Kadlec and Kadlec, 1979). Similarly, the dominance of a landscape by *Typha* tends to indicate disturbance in the landscape (Mallick and Wein, 1986).

1.7. Objectives of the study

1.7.1. General objectives

The major objective of this study is to determine floristic composition & diversity of wetland vegetation.

1.7.2. Specific objectives

1. To compile the floristic composition and diversity of the wetlands,
2. To identify plant community types in the wetlands,
3. To determne the relation between environmental variables and identified plant community types,
4. To determine the existing potential threats to the plant species of the study area, and
5. To recommend conservation measures for the vegetation in the area.

1.7.3. Research questions

1. What are the major plant communities?
2. What are the structures, composition, density, and distribution and cover abundance of plant species in the study area?
3. What are the dominant and common species?
4. What are the apparent correlations of the occurrence of various types of plant communities with environmental variables?
5. Which species would be classified as wetland dependent, wetland associated and non-wetland plants?

2. LITERATURE REVIEW

2.1. Plant community concept

A plant community is an organized complex having typical composition (floristic aspect) and structure (morphological aspect) that result from the interaction through time. A community is a sociological unit of any rank, occupying a territory and having a characteristic composition and structure. One of the characteristics of a community is its physiognomy, the way it appears. Physiognomy is largely a product of the predominant life forms of the organisms composing the community (Cain and Castro, 1959).

Kent and Coker (1992) view plant community as the collection of plant species growing together in a particular location that show a definite association or affinity with each other. Plant association is characterized by combination of different characteristic species, having a defined floristic composition in that association than the other association (Andreucii *et al.,* 2001). The idea of association implies that certain species are found together in certain locations and environments more frequently than would be expected by chance. The reason that certain species grow together in a particular environment will usually be because they have similar requirements for existence in terms of environmental factors such as light, temperature, water drainage and soil nutrients (Kent and Coker, 1992).

The concept of plant community include; the organismal concept, the community as super organisms; the individualistic concept (Gleason, 1926), the community as a changeable mixture of individualistically distributed plant species and the concept of population structure (Whittaker, 1970), the community as a system of interacting species and vegetation as a complex population pattern.

2.2. Theoretical view points on the nature of plant community

Regarding the structure of communities, two different views have been presented in the past. The first community concept is the organismic (the discrete community) concept or

community unit theory. This concept is also known as Clements view point. The second plant community concept is the individualistic (community continuity or continuum) concept. This concept is also called the Gleason's viewpoint of plant community.

The Clementsian school of thought considers communities as discrete units that can be identified and defined. The Clementsian School, understands communities as super organisms that have their own life and structure as well as their own temporal and spatial limits (Chapman and Reis, 1992; Brown and Lomolino, 1998). The Gleason's concept viewed plant communities as continuous entities (Lewis and Tayler, 1997). Gleason (1926) viewed all plant species distributed as a continuum. He argued that species respond individually to variation in environmental factors and those factors vary continuously in both space and time. Whittaker (1975) viewed that plant community's change gradually along complex environmental gradients, so that no distinct association of species can be identified. However, recently, Collins and Roberts (1993) have proposed a "hierarchical continuum" concept of the community patterns, which reconcile the two views. These community concepts are briefly discussed as follows.

2.2.1. Organismic (discrete) community concept

This concept states that the plant communities are clearly recognizable and definable entities, which repeat themselves with great regularity over a given region of the earth's surface (Clements, 1928). The discrete community unit theory implies the existence of distinct communities (Walter, 1971). The distinct vegetation of each area represents a distinct community, which is separated by sharp vegetation transition from other communities (Ricklefts, 1997).

Species belonging to a community are closely associated with one another implying, the ecological limits distribution of each species will coincide with the distribution of the community as a whole (Burbour *et al*., 1987). The discrete community concept predicts that the distribution of species along certain gradients, groups of species or communities would replace one another (Shipley and Keddy, 1987). Within each grouping, most species have

similar distributions and the end of one group coincides with the beginning of another (Shipley and Keddy, 1987).

For discrete communities to exist they must show discontinuities over the continuous environmental template (Robert, 1987). Within this community unit concept, the plant community is the basic unit, and may be represented by a group of relatively homogeneous samples classified based on floristic similarity into a hierarchical table (Palmer and Van Staden, 1992). Therefore, the existence of each community could be attributed to the competition and exclusion of other less competitive ones by few dominant species (Roberts, 1987 and Paul, 1993).

2.2.2. Individualistic (continuum) concept

Plant species respond individually to variation in environmental factors (Gleason, 1926) and those factors vary continuously in both space and time. Every species has a different distribution or tolerance range and abundance (Gleason, 1926). The assemblage of plants growing in an area is not only the result of environmental conditions but also species migration. The success of these species depends on the combination of environmental factors at that site and the tolerance range of the invading species (Grime, 1997). Gleason argued that the range of permutations of combinations of environmental factors together with the different tolerance ranges of the species, would always give a different combination and abundance of species (Kent and Coker, 1992).

The individualistic concept implies the gradual distribution pattern in plant communities. This may be due to many environmental factors like moisture, temperature, light, and soil condition (Ricklefts, 1997). In this concept communities replace one another (Cloessen *et al*., 1994) and distribution of one species within each group has similarity and the end of one group becomes the beginning of another.

The continuum concept suggests that plant community's change (in their composition) gradually along the complex environmental gradients and hence identification of distinct community association is not possible (Collins and Roberts, 1993). The distribution centers

and species range boundaries are widely scattered so that no groups of species would aggregate to form a distinct community unit (Burbour *et al*., 1987). Rather each species has its own physiological tolerance limit to environmental variables and the environmental variables would also fluctuate and vary across partial scales (gradients).

Both concepts (discrete and continuum) emphasize an environmental factor giving little attention to the modification effect of the vegetation and their subsequent influence on the pattern of community (Roberts, 1987).

As indicated by Shipley and Keddy (1987), the dichotomy should be avoided since both hypotheses do not exhaust the natural community patterns but they are competing rather than complementing as well as dealing with a special case of dynamical system (Roberts, 1987). Therefore, the need for a hypothesis that incorporates the two different views with regard to the existence of natural patterns of a community became crucial. Collins and Roberts (1993) developed the hierarchical continuum concept, with regard to the distribution patterns of plant communities. The hierarchical continuum concept can be viewed as an attempt to incorporate both hypotheses and the pattern of community organization may take hierarchical structure.

Thus, the hierarchical continuum concept assumes that some species will have a wider distribution, others localized, and still some others will have a much-restricted distribution across the sample area. Hence, the distribution pattern and abundance of species assumes a hierarchical structure where species with wider, intermediate and restricted distribution ranges show some kind of hierarchy than a continuum or discrete.

2.3. Diversity indices

Ecologists have been devising different diversity indices (Pielou, 1969; Greig-Smith, 1983). A large number of indices have been devised each of which seeks to express the diversity of a sample or quadrat by a single number (Kent and Coker, 1992). Recently the use of parametric families of diversity indices was proposed instead of a diversity index with a

numerical value (Bela, 1995). Of the various indices, the most frequently used is the simple totaling of species numbers to give species richness (Magurran, 1988). However, the most applicable index is Shannon-Weaner index of diversity (Tramer, 1974 and Greig-Smith, 1983).

2.4. Techniques for analyzing vegetation data

Multivariate techniques have been developed to study the complex nature of plant communities. Techniques of summarizing and arranging the available information are necessary since they are the basis for comparing the information with environmental and other factors affecting the composition of vegetation (Greig-Smth, 1983). In aiming for a detailed floristic vegetation description, two major approaches can be distinguished. These are the releve analysis for classification and the continuum analysis for ordination (Mueller-Dombois and Ellenberg, 1974). These two approaches towards vegetation study are based on different concepts of the essential nature of vegetation. Classification aims at grouping individual stands into categories. The stands that are similar to one another form one class, which is separated from other classes that also consists of similar stand (Mueller-Dombois and Ellenberg, 1974). This method emanated from the belief that vegetation is composed of certain distinct and fairly discrete plant communities (the concept of community unit theory) (Whittaker, 1962 and 1967; Shimwell, 1971). The properties common to a group of similar stands in a class are then abstracted to serve as description of that class.

In contrast, an ordination is believed to have developed from the concept of vegetation as a continuum. It aims at portraying the individuality of each stand. Demonstrating the similarity does this or dissimilarity of all stands to one another (Kershaw, 1973; Mueller-Dombois and Ellenberg, 1974). In spite of their differences, both methods compete in obtaining a thorough description of a restricted vegetation region or widely distributed vegetation information.

In the past, although there has been considerable controversy between the applications of these techniques by ecologists, it is now generally recognized that both classification and ordination techniques could be appropriately applied to the same vegetation data and that the

choice between the two approaches depends on the ecological question to be answered (Greig-Smith, 1983). Stands sampled for classification can be subjected to ordination, while stands sampled for an ordination can also be classified. Both methods are complementary in their treatment of sample data (Mueller-Dombois, 1974).

Similarly, Zerihun Woldu and Backeus (1991) in the study of shrub land vegetation of western Shewa and Tamrat Bekele (1994a), in his studies on remnant afromontane forests of the central plateau of Shewa employed the same techniques.

2.5. **Aboveground biomass**

The production of primary producers is defined as the rate at which energy is bound or organic material created by photosynthesis per unit area of vegetation on the earth's surface per-unit time (Ewusie, 1980). Productivity can be measured in terms of dry weight per square meter area per year or other given period. Standing crop is the dry weight of plant material present in a system at a given period of time (Zerihun Woldu, 1985). Thus, production values can be estimated from standing crop values in some circumstances.

If samples of vegetation are taken from adjacent plots at different time, an increase in biomass between the first and the second harvest is known as the yield or productivity of the species and the community (Kent and Coker, 1992).

Determining primary productivity and studies of competition between plant species often require information on the quantities of plant tissue present in a quadrat (Kent and Coker, 1992). Biomass or standing crop is the amount of plant material present in a quadrat at a given time (Kent and Coker, 1992). The figure is obtained by clipping the aboveground vegetation using secateurs and sorting the resulting crop into species.

In many cases, only the aboveground herbaceous phytomass has been studied since the study of belowground phytomss is difficult and time consuming to measure (Isichei, 1982; Lamotte and bourliere, 1983). The most widely used method of clipping aboveground herbaceous

vegetation phyto-mass is cutting to the base (Mayhew *et al.,* 1984; cited in Zerihun Woldu, 1985).

Ideally, root biomass and yield should also be measured but this can be done only with great difficulty. No completely satisfactory method of assessing root biomass exists, although methods such as coring followed by estimation of the volume of roots in the core and techniques involving the washing of roots have been tried. All methods are extremely time consuming.

Several factors have been reported to affect herbage yields. For example, in more humid regions, the maximum standing crop of the herbaceous layer usually reaches higher value than in semi-arid areas.

3. MATERIALS AND METHODS

3.1. Description of study area

3.1.1. Geographical location

Kefa zone is one of the zones found in Southern Nations Nationalities and Peoples Regional State (SNNPRS). It consists of ten weredas namely Gimbo, Chena, Decha, Tello, Gawata, Bita, Gesha, Menjiyo, Saylem, and Cheta. The study area is found within the geographic location of $06^0$35' to $07^0$15'North and $35^0$25' to $36^0$42'E (RDCMD, 2003) within Tello Wereda. The map of the study area is shown in Fig. 1.

Due to the vastness of the Kefa zone, time, labor and budget and other constraints, the research work focused on six wetlands in Tello Wereda. The study sites include Shupa swamp ($07^0$09'N, $036^0$25'E); Dinger (Megera) swamp ($07^0$05'N, $036^0$30'E); Ada swamp, ($07^0$02'N, $036^0$29'E); Shashele swamp ($07^0$02'N, $036^0$29'E); Kitima swamp ($07^0$02'N, $036^0$29'E) and Kureba swamp ($07^0$05'N, $036^0$30'E).

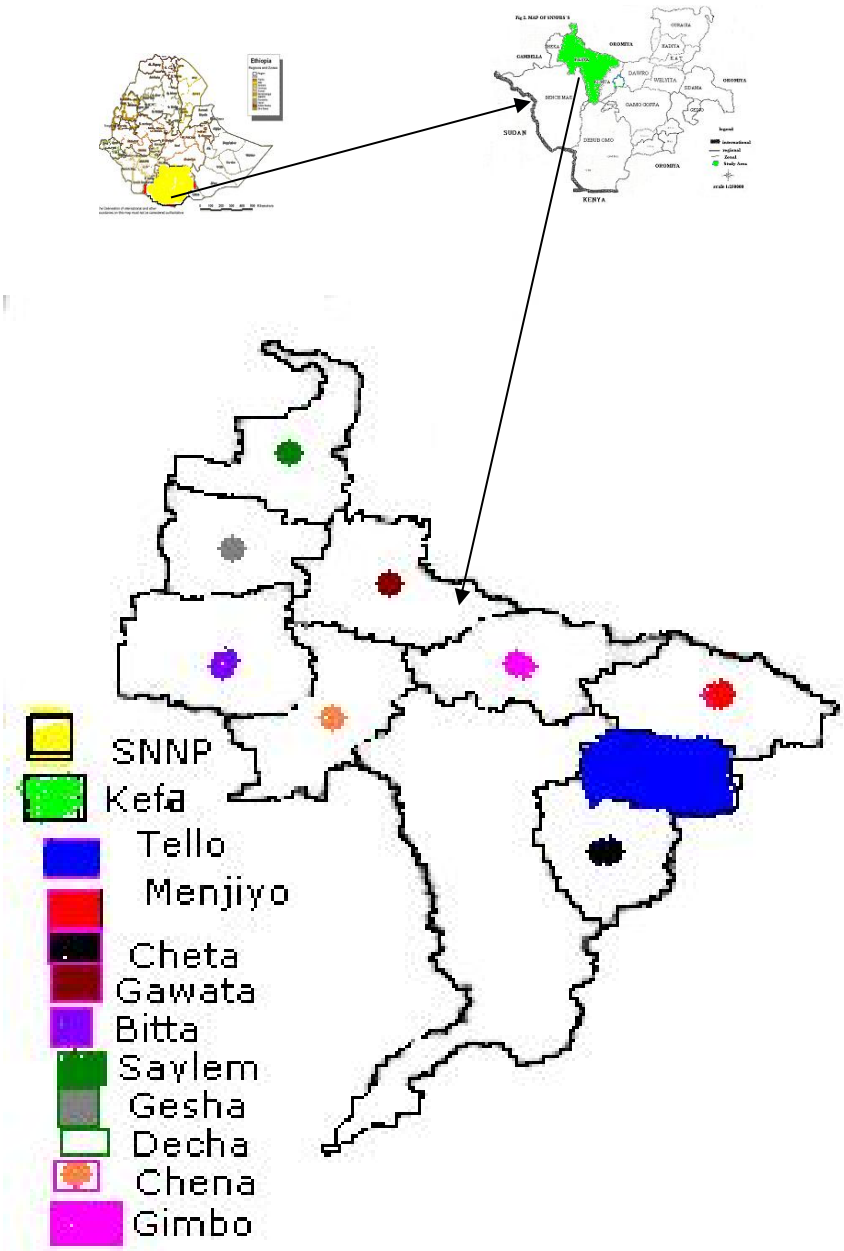


Fig. 1. Map showing the study area (shown in blue color) in Kefa zone (Source: Kefa Zone, Finance & Economic Development Coordination Main Department).

