REPORT

ECOLOGICAL EVALUATION OF THE STATUS OF THE WETLANDS OF LAKE TANA AND THEIR CAPACITIES TO PROVIDE MULTIPLE ECOSYSTEM SERVICES

As part of the wetland sub-component of the project

"For People and Nature – Establishment of a UNESCO biosphere reserve at Lake Tana in Ethiopia"

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CONTENT

1 INTRODUCTION AND OBJECTIVE OF THE ASSIGNMENT

Wetland ecosystems have a high local and global significance as natural and economic resource. They provide a wide set of environmental services, such as flood control and biodiversity maintenance, and socioeconomic services for production and use, such as plants, crops, fish and grazing and thus are important for human use as well as for plants and animals. Therefore they are recognized as extremely valuable and the protection of wetland ecosystems has become highly important all over the world. According to Davis (1994), wetlands can be defined as, "areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water (…). "Wetlands are areas of marsh, fen, 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 tide does not exceed six meters."

The Lake Tana Region is endowed with a large number of wetlands that are among the largest and ecologically most important ones of the country and the Horn of Africa. They surround the whole Lake and are flooded during the rainy season. Lake Tana and its associated wetlands are part of the Central Ethiopian Highland Wetland Complex (Hailu 2005) including:

- Lake Tana;
- Fogera Floodplain to the east (see Keffie 2005);
- Dembia Floodplain to the north;
- Dangela and the surrounding Wetlands (see Guade 2005);
- Bahir Dar Zuria (see Negatu 2005);
- Kunzula to the southwest.

Wetlands account for 13,699 km² (i.e. 1.14 %) of land surface in Ethiopia. Of this 1,803km² (0.16 %) of Ethiopia is covered by marshes and swamps. If water bodies are included, in ANRS 3.7 % is covered by wetlands, with 288,744 ha covered by swamps and marshes, and 316,609 ha by water bodies (Kindie 2001). Wetland ecosystems support a diverse flora and fauna, high diversity in habitat types dependent on altitude, rainfall, temperature and geographic

location. The National Consultative Workshop on the Ramsar Convention and the World Habitat Society already identified Lake Tana and the Fogera wetlands as potential sites for a Biosphere Reserve and wetland conservation in 2004.
More than 60 seasonal and perennial rivers that are equipped with distinct riparian and wetland vegetation can be found in the Lake Tana region. But the vast majority of this vegetation type is concentrated in the flat plains of Lake Tana.
One of the characteristic features of Lake Tana, the papyrus populations, has dramatically declined in its distribution due to overexploitation and habitat fragmentation and loss. Nowadays papyrus populations are mainly found in pocket habitats along the shorelines (Woldegabriel & Solomon 2006).

The specific objectives of the assignment were the evaluation of the ecological status of the wetlands around Lake Tana with special focus on specific site parameters for ecological integrity and carbon accounting (soils and carbon stocks and sinks, peat accumulation) and the evaluation of the ecological capacity of the wetlands to provide various ecosystem services.
This should include the assessment of specific site parameters for ecological integrity, a wetland soil analyses (including carbon contents), the accounting of the carbon sink potential, carbon stocks and peat accumulation as well as the evaluation of the wetlands as habitats for breeding and wintering birds. Furthermore the ecological capacity of the wetlands to provide ecosystem services should be examined with focus on land productivity, usability, risks of degradation, importance for biodiversity, nutrient accumulation capacity and carbon sequestration.

2 MATERIAL AND METHODS

The field phase was conducted between 20th of November till 5th of December, 2013.
Because of the large area to be covered, data sampling was concentrated on 2 representative wetlands in order to make generalizations possible.

Aim of the fieldwork was to take samples along and within the papyrus wetlands to evaluate the ecological status of the papyrus wetlands around Lake Tana and especially their ability to accumulate peat and the amount of the already accumulated peat.

Due to extraordinarily high water levels fieldwork was difficult and done by using motorboats or tankwas (local reed boats, made from papyrus).

Soil samples were taken along transects of 80-150m length (see Table 1). Along the transects the vegetation assessment was done by assessing the plant species, measurement of vegetation height and estimation of abundance according to Braun-Blanquet as described in (Glavac, 1996).
Soil samples were taken by the use of a common soil sample driller/gouge auger.

Neighboring villages, agriculture, grazing animals, human influence and other distinctive features noticed in or close to the transect area were recorded. GPS coordinates and a rough altitude value were measured using a GPS unit (Global Positioning System, in meters asl, in 1.3 m height, accuracy of GPS varying between 2 - 9 m, settings: hddd°mm'ss.s''; WGS84; metric; GRID; 000°; degrees).

The identification of the plant species and the nomenclature follows the Flora of Ethiopia & Eritrea Vol.1-8 (Edwards & Hedberg , 1995; Edwards, Demissew, & Hedberg, 1997; Edwards et al., 2000; Hedberg, 2003; Hedberg & Edwards, 1989; Hedberg & Friis, 2009; Hedberg, Friis & Persson, 2009; Hedberg et al., 2006; Phillips, 1995; Tadesse, 2004)

Rough bird observation with binoculars (8x40) was conducted in addition to the vegetation assessment based on Redman, Stevenson & Fanshawe, (2009) along the transects.

Analyses of the soil sample was done by the Soil chemistry and water quality section of the Amhara Design & Supervision Works Enterprise

A comprehensive literature study was done additionally to the over-years collected experience at Lake Tana in order to evaluate the ecosystem services.

Table 1: information on investigated transects

Transect	Characterizations of transect location	Transect structure and length	GPS coordinates of the starting point of the transect
Chimba	Close to Gilgel	Dense Papyrus swamp, 120m length	N 11.67888 E 037.15407
Yiganda	Southern shore of Lake Tana, close to Zege peninsula	Dense Papyrus swamp, 150m length	N 11.71414 E 37.32244

3 CHARACTERISATION OF HABITATTYPES & EVALUATION OF ECOLOGICAL CAPACITY OF THE WETLANDS TO PROVIDE ECOSYSTEM SERVICES

Lake Tana is Ethiopia's largest lake, the highest-lying of the great lakes of Africa and the source of the Blue Nile River that tributes most of the water of the Nile River.

The Lake Tana Basin is rich in biodiversity and is harborage for a number of endemic flora and fauna and well known for its cultural heritage and the waterfalls of the Blue Nile.

Yet, this "Eldorado" is threatened by intensive farming, serious land degradation, irrigation projects and hydropower stations. Excessive siltation due to inappropriate water and vegetation management in the surrounding highlands is damaging the lake too.

Setegn et al. (2009) stated that the Lake Tana Basin is of critical national significance as it has great potential for irrigation, hydroelectric power, high value crops and livestock production, ecotourism and more. Moreover it is one of the major basins that significantly contribute to the livelihoods of tens of millions of people in the lower Nile river basin. (Setegn et al., 2009)

The Lake Tana region comprises the largest wetlands of Ethiopia, surrounding the whole Lake and flooded during the rainy season. The papyrus stands, one of the characteristic features of Lake Tana, have declined in their extent dramatically due to over exploitation, habitat fragmentation and loss (G/kidan & Teka, 2006).