3.1.2. Geology

The oldest known rocks in Ethiopia are of Precambrian origin (Mohr, 1971) and over 600 million years old. Because these rocks (Pre-Cambrian rocks) underlie all other rocks, they are called the basement complex. The Kefa highlands comprise a great thikness of Tertiary basalts, which overlie the basement complex (Mohr, 1971). In this region, crystalline basement rocks are exposed in some places (Davidson, 1983). The topography in this region is characterized by undulatig surfaces (Mohr, 1971).

Throughout its geologic history, Southwest Ethiopia has been affected by rifting volcanism, and its position at the edge of the Ethio-Arabian uplift than by marine transgression (Davidson, 1983). Precambrian basement rock and trap series volcanic are evident, while Mesozoic Sedimentary formations are virtually absent. The Pre-Cambrian complex is made up of several different kinds of metamorphic rocks in three domains.

3.1.3. Soil

In Kefa and other parts of southwest Ethiopia, soils are predominantly developed on Trap series volcanic felsic and Metamorphic Precambrian material (FAO, 1984). The range of parent materials on the highland plateau is not strongly reflected in soil development because of high rainfall, greater than 2220 mm during some years (FAO, 1984). This situation, therefore, has resulted in very similar soils irrespective of parent materials, and the predominant soil is one of Dystric Nitosols and Orthic Acrisols, with the inclusion of Dystric Cambisols (FAO, 1984). Dystrict Nitosol, which is suitable for agricultural activity, is found in most of the area. Since agricultural is undertaking in wetlands, the type of soils in these particular areas may be also Dystrict Nitosol.

3.1.4. Climate

Seasonal variation in pressure systems and air circulation seem to determine the seasonal distribution of rainfall in Ethiopia (Daniel Gamachu, 1977). According to Daniel Gamachu (1977), there exists 14 rainfall regimes in Ethiopia, which fall into two main types, and the Kefa highlands come under type one that is characterized by contiguously distributed rainy months and evenly distributed rainfall. Southwest Ethiopia captures more rain than other

region in the horn of Africa and has the most even distribution of precipitation throughout the year (Friis, 1992). The southwest region of Ethiopia is the wettest with eight rainy months that extend from March to October (Daniel Gamachu, 1977; Kumilachew Yeshitela and Tamrat Bekele, 2002). According to Daniel Gamachu (1977), the annual rainfall of the highlands in southwest Ethiopia ranges from 1400 and 2200, mm and has even distribution through out the year (Friis, 1992). According to Hildebrand (2003), southwest Ethiopia gets more rainfall with even distribution through out the year because of two factors: (1) Moist Atlantic cells dump abundant moisture when they encounter the first major topography in thousands of kilometers, and (2) The southwestern Ethiopian highlands lie not at the extreme northern edge of the Inter-Tropical Convergence zone (ITCZ) but near the boundary of summer and bimodal rainfall system.

The climate diagram of Bonga, which is based on climate data obtained from the Ethiopian National Metrological Service Agency, indicate that the rainfall in the area is uni-modal, having one long rainy season. The peak is between April and September (Fig. 2).

The mean annual temperatures are between 15^0C to 25^0C, the mean daily temperature minima range from 9.7^0C to 16.3^0C and the corresponding maxima from 20^0C to 30.4^0C (Kumilachew Yeshitela and Tamrat Bekele, 2002). From the climate diagram, maximum average annual temperature is 20.185^oc and maximum average annual rainfall is 207.72mm.

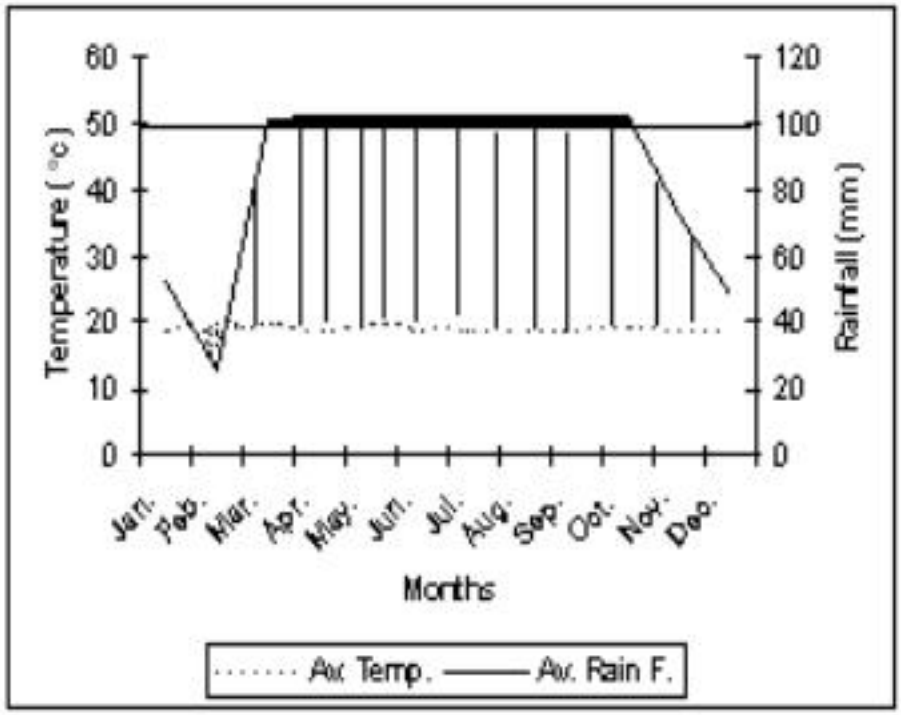


Fig. 2. Climate diagram of Bonga meteorological station, northeast and southwest of Tello Wereda (1996-2005). Source: Ethiopian National Meteorological Service Agency

3.1.5. Vegetation

Vegetation is the sum total of plants covering an area. It may be a forest with trees, under shrubs and herbs and the forest floor with mosses, fungi and lichens. It may consist of plants growing in marshes or of algae submerged in water, or of the sparsely spaced cacti of the desert, or of the crust like growth of lichens on other with bare rocks (Weaver *et al*., 1980).

Southwest Ethiopia contains a range of vegetation types according to elevation and substrate (Friis, 1992). The Kefa zone is one of the places in the country with a good vegetation cover. The forest in this area is one of the few remaining extensive tracts of primordial forests left in Ethiopia (Davidson, 1983). Out of the total land area of the zone, about 32.4%, which is some 388,522 ha, is covered with different vegetation types (RDCMD, 2003). This makes the zone to have relatively high vegetation cover in the country (RDCMD, 2003).

The wetlands of Tello Wereda are mostly composed of herbaceous *Cyperus* swamps (vegetation >1 m height) and marsh communities (vegetation <1 m height) dominated by *Cyperus* and grass species. Floristically, the core study wetlands are dominated by members of the family Cyperaceae (sedges), Poaceae (grasses) and Asteraceae together with some tree species such as *Syzygium* and *Erythrina* and shrubs such as *Maytenus.*

3.1.6. Population and land use

As of July 2004, the human population of Kefa Zone was estimated to be 792,097, out of which 725,465 live in the rural area and the remaining 66,632 live in Bonga and other small village towns in the zone (FEDCMD, 2004). More than 90% of the populations live in rural areas and they depend mainly on agricultural activities for their existence. They practice mixed type of farming system (crop producing and animal rearing). The agricultural practice is enset-based mixed cultivation. The major subsistence crops cultivated include *enset,* maize, sorghum, beans and cabbage. Coffee is the main cash crop, except in areas at higher altitude where it does not grow naturally. Crops that are cultivated to generate income include teff, wheat, barley, sorghum, some legumes and tuber crops. The total land area of Kefa zone is estimated to be 1.2 million ha (RDCMD, 2003). Land is used exclusively for agriculture, and the Kafficho categorize their surroundings into different systems: home garden; crop field, fallow or grazing land, managed forest (private) and intact forest (government owned). Land use classification of Kaffa zone is shown in table 3.

Table 3: Land use classification of Kefa Zone

Land use	% Cover
Cultivated land	31.1
Forest	31.5
Bamboo forest	1.9
Bush and Shrub land	20.7
Land for other uses + wetlands	12.8

(Source: Kefa zone Agriculture and rural development office, 2005).

3.2. Vegetation sampling

Vegetation sampling to assess cover abundance of species in the wetlands of Kaffa, Tello Wereda, was conducted during the begnning of December 2005 (wet period) and during the end of January 2006 (dry period). The core study sites were at Ada, Shashele, Kitima, Dingera, Kureba and Shupa swamps.

From a ventage point that would enable one to view the entire wetland, the major community types in the wetland were noted. After the major vegetation pattern has been identified, the place where transect could be laid out to represent the community types found in the wetland was determined systematically.

Systematic sampling was employed following Muller-Dombois and Ellenberg (1974). Sampling was performed along transects. Transects were selected to represent the variation in wetlands. Transects were laid out systematically across the six study sites and selected to represent hydrological variations and habitat heterogeneity. More than one transect was set up across most of the wetlands. The number of transects depends on the size of wetland and the variation observed. Transects were laid from about the middle of the wetland and extended to the ecotone along the edge of the wetland to include those wetland plant species that are not completely within the wetland.

The size of the sample was determined by the structure of the vegetation under study. Along each transect quadrat size of 4 m x 4 m (16 m^2) were used to sample wetland vegetation. Quadrats were laid adjacent to each other. A total of 14 transect and 105 quadrats were placed across the wetland during wet periods and 12 trnasects and 85 quadrats were placed during dry periods. These samples included some quadrats from the transition between the wetlands and the adjacent farmlands. Only those quadrats, which were entirely within the wetland, were used for the wetland vegetation analysis (i.e. a total of 88 and 77 quadrats were sampled for wet and dry seasons respectively). Detail of sampling regions in the welands in both seasons is given in Table 4 and Table 5.

Table 4: Details of sampling regions in the wetlands in the wet season.

Wetland sites	No. of transects	No. of quadrats
Kitima	3	20
Ada	3	17
Shashele	2	11
Dingera	1	7
Shupa	4	26
Kureba	1	7
Total	14	88

Table 5: Details of sampling regions in the wetlands in the dry season.

Wetland sites	No. of transects	No. of quadrats
Kitima	3	24
Ada	3	19
Shashele	2	9
Dingera	1	6
Shupa	2	13
Dingera	1	6
Total	12	77

In each sample plot, all vascular plant species were recorded and the percentage aerial cover/abundance of each species was estimated. This was later converted to 1-9 scale following the modified Braun-Blanquette method by Van der Maarel (1979) as follows:

1=Rare, generally one individual

2=Occasional, with less than 5% cover

3=Abundant, with less than 5% cover

4=Very abundant, with less than 5% cover

5=5-12% cover

6=12.5-50% cover

7=25.5-50% cover

8=50.5-75% cover

9=above 75% cover

Within each quadrat, the plant species and growth form were recorded. Knowledgeable traditional elders were interviewed on the vernacular plant names and use of wetland plants and information was gathered. Voucher specimens were collected, coded, pressed, dried for subsequent identification or verification made at the National Herbarium (ETH) of Addis

Ababa University, by comparing with the previously identified specimens in the ETH and with reference to the published volumes and unpublished manuscripts of Flora of Ethiopia and Eritrea and Flora of other neighboring countries. The specimens have been stored at the Herbarium for future reference. Whenever specimens or study sites of particular interest were encountered, photographs were taken.

An inventory of plant species was conducted in all wetlands considered for the study in both seasons. All microhabitats were visited in order to capture the variability that may have been missed in the systematic and random sampling. Wetland plants will be classified as wetland dependent, wetland associated and non-wetland plants. This was done by following the procedure used by Zerihun Woldu and Kumlachew Yeshtela (2003) on the classification of wetland plants collected from Illubabor Zone and other publications that incorporated wetland plant classifications.

The biodiversity values were calculated for the six wetlands. The method combines both species richness or the total number of species recorded and scarcity value or the rarity of each species recorded at the site (Omoding *et al.,* 1996 cited in Zerihun Woldu and Kumilachew Yeshitela, 2003). Each species was given a biodiversity value of 1.0, but its contribution to the biodiversity value of any particular site depends on the total number of sites in which the species was encountered. If for example, the species was recorded in 5 out of 20 sites studied, it contributes only a 0.25 biodiversity value to each of the 5 study sites and none to the rest of the sites. The sum of the biodiversity value contributions of the individual species at the site gives the biodiversity value of that site (Zerihun Woldu and Kumilachew Yeshitela, 2003).

3.3. Environmental data

Environmental data on topographic parameters such as altitude and position for each plot was measured with altimeter and GPS-48 respectively. At each site, disturbance ratings were recorded for grazing, cultivation, water enrichment and trampling. The ratings were based on physical evidence of the site (e.g. soil irregularities, additional water source, defoliation and

dung presence). Water enrichment refers to sites receiving additional runoff and thus experiencing increased potential of productivity continuously. Based on contribution of different environmental variables to variation in species composition, altitude and aspect (position) were recorded. No data on soil properties and nutrient status was collected due to limited resources.

3.4. Biomass sampling

Biomass was sampled during dry season in each wetland site, although the biomass data is considered as not only as dry season data. At each sampling site, all the aboveground vegetation of homogeneous quadrats of 1 m^2 (placed at the center of each quadrat 4 m^2) was clipped at the base using secateur. Whenever highly disturbed quadrats encountered, taking the aboveground biomass was avoided.

Clipping of all the aboveground vegetation was done to capture those plant species that contribute to the biomass accumulation and sequestration of photosynthetic products. The method was chosen to achieve a balance between time and accuracy. Determination of belowground biomass was not done because often the time available for survey and the amount of the data that can be collected will be limited by seasonality of climate or wheather conditions and resources available for survey. The maximum that the best and most suitable quality of data must be collected in the minimum or available time is a useful one to apply (Kent and Coker, 1992).

The species were clipped when the vegetation was sampled for description of the communities during the dry season. After clipping, the plants were sorted into species and were then dried at air temperature and packed in paper bags. These were then transported to the laboratory at Addis Ababa University. Because of the limited space in the oven, however, the large sized plant samples had been air dried, prior to oven drying. Oven drying was carried out at 100^0C during a period of 12 hours after which the plant material was weighed. Each sample was weighed using a beam balance. The average biomass of the species was then determined for each community.

Rank-abundance diagrams were drawn for the four dry community types in terms of biomass of the various species. The pi values are plotted in a logarithmic scale from the most abundant to the least abundant. In each figure, the biomass of each species is plotted on a logarithmic scale from the most dominant to the least dominant.

A rank abundance diagram can be drawn for the number of individuals or for the areas of ground cover by different sessile species or for the biomass contributed to a community by the various species. Three of the many forms that a rank abundance diagram can take are 'geometric series', the 'broken stick' model and 'log-normal' model. Broken stick model represents a more equitable distribution. Each species contributes to the total a fraction that can be represented by the fragments of a stick that has been broken at random points. Intermediate curves generally approximate to a lognormal distribution. Geometric series represents the least equitable distribution of resources among species.

3.5. Data analysis

Analysis of vegetation data was done using a computer program called SYNTAX-2000, multivariate numerical analysis. The percentage cover/abundance value of each species was converted into a modified 1-9 Braun-Blanquet scale and the data were subjected to Multivariate Numerical Analysis (Podani, 2000).

Similarity ratio was used as a resemblance index and average linkage was used to construct the dendrogram. Similarity ratio is one of the similarity indices, which measure the similarity or dissimilarity between vegetation samples or quadrats.

Average linkage is a polythetic agglomerative classification procedure where individuals or groups are fused into larger groups when their average similarity is greatest. In an average linkage, the distance between two clusters is the average distance between all possible pairs of stands, one in each cluster. Only 88 (from wet season) and 77 (from dry season) quadrats

from the transect sampling were analyzed in order to exclude those that are not completely included in the wetlands.

The mean cover value of each species in each cluster identified was calculated and the dominant species of the cluster that have higher mean cover value were then identified. Characteristic species are those species of the community type, which specifically differentiate one community type from the other by their presence. These are mostly restricted to a particular community type.

Statistical measurement regarding species richness and diversity was carried out using Shannon and Wiener (1949) diversity index. The mean cover of the species in the cluster was used as the input matrix. The Shannon diversity index is calculated from the formula:

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where S is the number of species

P is the proportion of the individuals of the ith species or the abundance of the ith species expressed as a proportion of total cover

H'is the Shannon diversity index

Ln= log $base_n$

Equitability (J), which determines the relative evenness of the species within the plant communities, was calculated. Species evenness measures the equity of the species in a given sample area. It should be noted here that H' is a good indication of the dominance of the community by one or a few species. This can however be related to the scale of disturbance. Equitability (evenness) is calculated using the following formula:

$$J = \frac{H'}{H'\max} = \frac{H'}{\ln S} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where J is the equitability (evenness)

H'_{max} is the maximum diversity index

H', ln, and S are the same as in formula (1) above

Rank-abundance diagrams were drawn for the community types in terms of proportional abundance of the various species against species rank. The pi values are plotted in a logarithmic scale from the most abundant to the least abundant.

4. RESULTS AND DISCUSION

4.1. Floristics

In total, 78 different species of vascular plants were found in the wetlands in the two seasons. Species nomenclature follows published volumes and unpublished manuscripts and Flora of Ethiopia and Eritrea

During the end of wet season sampling, 69 species of vascular plants, belonging to 28 families, were encountered in the six study sites. The families Cyperaceae, Poaceae, and Lamiaceae had the highest number of species, i.e. 13, 9 and 7 respectively.

During the dry season sampling, 56 species of vascular plants belonging to 27 families were recorded from the study sites. The families with the highest number of species during this period were Cyperaceae, Lamiaceae and Poaceae, i. e. 9, 8 and 6 respectively. The number of species recorded during wet and dry season is shown in Table 6.

Two main conclusions can be drawn from the information presented in Table 6. These are: (1) There are more species present in the wet season compared to the dry season. This is to be expected since the growth conditions for plant growth is better for annual species during the wet season rather than the dry season, and (2) Although not linear, there is an increase in species number with the level of disturbance. Ada and Kitima wetlands, for example, have more species compared to Kureba and Shashele during dry season. This is somewhat in line with the intermediate disturbance hypothesis which state that the intermidiate level of disturbance maximize species diversity because competitively dominant species exclude subordinate species at low disturbance, but too much of it leads to local extinction. This can be related to loss of wetland dependent species and addition of non-wetland species due to disturbance.

Table 6: Number of plant species, altitude and site conditions based on physical evidence of sites recorded per wetland during the two seasons.

Wetland	Wet season	Dry season	Altitude (m)	Level of disturbance				
				Grazing	Moisture Content	Trampling	Cultivation	Drainage
Kitima	17	23	2375	High	Low	High	Moderate	Low
Ada	31	24	2165	Moderate	High	High	Moderate	Moderate
Shashele	28	14	2273	Low	Low	Low	Low	None
Shupa	15	13	2052	Low	High	Moderate	High	Low
Dingera	20	11	2494	High	Low	High	High	Low
Kureba	7	15	2453	Low	Low	Low	Low	Low
Total	69	56						

4.2. Identification of plant communities

Three and four clusters representing plant communities, or assemblages, were recognized at higher hierarchical levels in the wet and dry season data sets respectively. These clusters were defined as the local community types, which have been named after two dominant species. The dry season communities are identified at similarity level between 0.7 and 0.6, while the wet season communities are identified at similarity ratio level between 0.72 and 0.62.

4.2.1. Wet season communities

The plant community types identified in the wet season at the six study sites based on the cluster analysis and the resulting Table 7 and Fig. 3 were described below. Based on the SYNTAX-2000 out put and ecological evaluation in the field, three community types (clusters) were identified. The plant community types were named after two dominant species, which occur in each group with relatively high mean cover/abundance values shown in bold (Table 9). Species such as *Alchemilla fischeri, Commelina diffusa*, *Cyperus dichroostachyus, Epilobium stereophyllum, Eriochloa fatmensis, Guizotia scarba, Impatiens ethiopica, Mentha spicata, Oenanthe palustris, Panicum maximum, Persicaria decipeins, Persicaria senegalensis, Schoenoplectus corymbosus*, and *Thelypteris confluens* were species occuring with high frequency (Appendix 3). Each of these species occurred in more than ten quadrats.

1. *Schoenoplectus corymbosus- Eriochloa fatmensis* community type.

The dominant species of this community type are *Schoenoplectus corymbosus* and *Eriochloa fatmensis*. *Schoenoplectus confusus, Panicum maximum* and *Isolepis costata* are other important species of this community type. This cluster consists of 18 quadrats of which 11 are from Shashele and the rest 7 are from Dingera.

2. ***Cyperus dichroostachyus-Persicaria decipiens* community type**

Cyperus dichroostachyus and *Persicaria decipeins* are the dominant species of this community type. The mean cover value table (Table 7) shows that following *Cyperus dichroostachyus* and *Persicaria deciepens*, *Oenanthe palustris* dominates this community type. This community is found in Ada, Kureba and Shupa.

3. *Cyperus dichroostachyus–Thelypteris confluens* community type.

The dominant species of this community type are *Cyperus dichroostachyus* and *Thelypteris confluens. Eriochloa fatmensis, Persicaria decipiens,* and *Schoenoplectus corymbosus* are other relatively dominant species of this community type. *Thelypteris confluens* is also an important characteristic species of this community type. Other characteristic species include *Hypericum scioanum, Koesteletzkya begonifolia*, *Polygonum afromontanum and Vernonia auriculifera*. This community type is dominant in Kitima and does not occur anywhere else.

Table 7: Synoptic table of vegetation with diagnostic species from wet season data

	Mean cover (%)		
Community type	**1**	**3**	**2**
Community size	**18**	**20**	**50**
Achyranthes aspera	.11111	.00000	.06000
Ajuga alba	.00000	.00000	.00000
Alchemilla cryptanta	.00000	.00000	.00000
Alchemilla fischerii	.00000	.25000	1.3000
Anemone thomsonii	.00000	.00000	.00000
Bidens prestinaria	.00000	.00000	.04000
Bracharia brinzantha	.22222	.00000	.00000
Carex conferata	1.1667	.00000	.12000
Carex monostachya	.38889	.00000	.00000
Centella asiatica	.94444	.00000	.00000
Chenopodium schraderianum	.27778	.00000	.40000
Commelina diffusa	**2.2222**	.00000	1.1400
Isolepis costata	**2.6111**	.55000	.00000
Panicum maximum	**2.4444**	.00000	.34000
Schoenoplectus confusus	**2.8333**	.30000	.00000
Schoenoplectus corymbosus	**4.8333**	**3.5000**	.30000
Eriochloa fatmensis	**3.0000**	**4.2500**	.64000
Thelypteris confluens	.00000	**5.9500**	0.0000
Cyperus dicroostachyus	.00000	**7.0000**	**6.7000**
Persicaria decipiens	1.8333	**3.5500**	**4.1200**
Impatiens ethiopica	.00000	0.0000	**2.4800**
Oenanthe palustris	.61111	0.0000	**3.7400**
Epilobium stereophyllum	.00000	1.95000	**1.7000**
Cyperus distans	.11111	.00000	.00000
Cyperus elegantulus	.00000	.00000	.24000
Cyperus mundtii	.44444	.00000	.00000
Cyperus longibracteatus	.00000	.00000	.20000
Cyperus rigidifolius	.33333	.00000	.00000
Cyperus triceps	.27778	.00000	.00000
Erythrina brucei	.00000	.25000	.10000
Guizotia scarba	.00000	.25000	.10000
Habenaria peristyloides	.00000	.00000	.50000
Hydrocotyle ranunculoides	.83333	.00000	.60000
Hypericum scioanum	.00000	1.0000	.00000
Impatiens hochstteri	.11111	.00000	.00000
Impatiens tinctoria	.00000	.00000	.10000
Ipomoea purpurea	.00000	.00000	.12000
Kosteletzkya begonifolia	.00000	.25000	.00000
Kyllinga odorata	.27778	.00000	.00000
Mentha aquatica	.00000	.00000	.28000
Momordica foetida	.00000	.00000	.10000
Panicum pusillum	.16667	.00000	.00000
Pennisetum clandestinum	.27778	.00000	.00000

Pennisetum glabrum	.27778	.00000	.00000
Pennisetum trachyphyllum	.00000	0.0000	1.1000
Pennisetum thunbergii	.55556	.00000	.20000
Phaenanthoecium koestlinii	1.5556	.00000	.00000
Plantago palmata	.00000	.00000	.12000
Plectranthus punctatus	.38889	.00000	.12000
Polygonum afromontanum	.00000	.65000	.00000
Persicaria senegalensis	2.1111	.00000	.00000
Psuedognaphalium luteo-album	2.1111	.00000	.00000
Ranunculus multifidus	.22222	.00000	.00000
Rubus steudneri	.05556	.95000	.00000
Rumex nepalensis	.05556	.95000	.00000
Salvia nilotica	.05556	.95000	.00000
Satureja paradoxa	.11111	.00000	.00000
Solenostemon latifolia	.00000	.00000	.36000
Acmella cauliohiza	.00000	.00000	.14000
Stachys aculeolata	.00000	.00000	.12000
Stellaria media	.05556	.00000	.00000
Stephania abyssinica	.00000	.60000	.00000
Syzygium guineense	.00000	.00000	.10000
Typha latifolia	.00000	0.0000	.10000
Trifolium rueppellianum	.66667	.00000	.28000
Triumfetta tomentossa	.05556	.00000	.06000
Uebelinia kiwensis	.05556	.00000	.06000
Urtica simensis	.00000	.00000	.06000
Vernonia auriculifera	.00000	.10000	.00000

Table 8: Summary of the occurrence of wet season plant communities in the study areas

Community type	Shashele	Kitima	Ada	Dingera	Kureba	Shupa	Total
Schoenoplectus corymbosus-Eriochloa fatmensis	1	0	0	1	0	0	2
Cyperus dichrostachyus-Persicaria decipeins	0	0	1	0	1	1	3
Cyperus dichroostachyus-Thelypteris confluens	0	1	0	0	0	0	1

Summary of the occurrence of the wet season plant communities (Table 8) shows that community type *Cyperus dichroostachyus-Persicaria decipiens* occured in half of the study sites. The community type *Cyperus dichroostachyus–Thelypteris confluens* occured only in Kitima. Each of the study sites is characterized by the presence of only one community type. The presence of a community in one site and its absence in other site may be due to the level of disturbance, land use history and physical characteristics of sites, such as, soil type, parent rock and availability of moisture.