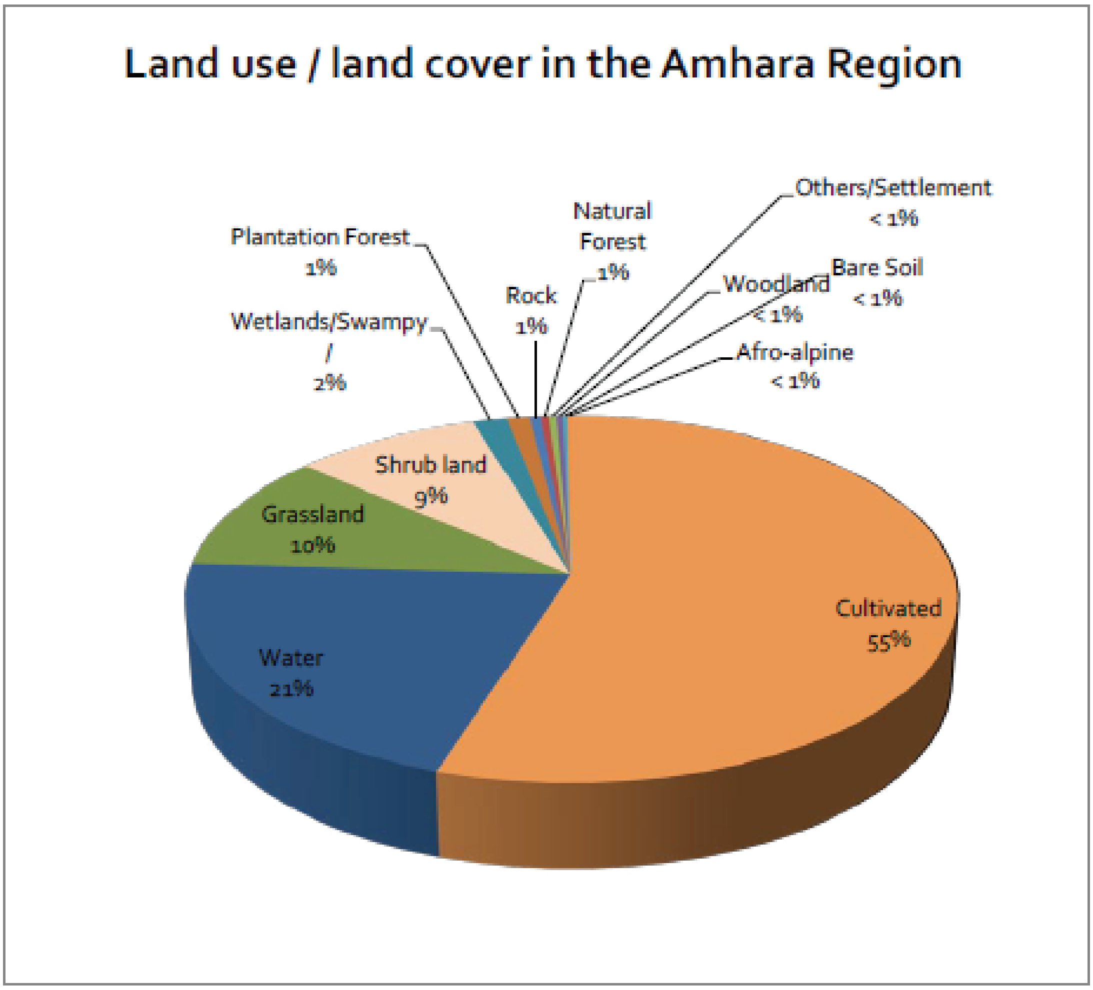

Figure 1: Land cover in the Amhara Region (source of data: WBISPP, 2002 in IFAD, 2007)

Wetlands perform ecosystem functions that are vital for the health and biodiversity of the terrestrial and aquatic systems that they connect. They also support the livelihoods of many people, both directly and indirectly, through their provisioning, regulating and cultural ecosystem services. Ecosystem services are based on the components, processes and functions of ecosystems (van Dam, Kipkemboi, Rahman, & Gettel, 2013). The degredation of wetlands is not only a serious threat to the ecology, but also to the lievlihoods of people living adjacent to Lake Tana and downstream the Blue Nile. (Mundt, 2012)

According to Friis, Demissew, & van Breugel (2011) the potential natural vegetation of the Lake Tana Area consists of dry evergreen Afromontane forest and Grassland Complexes, Lake Tana as freshwater lake, freshwater marshes and swamps, floodplains and lake shore vegetation and Combretum-Terminalia woodland and wooded grassland.

Due to the deforestation only little of the pristine vegetation is left (see Figure 1).

3.1 Characterizations of the catchment area of Lake Tana

The catchment area of Lake Tana is characterized on the base of specific area investigations and an additional excursion in the catchment area of Mount Guna on the 23./24.11.2013. The classification of the landscape is done in accordance with the Agroecological Belts of Ethiopia (Hurni, 1998). The classification of the belts can be seen in Figure 7.