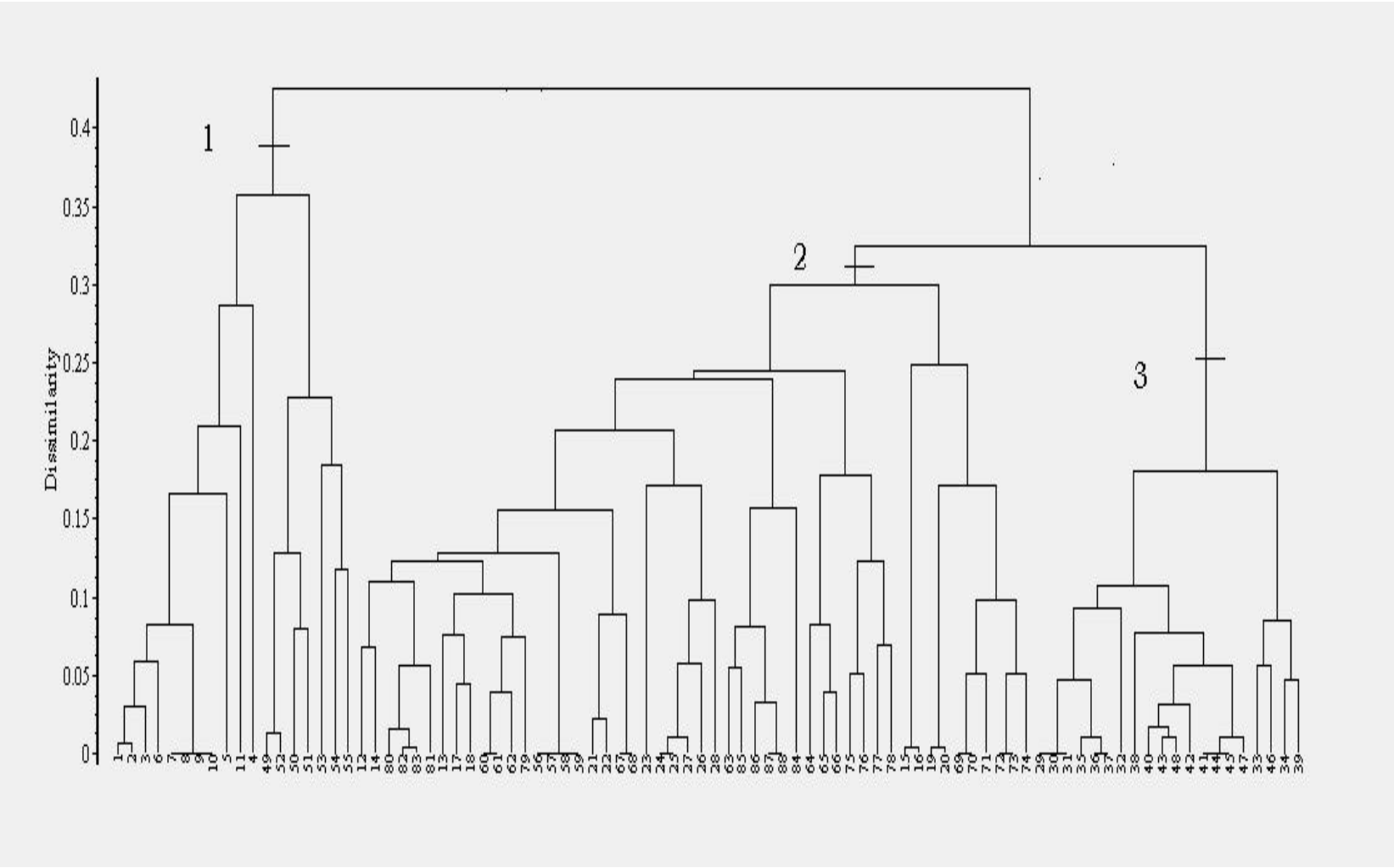


Fig. 3. Dendrogram showing wet season plant community types (clusters) from wet season data

4.2.2. Dry season communities

Plant community types of the wetland vegetation found in the dry season at the six study sites based on the cluster analysis and the resulting Table 10 and fig. 4 are discussed below. The plant communities were named by the dominant species, which occur in each group, using the relative magnitude of mean cover/abundance values. Species such as *Commelina diffusa*, *Cyperus dichroostachyus, Epilobium stereophyllum, Eriochloa fatmensis, Guizotia scarba, Impatiens ethiopica, Oenanthe palustris, Persicaria decipiens, Persicaria senegalensis Schoenoplectus corymbosus, Thelypteris confluens, Centella asiatica, Veronica abyssinica* and *Hypericum scioanum* were species occuring with high frequency (Appendix 3). Each of these species occurred in more than ten quadrats.

1. ***Cyperus dichroostachyus-Thelypteris confluens* community type**.

This community type is named after its dominant species *Cyperus dichroostachyus* and *Thelypteris confluens. Epilobium stereophyllum* is another relatively dominant species in this community type. The characteristic species of this type are *Carex bequaerti*, *Habenaria perityliodes* and *Hypericum scioanum*. This community type is found in Kitima, Shupa and Kureba.

2. ***Cyperus dichroostachyus-Guizotia scarba* community type.**

This community type is named after the dominant species *Cyperus dichroostachyus* and *Guizotia scarba*. Other relatively dominant species next to *Cyperus dichroostachyus* and *Guizotia scarba* of this community type are *Persicaria senegalensis* and *Oenanthe palustris*. The characteritic species of this type are *Impatiens hochstetteri*, *Pennisettum trachyphyllum, Sphaeranthus suaveolens* and *Acmella cauliohiza*. This community type occurs in Ada and Kureba.

3. ***Cyperus dichroostachyus-Oenanthe palustris* community type.**

Cyperus dichroostachyus and *Oenanthe palustris* are the dominant species of this community type. *Eriochloa fatmensis* and *Impatiens ethiopica* are other relatively dominant species of this type. The characteristic species of this community type are *Cyperus triceps*, *Pennisettum glabrum, Polygonum afromontanum* and *Rubus steudneri*. This community type occurs in Kitima, Shupa and Ada.

4. ***Schoenoplectus corymbosus-Persicaria senegalensis* community type.**

This community type is named after the dominant species *Schoenoplectus corymbosus* and *Persicaria senegalensis. Eriochloa fatmensis* is the other dominant species of this community type. *Ajuga alba, Achyranthes aspera, Carex conferata, Cyathula cylindrica Panicum maximum, Phaenanthoecium koestelinii* and *Stellaria sennii* are the characteristic species of this community type. This community type occurs in Shashele and Dingera.

The first three community types differ on the second species used for naming communities (*Thelypteris confluens, Guizotia scarab,* and *Oenanthe palustris,* respectively). This can be related to the differences in the availability of moisture content on different sites that determines the appearance and disappearance of wetland dependent and wetland associated plant species.

Summary of the dry season occurrences of plant communities in the study areas (Table 9) shows that the plant community situation is more complex than that of wet season. Although four communities have been identified, they are not found in the wet season with only *Cyperus dichroostachyus-Thelypteris confluens* found in both the wet and dry seasons. *Cyperus dichroostachyus-Thelypteris confluens* community type is found in three of the six sites, which provided data sets during dry season. In general, the diversity in the dry season communities reflect the diversity of land use and site specific characteristics which were more influential on plant communities at this time of the year.

Table 9: Summary of the dry season occurrences of communities in the study areas.

Community type	Kitima	Shupa	Ada	Shshele	Kureba	Dinge	Total
Cyperus dichroostachyus-Thelypteris confluens	1	1	0	0	1	0	3
Cyperus dichroostachyus-Guizotia scarba	0	0	1	0	1	0	2
Cyperus dichroostachyus-Oenanthe palustris	1	1	1	0	0	0	3
Schoenoplectus corymbosus-Persicaria-senegalensis	0	0	0	1	0	1	2

Table 10: Synoptic table of vegetation with diagnostic species from dry season data

Community type	**4**	**3**	**1**	**2**
Cluster size	**15**	**16**	**27**	**19**
Achyranthes aspera	.06667	.00000	.00000	.00000
Ajuga alba	.06667	.00000	.00000	.00000
Alchemilla cryptanta	.86667	.00000	.00000	.52632
Droguetia iners	.00000	.00000	.03704	.00000
Carex conferata	**1.3333**	.00000	.00000	.00000
Isolepis costata	**1.7333**	.00000	.37037	.00000
Panicum maximum	**3.0000**	.00000	.00000	.00000
Persicaria decipiens	**2.0000**	.31250	.18519	.26316
Phaenanthoecium kostelinii	**2.6667**	.00000	.00000	.00000
Schoenoplectus confusus	**3.0667**	.62500	.00000	.00000
Schoenoplectus corymbosus	**4.5333**	.43750	.66667	.15789
Trifolium rueppellianum	**1.0667**	.31250	.00000	.57895
Eriochloa fatmensis	**3.7333**	**3.1875**	1.1111	.00000
Impatiens ethiopica	.00000	**3.0000**	1.8148	.00000
Polygonum afromantanum	.00000	**1.8125**	.00000	.00000
Veronica abyssinica	.00000	**1.5000**	.03704	.47368
Oenanthe palustris	.20000	4.**0625**	.37037	4.3158
Cyperus dichroostachyus	.00000	**7.0000**	**7.2222**	**6.6316**
Thelypteris confluens	.00000	.87500	**4.6296**	.00000
Alchemilla fischerii	.06667	.37500	**1.9630**	.73684
Epilobium stereophyllum	.00000	.93750	**3.111**1	**3.6842**
Polygonum senegalensis	**3.8667**	.00000	**2.5185**	**5.1579**
Commelina diffusa	.40000	.12500	.00000	**3.8421**
Guizotia scarbaa	.00000	.43750	.00000	**5.3158**
Carex bequaertii	.00000	.00000	.25926	.00000
Centella asiatica	.26667	.75000	.44444	.00000
Cyathula cylindrica	.66667	.00000	.00000	.00000
Cynoglosum lanceolatum	.00000	.00000	03704	.00000
Cyperus mundtii	.00000	.00000	.00000	.21053
Cyperus triceps	.00000	.31250	.00000	.00000
Erythrina abyssinica	.00000	.00000	.00000	.52632
Geranium aculeolata	.00000	.00000	.03704	.00000
Habenaria peristyloides	.00000	.00000	.55556	.00000
Hypericum peplidifolium	.73333	.00000	.37037	.10526
Hypericum scioanum	.00000	.00000	.62963	.00000

Impatiens hochstteri	.00000	.00000	.00000	.10526
Ludwigia abyssinica	.00000	.00000	.00000	.05263
Oxalis radicosa	.00000	.00000	.11111	.00000
Pennisetum glabrum	.00000	4.0625	4.0625	.00000
Pennisetum trachyphyllum	.00000	.00000	.00000	.31579
Plectranthus punctatus	.00000	.31250	.00000	.05263
Pycnostachys eminii	.00000	.00000	.11111	.00000
Ranunculus multifidus	.06667	.06250	.00000	.26316
Rubus steudneri	.00000	.62500	.00000	.00000
Rumex nepalensis	.26667	.00000	.03704	.00000
Satureja paradoxa	.06667	.00000	.00000	.00000
Solenostemon autranii	.00000	.00000	.62963	.26316
Solenostemon latifolia	.00000	.62500	.51852	.00000
Sphaeranthus suaveolens	.00000	.00000	.00000	.10526
Acnell cauliohiza	.00000	.00000	.00000	.05263
Stachys aculeolata	.00000	.00000	.03704	.00000
Stellaria senni	.06667	.00000	.00000	.00000
Stephania abyssinica	.00000	.31250	.11111	.00000
Typha latifolia	.00000	.00000	.55556	.31579
Triumfetta tomentossa	.00000	.00000	.03704	.00000
Vernonia auriculifera	.00000	.00000	.11111	.05263

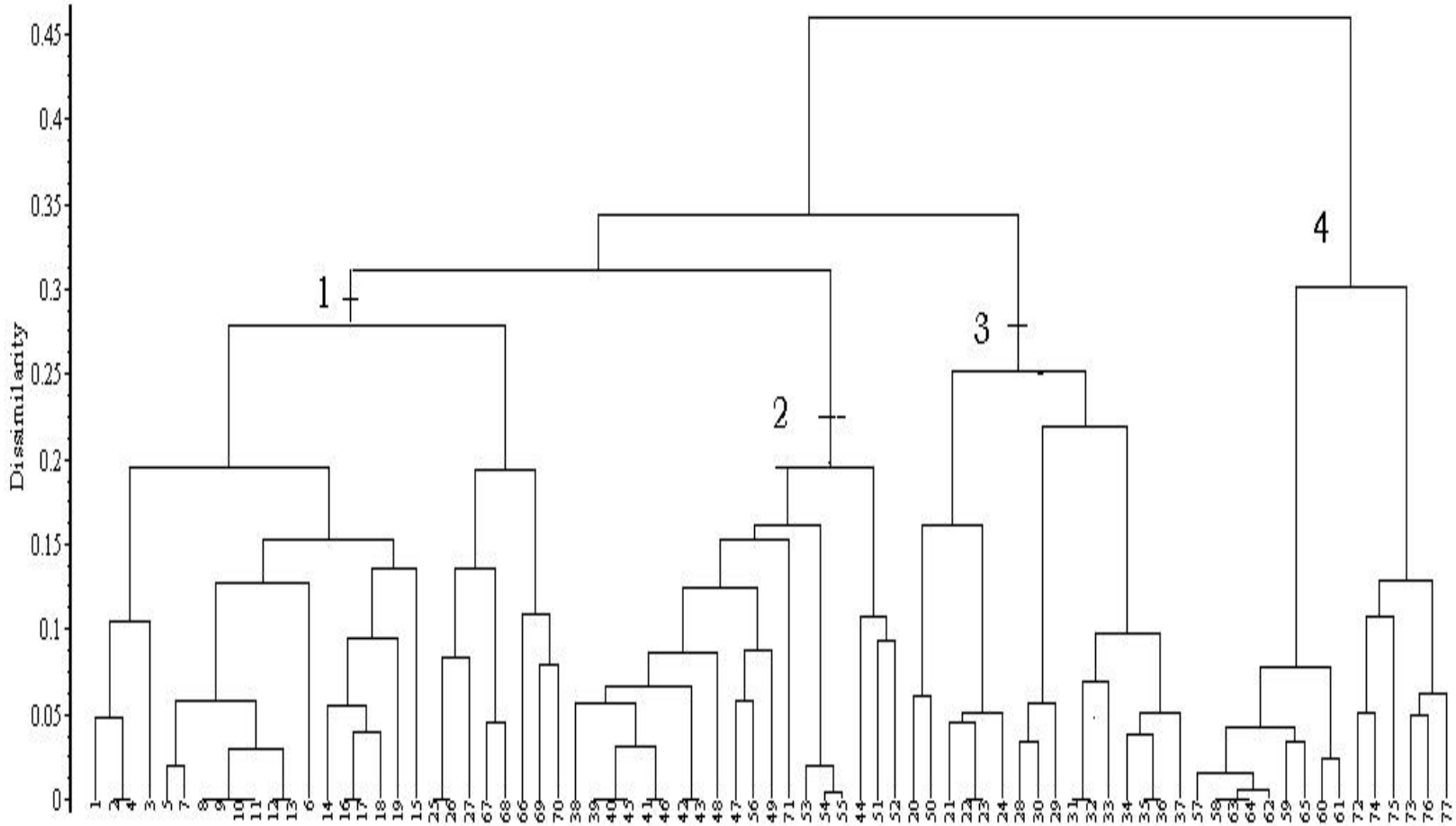


Fig.4. Dendrogram showing dry season plant community types (clusters) from dry season data

4.3. Diversity analysis

4.3.1. Diversity in the plant communities

Diversity analysis between the identified community types was made using the Shannon-Wiener diversity index. The mean cover values in Tables 7 and 10 were subjected to diversity and evenness analysis. The result of diversity and evenness analysis between the community types of the two seasons are given in Tables 11 and 12.

Table 11: Shannon-Wiener diversity index (H') and evenness (J) for the three community types from the wet season data.

NO.	COMMUNITY TYPE	SPECIES RICHNESS	H'	J	NO. OF PLOTS
1	*Schoenoplectus corymbosus-Eriochloa fatmensis*	38	3.021	0.830	18
2	*Cyperus dichroostachyus-Persicaria decipiens*	36	2.668	0.745	50
3	*Cyperus dichroostachyus–Thelypteris confluens*	19	1.525	0.518	20

Table 12: Shannon-Wiener diversity index (H') and evenness (J) for the four community types from the dry season data.

NO.	COMMUNITY TYPE	SPECIES RICHNESS	H'	J	NO. OF PLOTS
1	*Cyperus dichroostachyus-Thellypteris confluens*	30	2.522	0.742	27
2	*Cyperus dichroostachyus-Guizotia scarba*	25	2.333	0.725	19
3	*Cyperus dichroostachyus- Oenanthe palustris*	23	2.498	0.797	16
4	*Schoenoplectus corymbosus-Persicaria senegalensis*	23	2.543	0.811	15

Plant community type *Schoenoplectus corymbosus-Eriochloa fatmensis* has the highest species diversity (3.021) with the highest number of species (38). Plant community type *Cyperus dichroostachyus –Thelypteris confluens,* with the least number of species (19), has the lowest diversity index (Table 11).

Generally, as it can be seen from Table 11, diversity follows the trends observed in species richness. It is highest in species rich and lowest in species poor community. For the dry period, diversity does not follow the trends in species richenness (Table 12). The higher environmental stability leads to higher community stability, which in turn permits high diverist of species (Whittaker, 1975). This is probably attributed to the minimum level of disturbances during wet period.

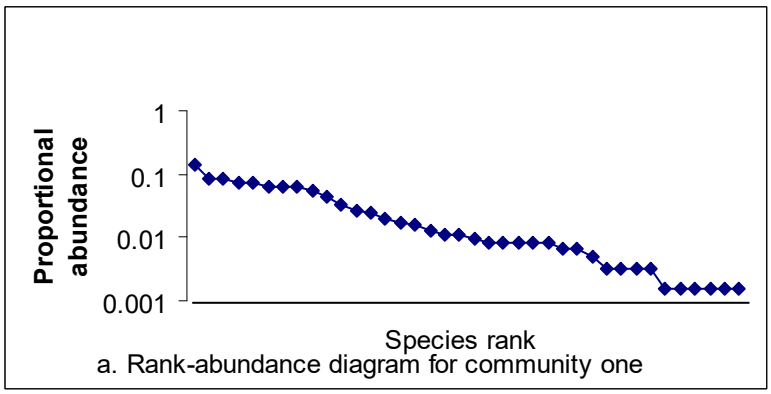
Species evenness measures the equitability of species in a given sample area, or indicate lack of or dominance of few species. It shows the relative proportional abundance of a species in communities. Low evenness values indicate the dominance of few species in the sample area The community type *Schoenoplectus corymbosus-Eriochloa fatmensis* has the most even distribution of species indicating that there are few or no dominating species within the type. *Cyperus dichroostachyus–Thelypteris confluens* has the least even species distribution of the clusters, which is due to the dominance of these two species (*Cyperus dichroostachyus* and *Thelypteris confluens*) within the type.

The Shannon-Wiener diversity and evenness index for the four clusters of the dry season data (Table 12) shows that *Schoenoplectus corymbosus-Persicaria senegalensis* has the highest score while *Cyperus dichroostachyus-Guizotia scarba* has the least. The community dominated by *Schoenoplectus corymbosus-Persicaia senegalensis* has the highest evenness index while *Cyperus dichroostachyus-Guizotia scarba* has the least. *Cyperus dichroostachyus-Thelypteris confluens* contain the highest number of sampled species.

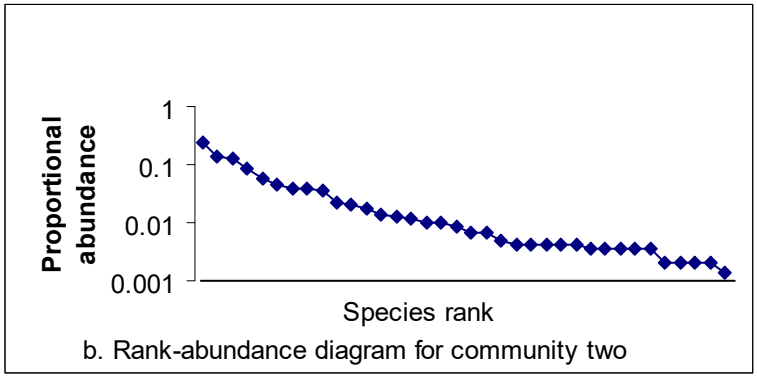
As can be seen from rank-abundance diagrams for wet season plant community types, community one has a more equitable distribution than the other two (Fig. 5). From the dry

season community types, community type four has a more equitable distribution than the other three (Fig.6).

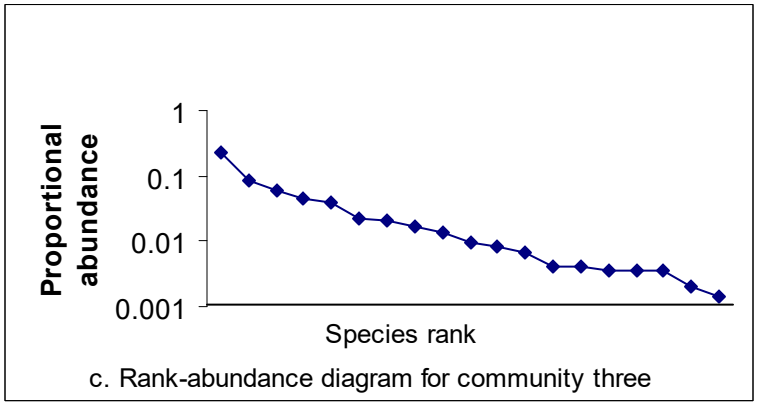
Fig. 5. Rank-abundance diagram for three wet season plant community types.



a. Rank-abundance diagram for community one

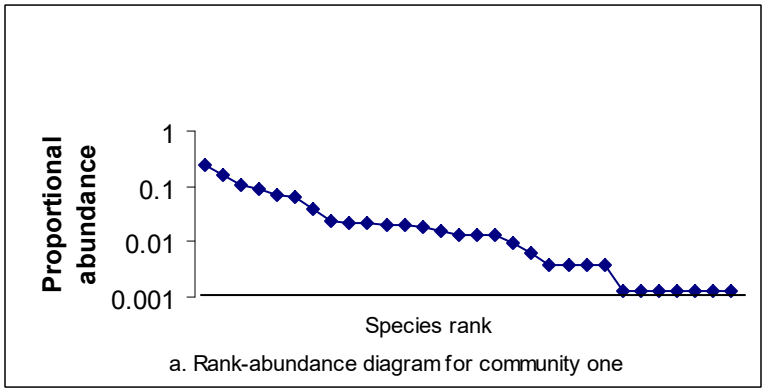


b. Rank-abundance diagram for community two

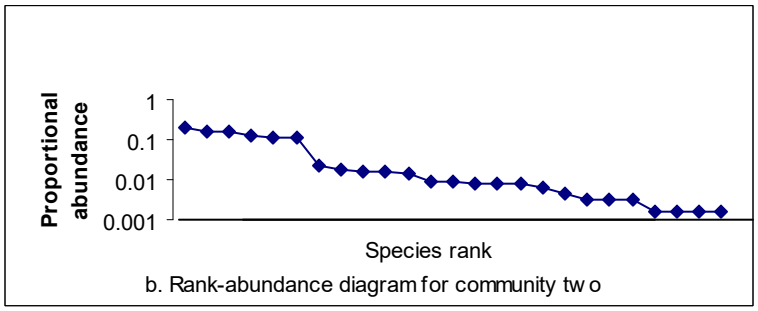


c. Rank-abundance diagram for community three

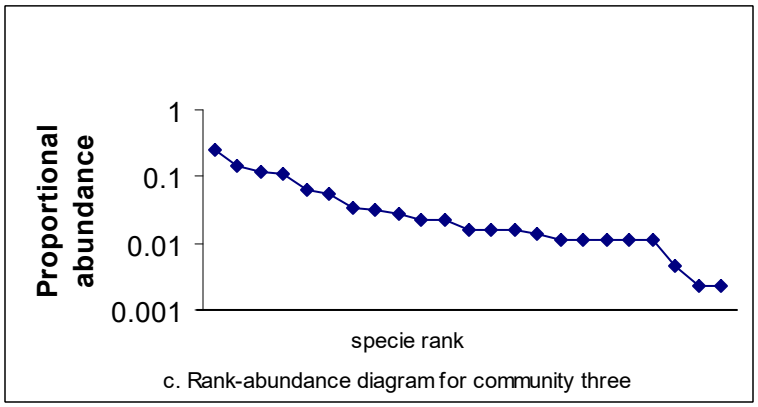
Fig. 6. Rank-abundance diagram for four dry season plant community types.



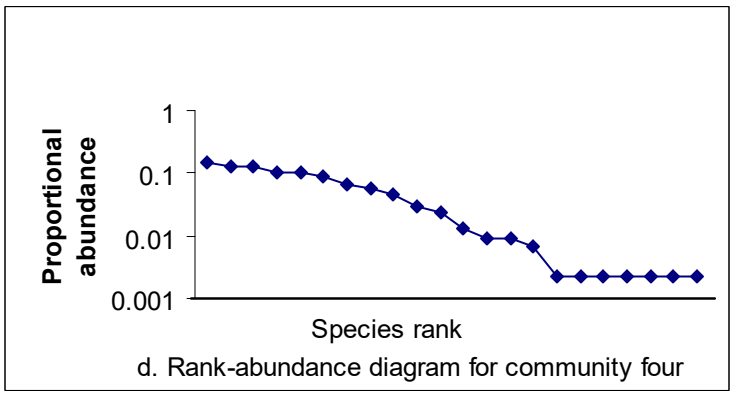
a. Rank-abundance diagram for community one



b. Rank-abundance diagram for community tw o



c. Rank-abundance diagram for community three



d. Rank-abundance diagram for community four

4.4. Wetland plant inventory

4.4.1. Species composition and life forms

Ninety-nine species were encountered during the inventory of plant species in the wetlands. All of these were identified and all the species were emergent macrophytes. These are plants, which anchor with their roots in the soil while the stem, and the leaves emerge above ground/ water surface. *Hydrocotyle ranunculoides* is a floating leaved plant. Floating leaved plants have their leaves floating on the surface of the water and the remaining parts stay below the water surface.

There were 29 (29.3%) wetland dependent, 57 (57.6%) wetland associated and 13 (13.1%) non-wetland plant species. Wetland dependent plants grow only in the wetland but wetland associated plants can grow both outside and inside of the wetland. The non-wetland plants are those that may have appeared as the result of the cultivation and grazing of the wetland.

Tables 13-15 Show non-wetland, wetland associated and wetland dependent plants collected from the wetland vegetation of the study area.