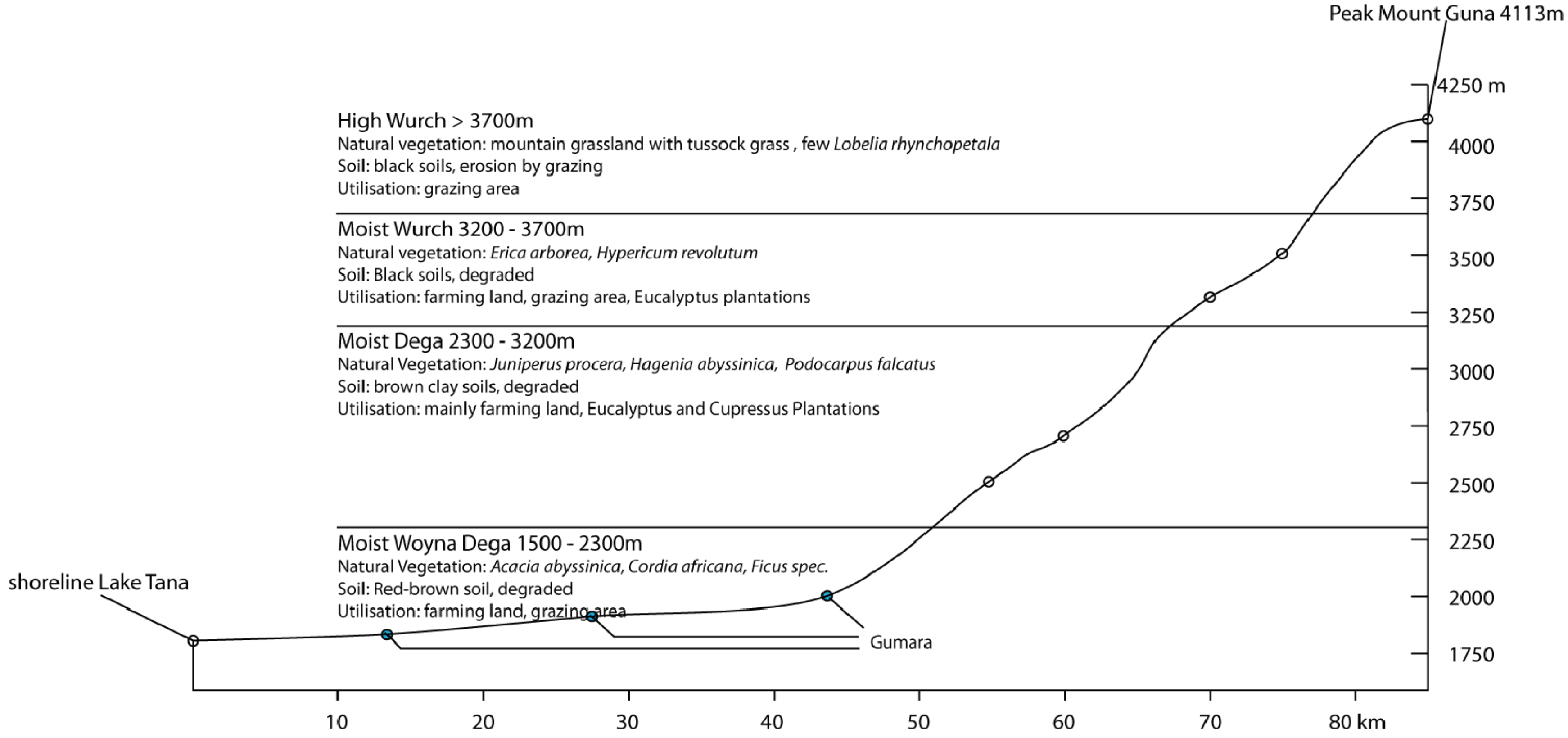

Figure 2: Profile Mount Guna by Fanny Mundt

At the top of Mount Guna, starting at a height of 3700m above sea level, the **Alpine zone or High Wurch** is situated (Figure 2). This Zone consists of a closed population of tussock grass on black, little disturbed soils.Figure 3 The tussock land is used as an important grazing area for horses, cattle, sheep and goats. The area close to the road is partly degraded by a narrow system of partly ½ m deep grooved animal trails. Erosion can be seen clearly (Figure 4). Although at least close to the road overgrazing is obvious is this the last natural vegetation zone. In remote areas few plants of *Lobelia rhynchopetala* can be seen.

The alpine zone accommodates a high stock of rodents, for example densely populated colonies of grass rats (*Arvicanthis* spec.). Natural large herbivores like Gelada Baboon or Walia Ibex are almost extinct, which leads to solely anthropogenic use as pasture.

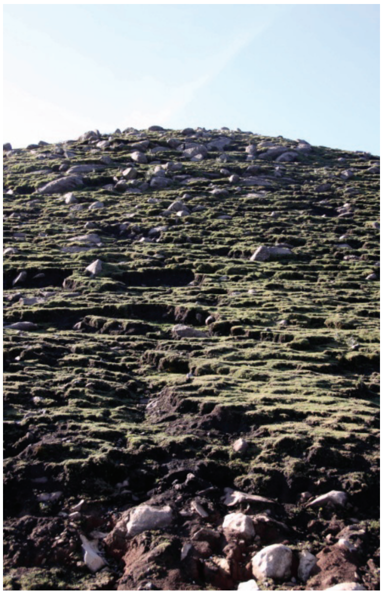

Figure 3: Eroded Tussok Area

Figure 4: Tussock Grassland

The **Subalpine Zone or Moist Wurch** is situated between 3200-3700m height. At the moment this zone is almost completely a zone of cultural landscape. The highest lying human settlements with tukuls (traditional Ethiopian round hut) occur at a height of 3700m.

The natural vegetation consisting of *Erica arborea* and *Hypericum revolutum* is remaining in one last area close to the road, but is threatened by browsing due to overgrazing. The loss of this area can be expected, unless the area isn´t put under strict protection what we highly recommend.

Figure 5: Moist Wurch with Erica arborea

At the moment the area is largely utilized as farming land (barley, wheat). The fields are in a very good condition, with dense productive stocks, without the use of fertilizer and pesticides. The soils are high-quality humus soils (often paludified soil). Agriculture is generally practised in slopes, according to the fact that during the rainy season the wide plains often become wet in huge extents and due to that are not suitable for the cultivation of grain.

The wide plains are habitat for the Wattled Ibis (*Bostrychia carunculata*) (see Annex 1) that lives here in flocks of hundreds of specimens. The plains serve as very important grazing areas for the livestock. We suppose that the agriculture within the Subalpine Zone has started in recent years, the main settlement zone is certainly the montane level.

Figure 6: Group of Wattled Ibis

Due to the eucalyptus plantations fuel wood and construction timber was available to allow the settlement in those extreme areas. The wooded areas of the Subalpine Zone are generally destroyed by grazing, what makes settlements without eucalyptus plantations impossible.