Table 13: Wetland associated plants

NO.	SPECIES	FAMILY	LIFE FORM
1	*Achyranthes aspera* L.	Amaranthaceae	Herb
2	*Ajuga alba* (Guerke) Robyns	Lamiaceae	Herb
3	*Alchemilla crypthanta* Steud. ex A. Rich.	Rosaceae	Herb
4	*Alchemilla fischeri* Engl.	Rosaceae	Herb
5	*Asystasia mysorensis* (Roth.) T. Anders	Acanthaceae	Herb
6	*Brachiaria brizantha* (A. Rich.) Stapf	Poaceae	Herb
7	*Caylusea abyssinica* (Fresen.) Fisch. & Mey.	Resedaceae	Shrub
8	*Chenopodium schroderianum* Schult.	Chenopodiaceae	Herb
9	*Commelina diffusa* Burm. f.	Commelinaceae	Herb
10	*Conyza tigrensis* Oliv. & Hiern	Asteraceae	Herb
11	*Crepis rueppelli* Sch-Bip.	Asteraceae	Herb
12	*Cyathula cylindrica* Moq.	Amaranthaceae	Herb
13	*Cyathula uncinulata* (Schrad.) Schinz	Amaranthaceae	Herb
14	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	Herb
15	*Cyperus microstylis* L. f.	Cyperaceae	Herb
16	*Cyperus distans* L.f.	Cyperaceae	Herb
17	*Cyperus elatior* (Nees) F. Muell.	Cyperaceae	Herb
18	*Cyperus elegantulus* Steud.	Cyperaceae	Herb
19	*Cyperus longibracteatus* (Cherm.) Kuk.	Cyperaceae	Herb
20	*Cyperus rigidfolius* Steud.	Cyperaceae	Herb
21	*Cyperus triceps* Endl.	Cyperaceae	Herb
22	*Dicrocephala integrifolia* (L.F.) O. Kuntze	Asteraceae	Herb
23	*Droguetia iners* (Forssk.) Schweinf.	Urticaceae	Herb
24	*Drymaria cordata* (L.) wild.	Caryophyllaceae	Herb
25	*Galinsoga quadriradiata* Ruiz & Pavon	Asteraceae	Herb
26	*Geranium aculeolatum* Oliv.	Geraniaceae	Herb
27	*Guizotia scarba* (Vis) Chiov.	Asteraceae	Herb
28	*Guizotia Villosa* (Vis) Chiov.	Asteraceae	Herb
29	*Hypoestes triflora* (Forssk.) Roem. & Schult.	Acanthaceae	Herb
30	*Kosteletzkya begonfolia* Ulbr.	Malvaceae	Shrub
31	*Lactuca inermis* L.	Asteraceae	Herb
32	*Leucas deflexa* Hook f.	Lamiaceae	Herb
33	*Leucas Urticifolia (*Vahl) R. Br.	Lamiaceae	Herb
34	*Momordica foetida* Schumach.	Cucurbitaceae	Herb

35	*Oxalis radicosa* A. Rich.	Oxalidaceae	Herb
36	*Panicum pusillum Hook*. f.	Poaceae	Herb
37	*Pennisetum clandestinum* Chiov.	Poaceae	Herb
38	*Pennisetum glabrum* Pilg.	Poaceae	Herb
39	*Pennisetum nubicum* (Hochst.) Schum. ex Engl.	Poaceae	Herb
40	*Pennisetum thunbergii* Kunth	Poaceae	Herb
41	*Pennisetum trachyphyllum* Pilg.	Poaceae	Herb
42	*Pennisetum unisetum* (Nees) Benth.	Poaceae	Herb
43	*Phaenanthoecium kostelinii* (Hchst. ex A. Rich) C. E.Hu	Poaceae	Herb
44	*Plectranthus alpinus (*Barker) Ryding	Lamiaceae	Herb
45	*Plectranthus punctatus* (L.) L` Herit	Lamiaceae	Herb
46	*Psuedognaphalium luteo-album* (L.) Hilliard & Burtt	Asteraceae	Herb
47	*Pycnostachys eminii* Gurke	Lamiaceae	Herb
48	*Ranunculus multifidus* Forssk.	Ranunculaceae	Herb
49	*Salvia nilotica* Jacq.	Lamiaceae	Herb
50	*Satureja paradoxa* (Vatke) Engl.	Lamiaceae	Herb
51	*Solenostemon latifolius* (Benth.) J.K. Morton.	Lamiaceae	Herb
52	*Spilanthes mauritiana* (A. Rich.) DC.	Asteraceae	Herb
53	*Stachys aculeolata* Hook. f.	Lamiaceae	Herb
54	*Stellaria sennii* Chiov.	Caryophyllaceae	Herb
55	*Trifollium rueppellianum* Fresen.	Fabaceae	Herb
56	*Truimfetta tomentosa* Boj.	Tilliaceae	Shrub
57	*Veronica abyssinica* Fresen.	Scrophulariaceae	Herb

Table 14: Wetland dependent plants

NO.	SPECIES	FAMILY	LIFE FORM
1	*Anemone thomsonii* Oliv.	Ranunculaceae	Herb
2	*Carex bequaertii* De Wild.	Cyperaceae	Herb
3	*Carex conferta* Hochst. ex A. Rich.	Cyperaceae	Herb
4	*Carex monostachya* A. Rich.	Cyperaceae	Herb
5	*Centella asiatica* (L.) Urb.	Apiaceae	Herb
6	*Cyperus dichroostachyus* A. Rich.	Cyperaceae	Herb
7	*Cyperus munditii* (Nees) Kunth.	Cyperaceae	Herb
8	*Epilobium stereophyllum* Fresen.	Onagraceae	Herb
9	*Eriochloa fatmensis* (Hochst. & Seud.) Clayton	Poaceae	Herb
10	*Habenaria peristyloides* Thomas & Cribb.	Orchidaceae	Herb
11	*Hydrocotyle ranunculoides* L. f.	Apiaceae	Herb
12	*Hypericum peplidifolium* A. Rich.	Hypericaceae	Herb
13	*Hypericum scioanum* Chiov.	Hypericaceae	Herb
14	*Impatienns hochstetteri* Warb.	Balsaminaceae	Herb
15	*Impatiens tinctoria* A. Rich.	Balsaminaceae	Herb
16	*Impatiens ethiopica* Grey-Wilson	Balsaminaceae	Herb
17	*Isolepis costata* A. Rich.	Cyperaceae	Herb
18	*Kyllinga odorata* Vahl	Cyperaceae	Herb
19	*Mentha aquatica* L.	Lamiaceae	Herb
20	*Oenanthe palustris* (Chiov.) Norman	Apiaceae	Herb
21	*Panicum maximum* Jacq.	Poaceae	Herb
22	*Persicaria decipiens* (R.Br.) Wilson	Polygonaceae	Herb
23	*Persicaria senegalensis* Meisn.	Polygonaceae	Herb
24	*Schoenoplectus confusus* (N. E. Br.) Lye	Cyperaceae	Herb
25	*Schoenoplectus corymbosus* (Roem. & Schult.) Rayn.	Cyperaceae	Herb
26	*Stellaria media* (L.) Vill.	Caryophyllaceae	Herb
27	*Thelypteris confluens Schott.*	Thelypteridaceae	Herb
28	*Typha latifolia* L.	Typhaceae	Herb
29	*Uebelinia kiweunsis* Th. C. E.Fries	Caryophylaceae	Herb

Table 15: Non-wetland plants

NO.	SPECIES	FAMILY	LIFE FORM
1	*Asparagus racemosus* Willd.	Asparagaceae	Shrub
2	*Bidens prestinaria* (Sch. Bip.) Cuf.	Asteraceae	Herb
3	*Cynodon dactylon* (L.) Pers.	Poaceae	Herb
4	*Erythrina brucei* Lam. ex DC.	Fabaceae	Tree
5	*Ipomoea purpurea* (L.) Roth.	Convolvulaceae	Herb
6	*Plantago palmata* Hook. f.	Plantaginaceae	Herb
7	*Polygonum afromontanum* Greenway	Polygonaceae	Herb
8	*Rubus steundneri* Schweinf.	Rubiaceae	Shrub
9	*Stephania abyssinica* (Dill. & A. Rich.) Walp.	Menispermiaceae	Herb
10	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Tree
11	*Urtica simensis* Hochst. ex Steud	Urticaceae	Herb
12	*Vernonia auriculifera* Hiern	Asteraceae	Shrub

4.4.2. Biodiversity values

Table 16 shows biodiversity values derived from the wetland dependent and the biodiversity value derived from the combination of wetland dependent and wetland associated species respectively.

Ada had the highest biodiversity value (7.00) and Kureba had the lowest value (4.00) for wetland dependent species. Ada also had the highest score (15.67) for the combination of wetland dependent and wetland associated species while Kureba has the lowest value (8.33). Kitima Ada and Shuppa wetlands had biodiversity values above the average recorded for all wetlands (5.58) and Shashele, Kureba and Dingera had biodiversity values below the average recorded for all wetlands for wetland dependent plants. All the sites had biodiversity values above the average recorded for all wetlands (8.17) for the combination of wetland dependent and wetland associated plants. In Ada human interference appears to be responsible for the various anthropogenic habitats that increased the total number of plant species recorded. The wetland of Kureba is relatively uniform with a climax swamp community dominated by *Cyperus dicroostachyus*. As a consequence, this site supports a low number of both wetland dependent and wetland-associated plants.

Table 16: Biodiversity value of wetland dependent (WD) and a combination of wetland dependent and wetland associated plant species (WA).

Wetland	Biodiversity value of WD plant species	Biodiversity value of WD +WA plant species
Kitima	6.50	9.67
Ada	7.00	15.67
Shupa	5.67	10.34
Shashele	4.83	11.66
Kureba	4.00	8.33
Dingera	5.50	11.33
Average	5.58	8.17

4.5. Biomass

Out of the 56 plant species, 18 (32%) were recorded for the study of biomass (primary production). These plant species belong to angiosperm families except *Thelypteris confluens*, which belongs to the fern family *Thelypteridaceae*. Most of the herbaceous species recorded for aboveground biomass determination in four study areas belong to the families *Cyperaceae* and *Poaceae.* The family *Cyperaceae* is represented by four species, where as the family *Poaceae* is represented by three species. The family, species name, community type and average biomass in g/m^2 recorded is given in Table 18.

Rank-abundance diagram of the four dry community types in terms of biomass of the various species is given in Fig. 7a-d. The rank-abundance diagrams are a means of displaying how the resources are partitioned among the species. The interaction between species within the community can be inferred from the pattern in the figure. In community two and four, the pattern is nearly of broken-stick model. Thus, species interact to limit one another's abundance and they get a random fraction of total resources. The pattern is nearly lognormal model in community one and three and there is somewhat normal distribution of resources among species. In all of the community types, various wetland dependent plants that are tolerant of a high water table are dominant. *Cyperus dichroostachyus* and *Alchemilla fischeri* contributed the most and the least biomass, respectively, to both community type one and three. *Cyperus dichroostachyus* also had the highest biomass contribution to community two.

Schoenoplectus corymboosus contributed the most to the biomass of plant species in community four while *Commellina diffusus* contributed the least.

The variation in species encountered, altitude, the community type, and rate of disturbance could result in differences in the aboveground vegetation biomasses recorded. Numbers of species, altitude and plant community type recorded in each site are given in table 17. The hydrological conditions, the scale of human interference by way of cultivation and grazing determine which plant species would be the dominant ones. Since there is no accurate figure on the livestock population in the study areas, it has not been possible to determine or correlate the aboveground biomass and the livestock population of the sites.

Table 17: Number of species, altitude and plant community type with the respective sites

Study site	Altitude (m)	Number of plant species	Plant community type
Kitima	2375	23	*Cyperus dichroostachyus-Thelypteris confluens* and *Cyperus dichroostachyus-Oenanthe palustris*
Ada	2165	24	*Cyperus dichroostachyus-Guizotia scarba* and *Cyperus dichroostachyus-Oenanthe palustris*
Shashele	2273	14	*Schoenoplectus corymbosus-Persicaria senegalensis*
Kureba	2453	15	*Cyperus dichroostachyus-Thelpteris confluens* and *Cyperus dichroostachyus-Guizotia scarbaa*
Shupa	2052	13	*Cyperus dichroostachyus-Thelypteris confluens* and *Cyperus dichroostachyus-Oenanthe palustris*
Dingera	2494	11	*Schoenoplectus corymbosus-Persicaria senegalensis*

Fig.7a-d. Rank-abundance diagram for dry season plant community types in terms of biomass.