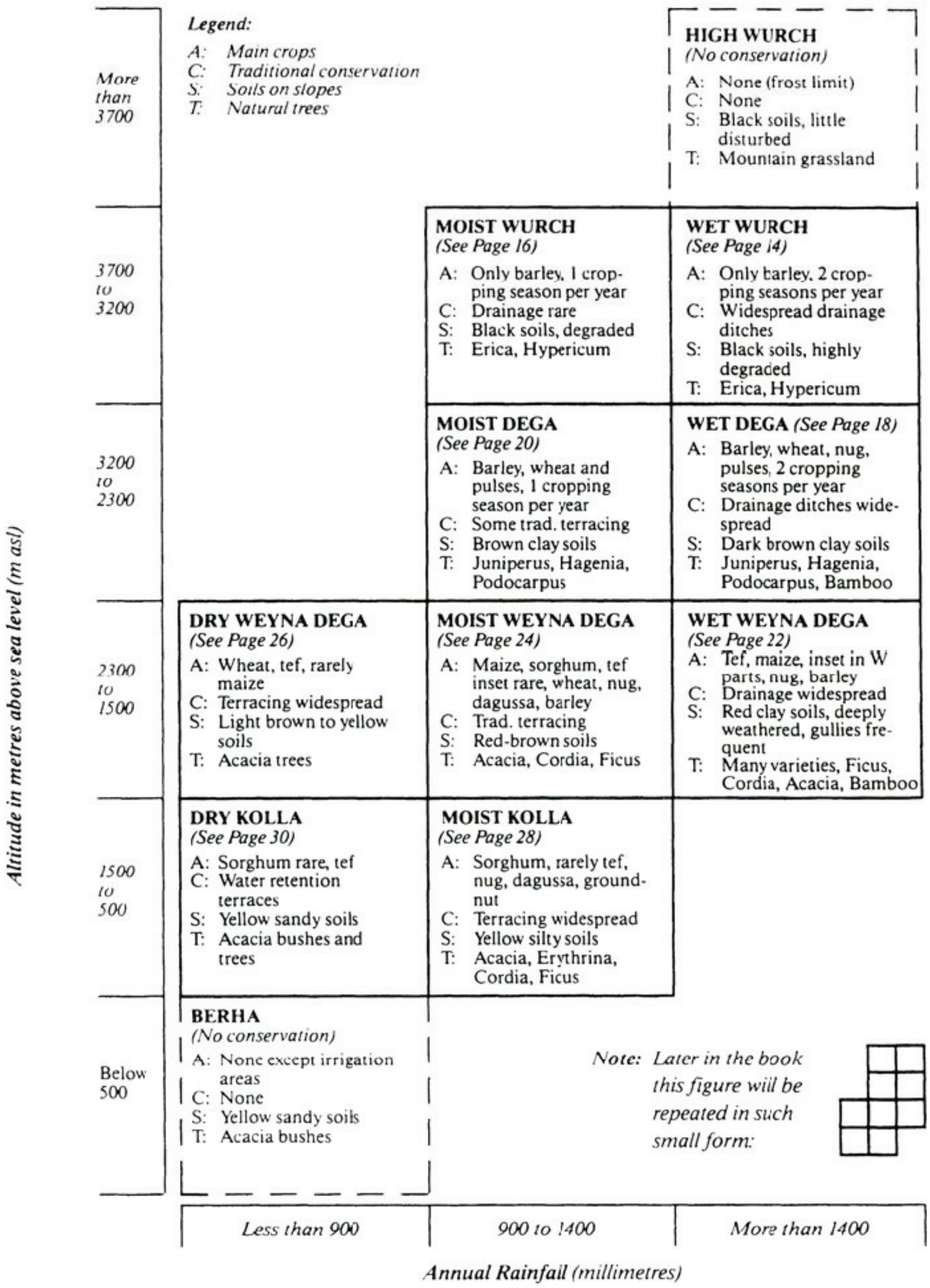

Figure 7: Agroecological zonation system (Hurni, 1998)

The **Upper Montane Zone** or **Moist Dega** is situated at a height of 2300 – 3200m. The primary vegetation consists of *Hagenia* woodland, with a tree height of less than 15m. Remaining forest was seen only at one place which seems to be a church forest with an area of less than 10 ha. Besides, only eucalypt plantations were seen. Hill tops were often completely afforested. At degraded steep slopes plantations of *Cupressus lusitanica (in Amharic Yeferenj T`d),* not older than 50 years, were seen several times. *Cupressus lusitanica* grows well in dry, moist and wet Weyna Dega and Dega. The wood is used for poles, posts, as timber, as firewood and as a living fence. It is propagated from seedlings or wildlings and it is fast-growing. Next to Eucylaptus it is the most widely planted non-indigenous tree in Ethiopia (Tadesse K. , 2012). The rest of the area is completely used as farming land.

Repeatedly deep gully erosion up to a depth of 4m was seen. On the other side one can see farming activities with intensive use of terracing on steep hills with inclinations up to 60°.Corresponding to that intensive erosion is caused under the euhumid climate (annual precipitation ~1800mm).

Although the population density is very high at the moment, the earning potential is supposed to be at a high level. In contrast to that the deeper lying areas are heavily degraded due to the intensive land use over a long period of time.

Figure 9: Deep gully erosion

Figure 8: Zone of Moist Dega

Main cultivated plants are barley, wheat, linen and fava beans.

The natural vegetation would correspond to *Hagenia abyssinica (*in Amharic Ducca/Kosso*)*, *Podocarpus falcatus (*in Amharic Birbirsa/Zigba*)* and *Juniperus* *procera (*in Amharic Gatira/T´d*)* (Tadesse K. , 2012). The montane zone as main population area and primary supplier of timber was deforested for several hundred years.

The **Middle Montane Zone** (**Moist Woyna Dega**) lies between 1500 and 2300 m height. This zone is supposed to be an old settlement area of the Amhara people. The temperate, humid climate is most suitable for agriculture, practiced here since hundreds of years. Within this zone very few natural forest areas can be found in lower slopes, for example the Alem Saga State Forest. Species like *Acacia abyssinica (*in Amharic Ambo/Garbii/Grar*), Cordia africana (*in Amharic Wedecha/Wanza*), Celtis africana (*in Amharic Mec`ersa/Ameleqqa*), Ficus sycomorus (*in Amharic Oda/Bamba*), Ficus vasta (*in Amharic Dembi/Warka*)*, on south exposed slopes *Olea capensis hochstetteri (*in Amharic Geeccaa/Damot Weyra*)* und *Cussonia holstii (*in Amharic Harfatu/Gombocerie*)* occur naturally within this forest. Autochthonous trees and shrub-species are practically vanished. In large scale the only planted tree species is Eucalyptus, besides that very seldom small remnant trees of umbrella thorn acacias can be found. *Juniperus* species are only found in church forests. Due to soil erosion many areas are completely depleted to agriculture. The natural soil fertility is lost to an extreme degree, in contrast to the newly populated areas of the subalpine zone, where thick humus layers are existing, yet. In this zone mainly barley, wheat, chick peas and noug are cultivated alternately with grassland for the production of hay (moderate productivity with 30-50 dt hay). Reasonably agriculture should be abandoned on those basalt stone fields and reforestation programs should be implemted instead. That should happen partly with autochthonous shrubs and trees (for example *Acacia spec, Juniperus spec., Olea spec.*). An urgent need is obviously the afforestation of abandonded fields as community actions. This stands in big

Figure 10: Zone of Moist Woyna Dega

contrast to the current usage as grazing area, what is ecologically and economically irresponsible.

The Woyna Dega is naturally a zone of dry evergreen mountain forest and grassland-complex or evergreen scrub vegetation.

Along rivers and streams riverine forests are found. The afforestation of riversides as particularly sensitive areas is strongly recommended. Here again a reforestation of the gallery forests with autochthonous species should be strived. But this involves fencing of larger areas along rivers. Natural species of riverine forests are *Sesbania sesban (*in Amharic Harca*) and Mimusops kummel (*in Amharic Buruurii*)*.

Figure 11: 3 Abyssinian Groundhornbills in Lake Tana area

Figure 12: remnant sycamores

Scattered around the lake remnants of natural vegetation can be found especially in rocky areas. The natural Combretum-Terminalia-Woodland (Friis, Demissew, & van Breugel, 2010) nowadays is restricted to special locations, above all lava streams. Main species in those remnant vegetation patches are *Combretum molle (*in Amharic Dadamsaa/Avalo/Weiba*), Terminalia brownie (*in Amharic Baresaa/Abalo*), Ficus sycomorus (*in Amharic Oda/Bamba*), Euphorbia abyssinica (*in Amharic Hadaamii/Qulqwal*), Cussonia holstii (*in Amharic Harfatu/Gombocerie*)*. Due to pasture and overgrazing those areas in general are strongly degraded.
Generally it is crucial to reduce the highly oversized livestock. Half of the livestock in a good condition and well fed would decrease the damage of the nature and would carry a higher yield. We strongly recommend a cost-benefit-calculation.

3.2 Lake Tana – Characterizations of the water body

Important information on the genesis, ecology, anthropogenic changes, fauna and flora and further literature can be found in zur Heide (2012), Mundt (2012), Springsguth (2013), Moreaux (2013), Alemayehu, McCartney, & Kebede (2010), Chorowicz et al.(1998), Francis & Aynalem (2007), Tadesse (2012), Getahun & Dejen (2012), Ligdi, El Kahloun, & Meire (2010), Lamb et al., (2007), Minale & Rao (2011), Vijverberg, Sibbing, & Dejen (2009).
At the moment the lake is in a highly eutrophic/polytrophic, partly even in highly polytrophic (northern shore) status, caused by melioration, river regulation and hydro melioration within the realms of wetlands. Within the vicinity of Bahir Dar a strong impairment by the discharge of waste water takes place.
Serious effects on the lake are caused by the enormous sediment transportation from the catchment area and its dominant agriculture (siltation process). Literature findings on the loading rate vary greatly between 8.96-14.84 million tons of soil per year (Yitaferu 2007; Wondie et al. 2007; Teshale et al. 2001; Wudneh 1998 & Nagelkerke 1997 in Goshu, Byamukama et al., 2010).
The lake is in alkaline status, with pH between 7-8 (Mundt, 2012), with a high content of electrolytes and a visibility depth of less than 30 cm.
The lake has changed its trophy status due to the early development of

agriculture in the catchment area extremely within the last decades (rapid eutrophication.) It can be assumed that under natural conditions the whole catchment area would be an area more or less covered by forest and thereby excluding soil erosion. This condition should have been prevailed until people started settling in this area.

The general rise of the lake bottom is that rapid that without any precautions the lake would be totally filled up within 20 years. Each year a total of 37 million to 59 million tons of soil is washed away from the catchment area of Lake Tana (GEF-IFAD-EPLAUA, 2007 in Kebede, 2013). Otherwise the rise of the lake bottom can be expected to cause increased flooding of the areas adjacent to the lake due to the distinctive rainy season in this humid area. The amplitude of the water level fluctuation varies depending on the precipitation intensity between 1-2m. As a result the lake has got a dynamic that is known by rivers and their periods of flooding.

Due to the very small visibility depth underwater vegetation is missing. Only three aquatic vegetation forms can be found: 1. Floating mats of *Ceratophyllum demersum,* 2. Floating mats of *Eichhornia crassipes* and 3. A floating leave vegetation with *Nymphaea spec.*. The floating mats of *Ceratophyllum demersum* spotty fill the upper water body (20cm) mainly in bays. They are moved by wind and are transported to the wind-exposed shore as throw-off. Those mats constitute a final kind of nutrient uptake within the ecosystem of the lake. Partly they are disposed to the shore and partly they sink down as sediment.

Especially in the northern part of the Lake, caused by enormous nutrient contamination coming from the city of Gondar and the drained and intensively used former wetlands along the rivers, extensive floating mats of *Eichhornia crassipes* can be found. This phenomenon started few years ago and characterizes hundreds of hectares in the meantime. Those *Eichhornia*-mats are considered to be a curse by the locals, but indeed are a clear indicator for the ecological situation (polytrophic conditions) and supposed to further spread in the future. The meanwhile practiced removing of the mats, the drying at the shore and the following burning of the biomass has to be forbidden in terms of ecology. Reasonably, the mats with their high possibility for nutrient uptake

Figure 13: Eichhornia crassipes

should be removed from the lake and afterwards spread and ploughed under on the fields as green manure. Therewith the fields get a high supply of plant fertilizer (nitrogen, phosphor, potassium). The biomass can be assessed as a mulch mat (keeps the soil moisture) which is ploughed under a valuable source of available organic substance within the soil. This would implement a circle economy, contributing to the health of the lake and providing the nutrient surplus and the organic substance to the farming land.

3.3 Natural siltation zones

In sheltered bays of the lake loose floating leave vegetation consisting of Nymphaea lotus and Nymphaea caerulea is formed in areas with a water depth up to two to three meters (deepest water depth during the dry season). The roots take up nutrients from the sediment and the floating leaves become accessible of the capability to use the light directly at the surface, due to the no longer transparent water body. By the development of this strategy they are able to populate not to heavy wind exposed segments in highly eutrophic and polytrophic lake ecosystems. Occasionally small thickets of *Cyperus cf. Digitatus*, that start initiating reeds, can be found. The siltation area with its water pioneer plants is an important

Figure 14: natural siltation zone

habitat for fry and juveniles of several fish species within the lake and thus food biotop for Cormorants, Darter, Little Grebe, hibernating Terns, Kingfisher and seagulls. In dense stands Jacanas can be found as well.

This ecosystem does not have the capability to store carbon, since the formed organic substance will be decomposed after dying and only sapropel results.

The value of these ecosystems is the temporary nutrient fixation, the importance as habitat for aquatic fauna and birds and its attractiveness and ornamental use for tourists.

The natural siltation zones are threatened by grazing. In areas where cattle can reach the floating leaves they will consume the whole stand.

In general those areas should be protected. Some untouched areas can be secured as core zones, whereas areas used for grazing should be protected as buffer zones. A further touristic utilization has to be prevented.

Table 2: Birds observed at the shore path

Latin name	English name
Acrocephalus gracilirostris	Lesser Swamp Warbler
Acrocephalus schoenobenus	Sedge Warbler
Actitis hypoleucos	Common Sandpiper
Actophilornus africanus	African Jacana
Alcedo cristata	Malachite Kingfisher
Alopochen aegyptiacus	Egyptian Goose
Amaurornis flavirostra	Black Crake
Anhinga rufa	African Darter
Ardeola ralloides	Squacco Heron
Bostrychia carunculata	Wattled Ibis
Bycanistes brevis	Silvery-cheeked Hornbill
Centropus senegalensis	Senegal Coucal
Ceryle rudis	African Pied Kingfisher
Chalcomitra senegalensis	Scarlet-chested Sunbird
Chlidonias leucopterus	White-winged Tern
Circus aeruginosus	Eurasian Marsh-Harrier
Colius striatus	Speckled Mousebird
Corvus rhipidurus	Fan-tailed Raven
Corythaixoides leucogaster	White-bellied Go-Away-Bird
Cossypha semirufa	Rüppell's Robin-Chat
Crinifer zonurus	Eastern Grey Plantain-eater
Dicrurus adsimilis	Fork-tailed Drongo
Gallinago nigripennis	African Snipe

Halcyon chelicuti	Striped Kingfisher
Haliaeetus vocifer	African Fish Eagle
Lagonosticta senegala	Red-billed Firefinch
Merops persicus	Blue-cheeked Bee-eater
Merops pusillus	Little Bee-Eater
Milvus (migrans) aegypticus	Yellow-billed Kite
Motacilla aguimp	African Pied Wagtail
Motacilla cinerea	Grey Wagtail
Nycticorax nycticorax	Black-crowned Night Heron
Passer swainsonii	Swainson’s Sparrow
Phalacrocorax africanus	Long-tailed Cormorant
Phoeniculus somaliensis	Black-billed Wood-Hoopoe
Platysteira cyanea	Brown-throated Wattle-eye
Plectropterus gambensis	Spur-winged Goose
Poicephalus flavifrons	Yellow-fronted Parrot
Psalidoprocne pristoptera	Black Saw-wing
Pycnonotus barbatus	Common Bulbul
Scopus umbretta	Hamerkop
Stigmatopelia senegalensis	Laughing Dove
Streptopelia lugens	Dusky Turtle-Dove
Tachybaptus ruficollis	Little Grebe
Terpsiphone viridis	African Paradise Flycatcher
Threskiornis aethiopicus	African Sacred Ibis
Tringa glareola	Wood Sandpiper
Tringa ochropus	Green Sandpiper
Turdus (olivaceus) abyssinicus	Mountain Thrush
Vanellus senegallus	African Wattled Lapwing
Vanellus spinosus	Spur-winged Lapwing

3.4 Graswetlands, extensively used in dry seasons

Coming from the shoreline in this zone there are often found lines of fabacae-shrubs (types of genera *Aeschynomene* und *Sesbania*). These shrubs represent a preferred nesting ground for weaver birds. Some plants growing and extending into the water may form dense covers in thickness up to 30 cm and can be entered by humans as well as cattle.