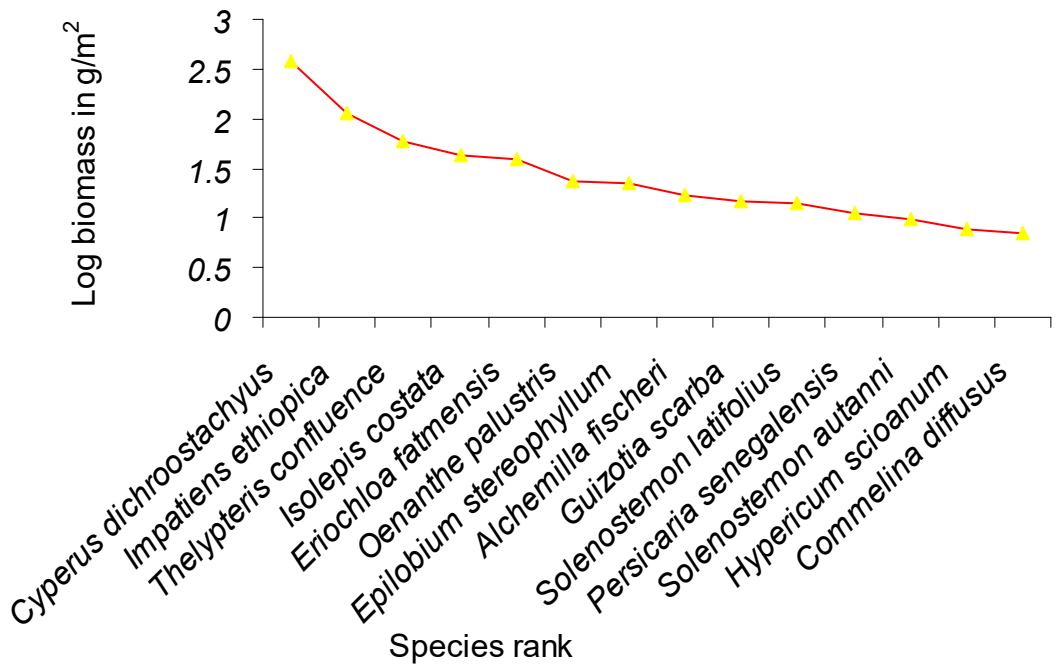


Fig. 7a. Rank biomass diagram for plant community type one

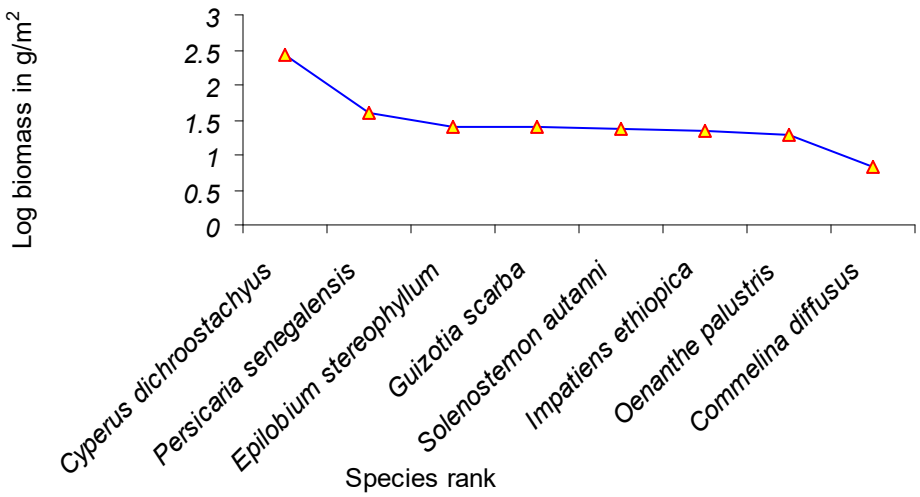


Fig. 7b. Rank biomass diagram of community type two

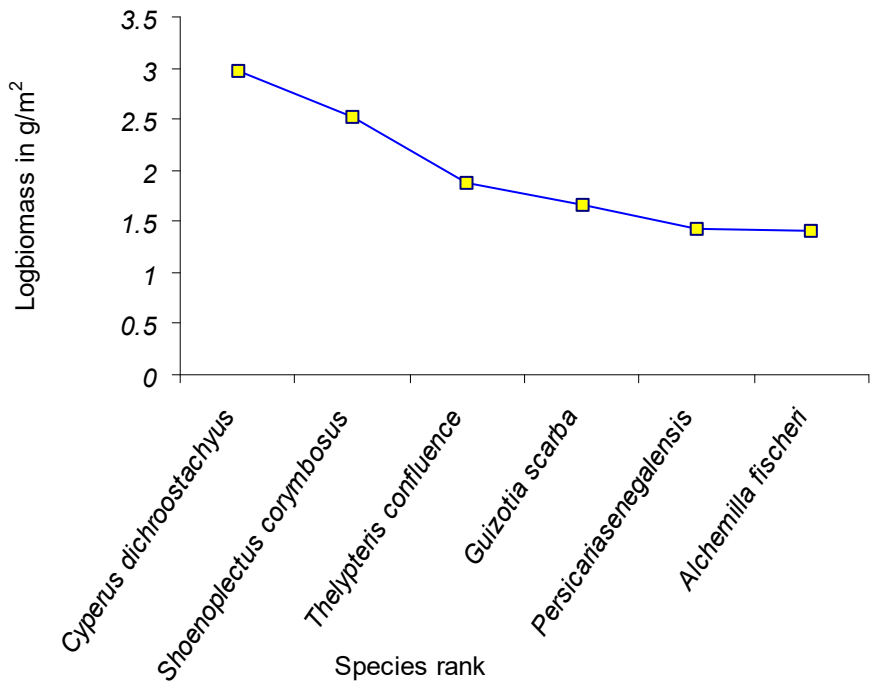


Fig. 7c. Rank biomass diagram of community type three

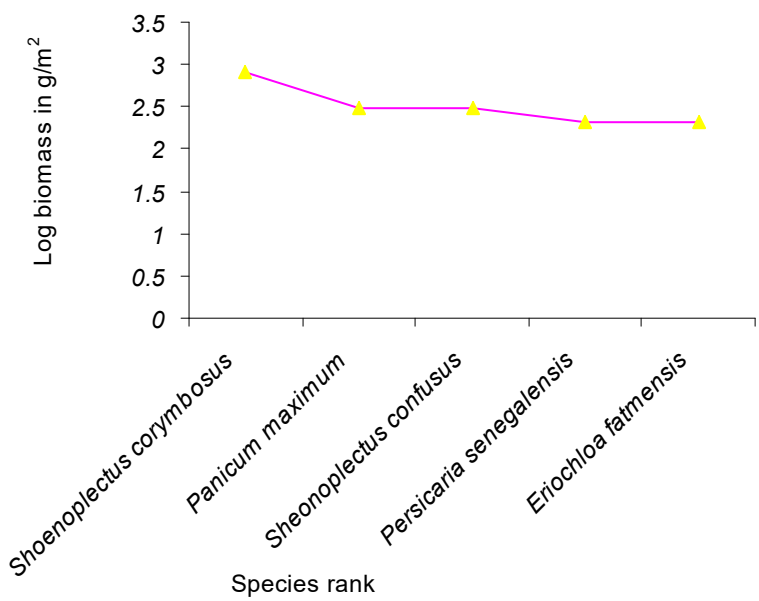


Fig. 7d. Rank biomass diagram of community type four

Table 18: Average biomass of plant species in the dry season plant community types.

CommunityType	Scientific name	Family	Av.Biomass in g/m²
1	*Cyperus dichroostachyus*	Cyperaceae	374.2
1	*Impatiens ethiopica*	Balsaminaceae	113.675
1	*Thelypteris confluence*	Thelypteridaceae	58.24
1	*Isolepis costata*	Cyperaceae	43.45
1	*Eriochloa fatmensis*	Poaceae	38.1
1	*Oenanthe palustris*	Apiaceae	23.2
1	*Epilobium stereophyllum*	Onagraceae	22.15
1	*Guizotia scarba*	Asteraceae	15
1	*Solenostemon latifolius*	Lamiaceae	14
1	*Persicaria senegalensis*	Polygonaceae	10.9
1	*Solenostemon autranii*	Labiatae	9.575
1	*Hypericum scioanum*	Hypericaceae	7.7
1	*Commelina diffusus*	Commelinaceae	7
1	*Alchemilla fischeri*	Rosaceae	6.17
2	*Cyperus dichroostachyus*	Cyperaceae	269.038
2	*Persicaria senegalensis*	Polygonaceae	39.6
2	*Epilobium stereophyllum*	Onagraceae	24.62
2	*Guizotia scarba*	Asteraceae	24.56
2	*Solenostemon autranii*	Lamiaceae	22.8
2	*Impatiens ethiopica*	Balsaminaceae	22.6
2	*Oenanthe palustris*	Apiaceae	19.8
2	*Commelina diffusus*	Commelinaceae	6.8
3	*Cyperus dichroostachyus*	Cyperaceae	945.62
3	*Shoenoplectus corymbosus*	Cyperaceae	333.27
3	*Thelypteris confluence*	Thelypteridaceae	75.4
3	*Guizotia scarba*	Asteraceae	45.2
3	*Persicaria senegalensis*	Polygonaceae	26.85
3	*Alchemilla fischeri*	Rosaceae	25.2
4	*Shoenoplectus corymbosus*	Cyperaceae	800.65
4	*Panicum maximum*	Poaceae	309.9
4	*Sheonoplectus confusus*	Cyperaceae	308.8
4	*Persicaria senegalensis*	Polygonaceae	207
4	*Eriochloa fatmensis*	Poaceae	205

4. 6. Wetland resource uses

Wetlands are a small but significant parts of the resource base in Kaffa. Although they only account for a small percentage of the surface area of the zone, virtually every household in one way or another uses them. This is shown by the estimates given in table 19. The estimate is based on data obtained through informal questioning. Wetlands in the area are important resources that supply essential raw materials such as reeds for the farming community for

thatching purposes and cheffe for ceremonial purposes. Wetlands are also the major sources of drinking water for humans and livestock and they are important dry season grazing areas.

Table 19: Estimate of wetland uses

Uses	Estimate of households benefiting
Social or ceremonial use of cheffe (wetland)	100% (including urban)
Thatching reeds	60%
Temporary crop guarding huts of cheffe	20%
Domestic water from springs	
Dry season grazing	80%
Water for livestock	>40%
Medicinal plants	>30%
Cultivation	4%
	10%

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Sixty-nine species of vascular plants representing 28 families were encountered during wet season sampling. The families with the highest number of species during this period were Cyperaceae, Poaceae, and Lamiaceae. Fifty-six species of vascular plants belonging to 27 families were recorded from the study sites during the dry season sampling. Cyperaceae, Lamiaceae and Poaceae were the families with the highest number of species during this period.

The analysis of data from 88 (wet season) and 77 (dry season) quadrats, using SYNTAX-2000, revealed three and four plant community types respectively, Accordingly, the plant communities of wet season include *Schoenoplectus corymbosus- Eriochloa fatmensis*, which is from Shashele and Dingera; *Cyperus dichroostachyus-Persicaria decipiens* which is from Ada, Kureba and Shupa; and *Cyperus dichroostachyus-Thelypteris confluens* which is from Kitima. The plant communities of dry season include *Cyperus dichroostachyus-Thelypteris confluens*, which is from Kitima, Shupa and Kureba; *Cyperus dichroostachyus-Guizotia scarba* that is from Ada and Kureba**;** *Cyperus dichroostachyus-Oenanthe palustris* that is from Kitima, Ada and Shupa; and *Schoenoplectus corymbosus-Persicaria senegalensis* that is from Shashele and Dingera.

The analysis of data from the wet season data showed that plant community *Schoenoplectus corymbosus-Eriochloa fatmensis* is a species rich while *Cyperus dichroostachyus-Thelypteris confluens* is species poor community. Plant community *Schoenoplectus corymbosus-Eriochloa fatmensis* is the most diverse while *Cyperus dichroostachyus-Thelypteris confluens* is species least diverse. Evenness appears to be highest in community *Schoenoplectus corymbosus-Eriochloa fatmensis* and lowest in *Cyperus dichroostachyus-Thelypteris confluens* for the wet season community types.

The analysis of data from the dry season showed that plant community *Cyperus dichroostachyus-Thelypteris confluens* is a species rich. *Schoenoplectus corymbosus-Persicaria senegalense* is the most diverse while *Cyperus dichroostachyus-Guizotia scarba*

is the least diverse. Evenness appears to be highest in *Schoenoplectus corymbosus-Persicaria senegalensis* and lowest in *Cyperus dichroostachyus-Guizotia scarba*.

Multivariate analysis of the vegetation data gave different plant community types in the two seasons indicating that the wetlands show spatial as well as temporal variations. The spatial variations are due to differece in exploitation, while temporal variations can be related to the variation in the moisture content of the substratum during the two seasons. During the dry period, some annual plant species that perform well when the soil is fully saturated wither away when the ground water lowers. This results in different species associations during the wet and dry seasons. Resemblence of the two season's community types in some wetlands suggests that the water level of the wetlands does not fluctuate as much.

Plant species composition changes to meet varying hydrological conditions, altitude and the use made by man and his livestock. Human interference by way of cultivation, biomass harvesting and grazing leads to the formation of new community types that can indicate the type and scale of interference. The scale of interference can be also judged by the biodiversity values of the species groups.

Although the wetlands are not currently under serious ecological problems, they need attention for ecosystem management and biodiversity conservation. Althogh the threat observed on the survey was not quantified, information gathered from local communities and observations indicate that farming and grazing are potential threats that could result in the destruction of habitats of the wetland plants. The wetland vegetation is shirinking and being replaced by weeds and grazing lands. This shows the need for a sound conservation and management measure of the wetland before the herbaceous species vanish.

5.2. Recommendation

Most of the species included under the family Cyperaceae are poorly represented in the National Herbarium or have few representative specimens. This could be due to the difficulty of collecting wetland specimens since they harbour numerous vectors (intermediate host of most diseases). Therefore, specimens of Cyperaceae and other families in other wetlands must be collected in due time, before they may be lost due to grazing, trampling and cultivation pressure.

Most authorities are aware of the problems related to forests, but the problems of wetlands are neither well addressed nor recognized. Many consider destruction of wetlands as just changing unproductive wastelands into productive farmlands, and the communities are encouraged to this effort. This requires an intervention on awarenness creation among the community, development workers and officials. To improve the diversity and structure of the plant communities and to minimize the negative impact of surrounding communities on the wetland resources and utilize the resources on sustainable bases, effective conservation measures should be carried out. This could be achieved through training and awarenness creation of the indigineous people of the surrounding areas.

It is suggested that as the wetlands of the study area are not located in nature reserve areas measures proposed to conserve biodiversity must take into consideration the other uses and services supplied by the resources. Attention should be given to conserving products, attributes and functions of wetlands for the future. The approaches in protecting and managing wetlands are based not just on preservation of species but it can be done by making seasonal farming and grazing around the margin and increasing the income of the local people through undestructive harvest of wetland plant species. The aim should be to reduce convertion of wetlands that brings about loss of biodiversity. The partial cultivation of wetlands conserving some areas permanently and others temporarly as natural vegetation may help to retain the gene pool for natural regeneration and recolonisation and allow maintenance of many wetland functions.

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Appendix 1. Vegetation data collected from the study area (Collection number, Family Scientific name, Habit and Vernacular name).