Towards the open water the stands become less dense and finally end in single plants growing far from the shore. This floating vegetation characterizes river deltas with high proportions of sedimentation.

May it be lines of reed/papyrus near the shore or growing out far into the open water, for the formation of land the floating vegetation plays a pioneering role. It may subsist to a depth of 4 meters during the rainy season and also persists in total regression/drop of the water level (see Figure 15).

The vegetation mainly consists of *Phragmites australis et karka*, several types of *Cyperus*, *Echinochloa spec.*, *Persicaria senegalensis* amongst others *Ludwigia abyssinica*, *Pycnostachys spec.*. *Nymphoides spec.*, *Ipomoea aquatica*., *Ottelia ulvifolia* (sporadic occurrence).

The floating vegetation at the lakes shores is highly important as habitat of Hippopotamus, the Nile monitor and following species such as African Jacana, Swallows, Wagtails, Herons (Black-crowned Night Heron, Great White Heron, Purple Heron, White Heron, Cattle Egret) , Black-Crowned Crane, Egyptian Goose, Spur-winged Goose, Egyptian Goose, Eurasian widgeon, White-faced whistling Duck, Marsh Harrier as hibernating bird.

Those areas are important grazing pastures for cattle during dry season as they get accessible through the lowering of the water level and are popular places for cut & carry systems and important points for reed harvesting.

When development is not disturbed, floating mats of papyrus reeds may be established at final phase of succession.

Presently these areas are important pasture grounds during dry season with vegetation highly damaged by overgrazing. The settlement of papyrus reeds is impossible under the present conditions.

Figure 15: graswetlands at Lake Tana

These ecosystems play an important role for nutrient consumption and thus improve the quality of water. Using them for pasture or cut&carry systems is essential for the removal of nutrients. They are important habitats for breeding, feeding and especially for migrating birds (Wagtails, Barn Swallows and Sand Martins)

Their preservation is an important management task. However, they are irrelevant as carbon dioxide storage since they don't accumulate turf but only sludge sediments. Due to the heavy sedimentation process a further spread of vegetation into the lake is most likely. This pioneering vegetation focuses mainly on the rivers delta areas.

Spread over the lake, selected areas shall be declared core areas which may be preserved as habitat of hippopotamus without any form of utilization (see attached map, Dresen 2014). Other areas may be declared buffer zones where possible sustainable use in pasture and cut&carry systems can be practiced.

3.5 Papyrus reeds

Cyperus papyrus can form extensive wetlands that are important to biodiversity and the livelihoods of millions of people. The importance of papyrus is not only a result of its vast areal coverage. Papyrus wetlands also provide vital ecosystem functions and services for millions of people and form a habitat for unique forms of biodiversity. Several papyrus wetlands have great importance for migratory bird species (van Dam A. , Kipkemboi, Zaal, & Okeyo-Owuor, 2011).

Characteristic for progression in siltation processes at Lake Tana and the flood plains are natural large scale stands of *Cyperus papyrus* (see Figure 16). Those stands are natural vegetation formations that underwent a strong decline throughout Africa (almost extinct within the area of the Nile (Sudan, Egypt)). They probably extend over more than ca. 8400 ha gathering at the entire Southern shore of the lake (east to west) and on the lower stretch/reach of the Gilgel Abay and the river delta.

The stands most well preserved may currently be found at the estuary of the Gilgel Abay. At the northern shore formerly rich stands were heavily depleted by hydro meliorating measures.

The reed stands do occur at two points: firstly, the siltation areas adjacent to the area of floating vegetation and floating mats of the grass wetlands. These stands may float with their peat layer with high water levels during rainy season and settle on the organic gyttja during dry season.

Secondly, reeds occur on the near-natural flood plains which are widely undisturbed especially at the Gilgel.

Figure 16: Papyrus reeds at Lake Tana

These are largely stationary mires which deposit peat heavy with clay and silt due to high sedimentation of the river waters. These usually don't float but get flooded with tips protruding from the turbid water and further assimilate.

Our few stratigraphic analyses do permit estimations of peat layers up to the thickness of several meters. Thus they may be the most important carbon sinks within the entire ecosystem of Lake Tana.

Cyperus papyrus is absolutely dominant among the undisturbed reeds with a coverage rate of up to 80 % of living papyrus plants and 30 % of dead papyrus and a height of 3 to max. 5 meters. The understory vegetation is correspondingly weak.

Culm densities of papyrus range from less than 10 to as high as 22 shoots per m^2, leaving little opportunity for other emergent plants to be successful although climbers and twiners (e.g. *Ipomoea sp.*) are common. In general papyrus stands can be rooted but papyrus mats can also get detached from the substrate and form floating mats. The structure of the floating mats is open, allowing unimpeded flow of water through the mat and easy uptake of nutrients (Azza et al., 200 in van Dam A. , Kipkemboi, Zaal, & Okeyo-Owuor, 2011).

Growing under the right conditions, papyrus plants can grow to a length of 5m and aboveground biomass density of 10 kg dry matter per m^2, although a biomass range of 1-5 kg m^{-2} is more common. (van Dam A. , Kipkemboi, Zaal, & Okeyo-Owuor, 2011)

Up to now there are no systematic evaluations of this habitat for birds and animals due to the impenetrability of the dense reeds, yet, we know that the reeds form an important habitat for weaver birds.

The cuckoo as an ichneumous bird is constantly found in these reeds which could serve as breeding grounds for Black Crowned Crane, Wattled Crane, the Black Crake and further species of rails as well. *Streptopelia lugens* occur regularly within the reeds. The papyrus reeds are major places for overnight stays of European swallows and wagtails. Also the marsh harrier is seen regularly as hibernating bird species.

Further they are of major importance as nursery for young fish.

The papyrus stands serve as necessary habitat for Nile monitor (*Varanus niloticus*), retreat area for hippo and the African rock python (*Python sebae*) are reported to live here.

In populated areas grazing within the papyrus stands plays an increasing role. Grazing obviously leads to the conversion of papyrus reeds to floating reedmats. It seems to be the most important threat especially during the dry season when cattle can get deep into the papyrus stands. Our few stratigraphic investigations indicate that the papyrus stands were significantly larger in size which can be explained by the finding of peat underneath floating mats.

Partly the upper tips of the papyrus plants are harvested by cut & carry systems as fodder for cattle. An important and traditional us of the papyrus culms is the manufacturing of tankwas (traditional papyrus boats). Papyrus wetlands in the Lake Tana area provide a wide range of ecosystem services such as purifying water, provisioning food, materials for building, crafts, fuel, cultural use, medicinal herbs and others, that are the results of livelihood activities such as water abstraction, papyrus and reed biomass harvesting, conversion of papyrus stands into crop fields, livestock grazing, sand and clay harvesting, fishing and fish trap construction, construction of drainage canals and others. Furthermore papyrus wetlands contribute to the retention of sediment and nutrients from inflowing water (van Dam A. , Kipkemboi, Zaal, & Okeyo-Owuor, 2011 und Saunders, Kansiime, & Jones, 2013).

The papyrus-wetlands are supposed to be the most important carbon sink – ecosystems around Lake Tana. We are forced to concentrate on the results of

Saunders et al. (2013) due to insufficient laboratory analyses. Their results base on studies conducted in central afrika, that should be valid for Lake Tana as well.

It is desirable to conduct further qualified investigations on the papyrus wetlands around in order to emphasize their character within the whole ecosystem Lake Tana.

Not yet exploited papyrus reeds are supposed to be one of the last anthropogenic undisturbed habitats due to their impenetrability. Their value as place of retreat for the fauna is only partly known.

The papyrus reeds do have great importance as areas of evaporation within the landscape water regime and are at the same time of great value as cooling systems (climatic compensation areas).

Especially the papyrus reeds of river systems are relevant filter areas (fixation of sediments, nutrients and pollutants). They are of enourmos significance for the ecologically critical state of the lake. Within the papyrus reeds already few meters away from the lakes water body clear water can be found (water purification is well known from papyrus wetlands). The further loss would cause a rapid eutrophication of the lake.

The papyrus reeds in the region are carbon sinks that have a higher importance than forests due to their accumulation rate, because they do render higher ecological benefits than forest locations.

In general all intact papyrus reeds have to be designated as corezones due to their great ecological importance. Adjacent areas should be accounted for buffer zones. It seems necessary to identify areas that can be used by the local communities whithin the management plan. Utilization rotations should be taken into account. Cattle must completely be kept out of the reeds.

In view of the significance of papyrus reeds the artificial planting of papyrus on selected locations is recommended. The preservation and the establishment of papyrus reeds could be a basic approach for international research cooperation.

3.6 Floodplains used as grazing areas

Within the wetland ecosystem of Lake Tana the floodplains used as grazing areas play a central role. This wetland type consists of a floodplain in the river delta with a core area in the great plain of Fogera and at the Gilgel Abay and partly of degraded Lake Tana shores. Most likely these resulted from intensive pasturing of papyrus reeds.

During the rainy season those areas are mostly flooded to water levels up to 2 meter above surface. At height of the dry season there usually is no open water, not even in the lowest depressions.

Depending on the rain intensity during the rainy season pasturing is constantly progressing from the lakes shores into the central areas.

The soils mostly are sedimentation soils (fluvisols) with high percentage of clay and silt and thus of high fertility (see Figure 18).

The vegetation cover adapted most impressively to high water level fluctuations as well as to centuries-old traditional utilization.

During the rainy season the open waters are covered with a floating vegetation, mats of *Nymphaea lotus* and *N. caerulea*, *Nymphoides brevipedicellata*, mixed with floating mats of *Cyperus* grasses, *Persicaria spec.* and *Ipomoea spec.*. The vegetation may cover the ground up to a 100 percent. However, it's mostly lacunose due to grazing pressure which usually prevents the growth of closed reed stands.

Numerous highly specialized plant species characterize these wetlands rich in flowers and blossoms.

These areas are the most significant habitats for wading birds and water birds such as shorebirds cranes, herons, storks, geese, wagtails and pipits.

Today these habitats at Lake Tana may represent Ethiopia's most important and still intact wetlands. Their preservation is highly significant since they also form a decisive hibernation ground for European and wading birds and water birds.

Those areas are of significance as common pasture land. The wetlands are highly attractive for bird watchers and nature tourism.

Since indigenous people highly respect birds these in return seem familiar to coexistence with human beings and least timid. A familiarity which is hardly encountered elsewhere.

Due to yearly desiccation there is no substantial accumulation of organic matter. Despite high productivity biomass is largely mineralized during the yearly cycle.

Thus, these areas are irrelevant to the climate but important for evaporation and cooling. Also they do relieve the lake with sedimentation.

Main problems are degradation by pasturing and conversion in arable lands. Currently lands are used as commons by the Woredas and Kebeles.

This form must be preserved, a conversion into arable lands would destroy pasture land indispensable to the tribes/communities during the dry season and cause a collapse of traditional land management. Also these habitats are important wintering grounds of many European wading birds and water birds and breeding habitats of numerous endangered bird species.

The partly initiated river regulation (projects at shores North and East) is resulting in destruction of these habitats, irresponsible and negative ecological consequences and social problems.

These explanations prove: the preservation of these ecosystems must be one of the central goals in the management scheme of a future biosphere reserve.

Since it is a landscape in traditional utilization it also has to be protected by a buffer zone.

The preservation of these landscapes in traditional utilization is one of the most important tasks during the biosphere reserve's implementation.

There is no hunting pressure. Even large birds such as geese, ducks, storks, cranes, pelicans and eagles display confidingness and lacking flight behavior.

This potential for tourism must be highly appreciated. Simple investments, such as observation desks, information centers and visitor trails and the engagement of local communities could unlock further potential.

3.7 Annually flooded farming land

One characteristic of the Fogera-Plain in the Easter catchment area of Lake Tana are periodic flooding areas with an adapted traditional land-use, which follows the receding water. It can be assumed that the formation of the present Fogera-Plain is connected to historical times, as a result of early introduction of agriculture in the Ethiopian highlands (see Figure 17). The deforestation of the catchment area, especially in the East, during a process that lasted centuries, lead to a filling of the eastern bay by fertile soil material.

Thus, in these areas the most fertile soils of Ethiopia were formed, mainly consisting of fluvisols. The ongoing floodings, which are tied to the rainy seasons, lead to further accumulation of clay- and silt-material and therefore to a constant regeneration of the Fluvisol-soils (see Figure 18). This is characterized by a high heterogeneity in the upper soil as a result of sedimentation processes of rivers. Along these, sandy material will settle, which is first to be deposited during a flooding, while regions further off the rivers are dominated by fine sediments such as clay and silt. umfassen . These far wider areas grow less fast and, hence, stay flooded longer. Consequently, this generally uniform looking plain is differing from slightly risen, less fertile areas along the stream courses, which tend to dislocate quite often, to more depressed areas that cover about 66% of the plain and have the highest fertility. Settlements of the farmers mostly are located on ridges following the rivers and not being flooded at high tides.

Figure 17: Fogera plain

The natural vegetation of the plain is hard to be reconstructed, as with its development also human settlement began. On the slightly sandy ridges Acacia-Savannah is assumed to be the natural vegetation, dominated by *Acacia abyssinica* which today can only be found scarcely and in small populations. This potential forest-site now is populated by Eucalypts in large areas as they ensure the survival of human culture after the clearance of acacia forests.