Coll.No	Family	Scientific Name	Habit	Vernacular Name
9	Commelinaceae	*Commelina difusa* Burm. f.	Herb	Naleto
24	Cyperaceae	*Kyllinga odorata* Vahl	Herb	
17	Lamiaceae	*Ajuga alba* (Guerke) Robyns	Herb	Dobo
31	Onagraceae	*Epilobium stereophyllum* Fresen.	Herb	Gidirigido
33	Lamiaceae	*Mentha aquatica* L.	Herb	
48	Balsaminaceae	*Impatiens ethiopica* Grey-Wilson	Herb	Ametibalo
50	Orchidaceae	*Habenaria peristyloides* Thomas & Cribb.	Herb	
54	Asteraceae	*Crepis rueppelli* Sch-Bip.	Herb	
57	Tiliaceae	*Triumfetta tomentosa* Boj	Shrub	Okokisho
59	Resedaceae	*Caylusea abyssinica* (Fresen.) Fisch. & Mey.	Shrub	
61	Lamiaceae	*Plectranthus alpinus (*Barker) Ryding.	Herb	

52	Poaceae	*Pennisetum nubicum* (Hochst.) Schum. ex Engl.	Herb	Keeposho
43	Poaceae	*Cynodon dactylon* (L.) Pers.	Herb	
45	Ranunculaceae	*Ranunculus multifidus* Forssk.	Herb	Nafnifo
96	Caryophylaceae	*Uebelinia kiwuensis* Th. C. E.Fries	Herb	
37	Polygonaceae	*Polygonum afromontanum* Greenway	Herb	
55	Asteraceae	*Conyza tigrensis* Oliv. & Hiern	Herb	
58	Asteraceae	*Lactuca inermis* L.	Herb	
30	Apiaceae	*Oenanthe palustris* (Chiov.) Norman	Herb	Shiido
49	Typhaceae	*Typha latifolia* L.	Herb	Nadogabo
42	Urticaceae	*Urtica simensis* Hochst. ex Steud.	Herb	Shimbrico
44	Asteraceae	*Bidens prestinaria* (Sch. Bip.) Cuf.	Herb	
47	Cyperaceae	*Cyperus longibracteatus* (Cherm.) Kuk.	Herb	
36	Rosaceae	*Alchemilla fischeri* Engl.	Herb	Deshwolo
41	Convolvulaceae	*Ipomoea purpurea* (L.) Roth.	Herb	
32	Cyperaceae	*Cyperus dichroostachyus* A. Rich.	Herb	Cheffe
40	Fabaceae	*Erythrina brucei* Lam. ex DC.	Tree	Holacho
46	Asteraceae	*Acmella cauliohiza* (A. Rich.) DC.	Herb	
20	Lamiaceae	*Satureja paradoxa* (Vatke) Engl.	Herb	Nado
35	Lamiaceae	*Solenostemon latifolius* (Benth.) J.K. Morton.	Herb	
3	Polygonaceae	*Rumex nepalensis* Spreng.	Herb	Godecho
39	Apiaceae	*Hydrocotyle ranunculoides* L. f.	Herb	
62	Plantaginaceae	*Plantago palmata* Hook. f.	Herb	
53	Amaranthaceae	*Achyranthes aspera* L.	Herb	Bakegecho
61	Cyperaceae	*Cyperus distans* L. f.	Herb	
66	Cyperaceae	*Cyperus elegantulus* Steud.	Herb	
13	Poaceae	*Brachiaria brizantha* (A. Rich.) Stapf	Herb	Keepo
26	Poaceae	*Pennisetum unisetum* (Nees) Benth.	Herb	
5	Poaceae	*Eriochloa fatmensis* (Hochst. & Steud.) Clayton	Herb	Shuuto
14	Poaceae	*Pennisetum thunbergii* Kunth	Herb	
25	Poaceae	*Pennisetum glabrum* Pilg.	Herb	
12	Polygonaceae	*Persicaria decipiens* (R.BR.) Wilson	Herb	Amichiato
2	Cyperaceae	*Schoenoplectus confusus* (N. E. Br.) Lye	Herb	Kitimo
19	Cyperaceae	*Cyperus rigidfolius* Steud.	Herb	Miicho
21	Lamiaceae	*Plectranthus punctatus* (L.) L` Herit	Herb	Doidokeno
7	Rosaceae	*Alchemilla crypthanta* Steud. ex A. Rich.	Herb	Magashimogabo
10	Ranunculaceae	*Anemone thomsonii* Oliv.	Herb	
8	Cyperaceae	*Schoenoplectus corymbosus* (Roem. & Schult.) Rayn	Herb	Kitimo
15	Fabaceae	*Trifolium rueppellianum* Fresen.	Herb	Magashimo
11	Asteraceae	*Psuedognaphalium luteo-album* (L.) Hilliard and Burtt.	Herb	Mandilo
29	Asteraceae	*Guizotia scarba* Sch.Bip.	Herb	Yagbaro
16	Chenopodiaceae	*Chenopodium schraderianum* Schult.	Herb	Brubusho
95	Cyperaceae	*Cyperus triceps* Endl.	Herb	Aato

23	Caryophylaceae	*Stellaria media* (L.) Vill.	Herb	
28	Poaceae	*Pennisetum clandestinum* Chiov.	Herb	
73	Cyperaceae	*Cyperus munditii* (Nees) Kunth	Herb	
74	Cyperaceae	*Cyperus distans* L. f.	Herb	
18	Cyperaceae	*Carex monostachya* A. Rich.	Herb	
90	Cyperaceae	*Isolepis costata* A. Rich.	Herb	
/86	Cyperaceae	*Carex conferta* Hochst. ex A. Rich.	Herb	Chocho
28	Poaceae	*Phaenanthoecium kostelinii* (Hochst. ex. A Rich.) C. E.Hu	Herb	
60	Cyperaceae	*Cyperus elatior* Bock.	Herb	Mero
63	Lamiaceae	*Pycnostachys eminii* Gurke	Herb	Bokelkako
38	Poaceae	*Pennisetum trachyphyllum* Pilg.	Herb	Shomeco
1	Poaceae	*Panicum maximum* Jacq.	Herb	Sheko
4	Polygonaceae	*Persicaria senegalensis* Meisn.	Herb	Amichiato 2
80	Asparagaceae	*Asparagus racemosus* Willd.	Shrub	
72	Asteraceae	*Vernonia auriculifera* Hiren	Shrub	Dangerto
34	Myrtaceae	*Syzgium guineense* (Willd.) DC.	Tree	Wondifo
91	Lamiaceae	*Leucas deflexa* Hook f.	Herb	Raskimiro
79	Thelypteidaceae	*Thelypteris confluens Schott.*	Herb	Giito
67	Cucurbitaceae	*Momordica foetida* Schumach.	Herb	
65	Lamiaceae	*Salvia nilotica* Jacq.	Herb	
78	Balsaminaceae	*Impatiens hochstetteri* Warb.	Herb	Ekeko
70	Rubiaceae	*Rubus steudneri* Schweinf.	Shrub	Garo
88	Lamiaceae	*Stachys aculeolatum* Hook. f.	Herb	Kuteero
94	Menispermiaceae	*Stephania abyssinica* (Dill. & A. Rich.) Walp.	Herb	I`ko
87	Asteraceae	*Guizotia scarba* (Vis) Chiov.	Herb	Hichaso
89	Malvaceae	*Kosteletzkya begonfolia* Ulbr.	Shrub	
92	Acanthaceae	*Hypoestes triflora* (Forssk) Roem. & Schult.	Herb	
93	Asteraceae	*Galinsoga quadriradiata* Ruiz. & Pavon	Herb	Yagibaro
59A	Caryophyllaceae	*Drymaria cordata* (L.) willd.	Herb	
56	Lamiaceae	*Leucas urticifolia (*Vahl.) R. Br.	Herb	
95	Acanthaceae	*Asystasia mysorensis* (Roth.) T. Anders.	Herb	
91	Amaranthaceae	*Cyathula uncinulata* (Schrad.) Schinz	Herb	Shulsheto
64	Balsaminaceae	I*mpatiens tinctoria* A. Rich.	Herb	
22	Poaceae	*Panicum pusillum* Hook. f.	Herb	Dawa
29	Asteraceae	*Dicrocephala integrifolia* (L. F.) O. Kuntze	Herb	Mandilo
6	Apiaceae	*Centella asiatica* (L.) Urb.	Herb	
59B	Caryophyllaceae	*Stellaria sennii* Chiov.	Herb	
97	Scrophulariaceae	*Veronica abyssinica* Fresen.	Herb	
98	Cyperaceae	*Carex bequaertii* De Willd	Herb	
99	Boraginaceae	*Cynoglossum lanceolatum* Forssk.	Herb	
100	Amaranthaceae	*Cyathula cylindrical* Moq.	Herb	

101	Hypericaceae	*Hypericum pepidifolium* Oliv.	Herb	
102	Oxalidaceae	*Oxalis radicosa* A. Rich.	Herb	
103	Geraniaceae	*Geranium aculeolatum*Oliv.	Herb	
104	Hypericaceae	*Hypericum scioanum* Chiov.	Herb	

Appendix 2. Family and percentage of species in each family of vegetation data collected from the study sites.

NO.	Family	% Species.	
		Wet season	Dry season
1	Lamiaceae	10	14
2	Acanthaceae	1	2
3	Rosaceae	3	4
4	Ranunculaceae	3	5
5	Asteraceae	7	5
6	Poaceae	13	11
7	Cyperaceae	19	16
8	Apiaceae	4	3
9	Chenopodiaceae	1	0
10	Commelinaceae	1	2
11	Onagraceae	1	4
12	Fabaceae	3	4
13	Orchidaceae	1	2
14	Hypericaceae	1	2
15	Balsaminaceae	4	4
16	Convolvulaceae	1	0
17	Malvaceae	1	0
18	Cucurbitaceae	1	0
19	Polygonaceae	6	7
20	Plantaginaceae	1	0
21	Rubiaceae	1	2
22	Caryophylaceae	3	2
23	Menispermaceae	1	2
24	Myrtaceae	1	0
25	Thelypteridaceae	1	2
26	Tiliaceae	1	2
27	Urticaceae	1	2
28	Typhaceae	1	2
29	Amaranthaceae	0	2
30	Boraginaceae	0	2
31	Oxalidaceae	0	2
32	Scrophulariaceae	0	2
33	Geraniaceae	0	2

Appendix 3. List of widely distributed species and the quadrats (plots) in which they occur

Species/scientific name	Season	Quadrats (plots)
Alchemilla cryptanta	D	38, 44, 47, 49, 71, 72, 73, 75, 76, 77
Alchemilla fischeri	W	21, 22, 23, 24, 25, 26, 27, 35, 36, 37, 38, 56-62, 75-79
Commelina diffusa	W	1, 4, 6, 11, 13, 17-22, 53, 54, 60, 61, 66-68, 77-79
	D	29, 38-49, 51-56, 60, 61, 71
Cyperus dichroostachyus	W	12-114, 17-48, 56-88
	D	1-56, 66-71
Centella asiatica	D	21, 25-29, 58-61, 65
Epilobium stereophyllum	W	12-114, 21-32, 35-37, 46, 63, 65-68
	D	5-14, 16-19, 25-30, 38-43, 45-49, 53-56, 66-71
Eriochloa fatmensis	W	1-3, 6-11, 29-31, 32-48, 50, 51, 56, 64-66, 72-78
	D	14-19, 21-24, 28-30, 34-37, 57-65, 72-74, 76-78
Guizotia scarba	W	11-20, 23-25, 27, 53-55, 60-62, 71-73, 76-78, 82, 83
	D	33,3 34, 38-49, 52-56
Impatiens ethiopica	W	63-79, 84-88
	D	25-29, 31-37, 66-70
Veronica abyssinica	D	31, 32, 34-37, 41-43, 46-48,53-55,70
Mentha spicata	W	12-14, 69,70, 74-78, 86-88
Oenanthe palustris	W	11-22, 51, 54-83
	D	27-46, 48, 52-56, 66, 71, 72, 74, 75
Panicum maximum	W	1-4, 7-11, 77, 79, 87, 88
Persicaria decipiens	W	4, 12-14, 17, 18, 21-32, 35-38, 39-45, 47-68
	D	27-30, 38, 72-77, 75-88
Persicaria senegalensis	W	1-4, 6-10
	D	1, 2, 4, 5, 7,-19, 38-49, 51, 52, 56-66, 69-71
Schoenoplectus corymbosus	W	1-11, 29-33, 35-37, 41, 44-47
	D	12-15, 24, 52, 57-65
Thelypteris confluens	W	29-48
	D	1-19, 21-24
Hypericum scioanum	D	1-13, 19, 68

Appndex 4: Botanical, vernacular, growth habit and uses of some wetland plants.

No.	Botanical name	Vernacular name	Growth Habit	Uses
1	*Hypericum peplidifolium*	Ashiafe	Herb	Human eye treatment
2	*Rubus steudneri*	Garo	Shrub	Fruits are edible
3	*Cynoglosum lanceolatum*		Herb	Used against 'mich'
4	*Persicaria senegalensis*	Amichiyato	Herb	Insecticide especially for killing ticks.
5	*Thelypteris confluens*	Gito	Fern	Used to treat rabbis
6	*Ludwigia abyssinica*	Mukoche	Shrub	Fertilizes soil
7	*Panicum maximum*	Sheko	Herb	Grazing

8	*Stellaria senni*		Herb	Used to treat foot fungus
9	*Rumex nepalensis*	Godecho	Herb	Used against stomach ache
10	*Droguetia iners*		Herb	Used against spider infection
11	*Crassocephalum macropappum*	Mandilo	Herb	Used for fermenting 'enset' products
12	*Schoenoplectus corymbosus*	Chaffee	Herb	Spreading on floor, grazing
13	*Leucas deflexa*	Raskimiro	Herb	Grazing (forage for sheep)
14	*Cyperus dichroostachyus*	Chaffe	Herb	Grazing thatching roofs
15	*Imatiens ethiopica*	Eki'eko	Herb	
16	*Eriochloa fatmensis*	Shuto	Herb	Grazing
17	*Acmella cauliohiza*	Gorgosa	Herb	Used against throat infection
18	*Commelina diffusa*	Naleto	Herb	Grazing soil fertility
19	*Pennisetum thunbergii*	Shomeco	Herb	Grazing
20	*Satureja paradoxa*	Nado	Herb	Soil fertility
21	*Plectranthus punctatus*	Boye	Herb	Soil fertility
22	*Solenostemon latifolius*		Herb	Grazing, soil fertility