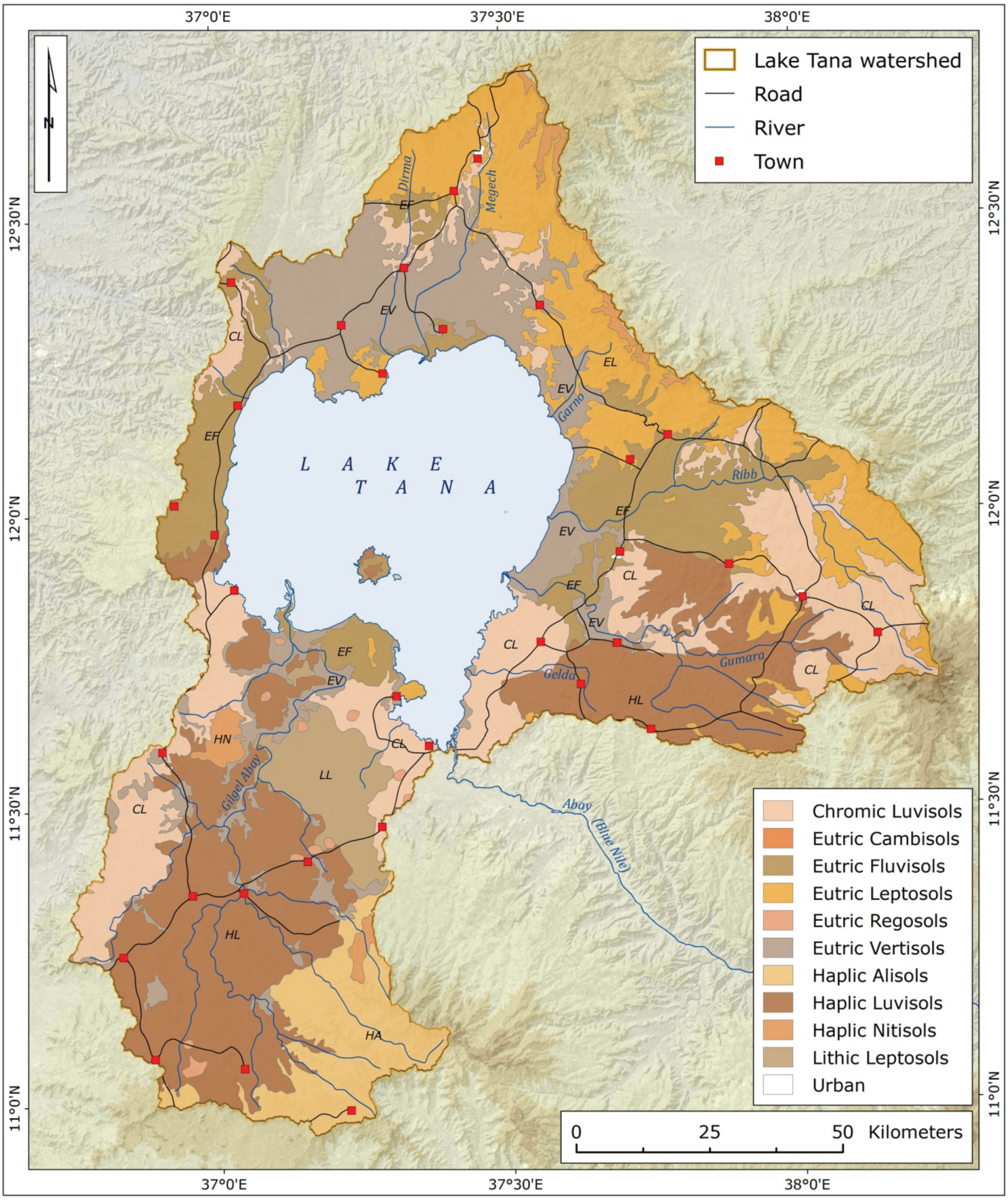

Figure 18: Soil map (design: Stephan Busse; source of data ANRS BoA in zur Heide, 2011)

The traditional land use, still characterized by ox-pulled ploughs, forces the farmers after the flood to straight plough and cultivate their fields. This leads to the impressive view on the fields, with their mosaic patterns and plants in the most diverse stages of development. The most important traditional crops are: Teff, to be the first after the flood, followed by corn (source of carbo-hydrates) or chickpea (source of proteins), finger millet and noug as an oleiferious fruit.

Moreover fenugreek and rape are cultivated. Yet, during the last 10 years there has been a big change in traditional agriculture: rice is becoming the dominant field crop which is able to be sowed right after the water ebbs away while guaranteeing maximum harvest. Field areas are the most important habitats and food sources for hibernating European cranes (23.000 individuals, during hibernation the crane settles on farmland and only uses shallow waters to stay overnight). Furthermore farmland is an important habitat for the survival of European chat, wagtails, pipit, lark as well as barn swallow and sand martin. Especially when the fields are being ploughed there are thousands of shorebirds (especially ruffs) coming to the fields.

Because of the absence of herbicides these arable crops show a high number in field herbs that serve as an important life base for a number of animals, including insects.

Due to a lack of mineral fertilization or the use of herbicides and pesticides the Fogera-Plain holds a groundwater body of very high quality. It fluctuates in annual cycles, following the floods but never sinks under a level of 3-4meters. This guarantees a supply of high-quality freshwater in every region.

Within the planned biosphere reserve the farmland basin of the Fogera is intended to be a possible development zone. The large lakes and dead river channels crossing the plain shall be designed as buffer zone, as they provide space for the assembly of marsh and water birds and they also function as the most important fishing grounds for local fishermen. Nevertheless it must be discussed to declare some of them as core zones.

The Traditional land use provides work for many thousand people, even with its newest changes in crops. An intensification of farming would make many of them redundant. Consequently, the considered intensification would be irresponsible from an ecological as well as a social point of view. It would inevitably involve the enclosure of rivers and fields and thus disable the periodic flood system and natural sedimentation which therefore would intensify sedimentation in Lake Tana and inhibit the natural fertilization of the plain. Accordingly, artificial manure had to be brought to the fields, increasing eutrophication of the lake and leading to a collapse of rural farming and the disappearance of jobs. Finally, traditional land use with its enormous and astonishing biodiversity would vanish.

3.8 Estuaries

The most significant estuaries are Gilgel Abay in the Southwest, Gelda, Gumara and Ribb River in the Southeast and Garno, Megech and Dirma in the north.
All rivers joining into the lake form delta areas. The most important is the delta of the Gilgel Abay. The total annual sediment load is between 5-6 tons (Ligdi, El Kahloun, & Meire, 2010). The river estuaries are very unstable, continuously changing ecosystems. The shape and hence the sedimentation area can vary annually. Characteristical is the development of embankments with gross sedimentation (mainly sands) along the streams. According to the intensity of the sediment load those embankments can be up to 500m in width. The highest embankments can be found directly to the riverside. During the dry season at lowest water level, those embankments can rise up to 2-3m above the regular level. The river fringes are as a rule under the use of agriculture. Generally settlements with eucalypt plantations can be found here. As soon as the water is receding at the end of the rainy season, the agricultural activity starts. Those areas are mainly cultivated with corn.
The natural vegetation of those areas with sandy gross sediments should be an acacia savannah. Still some remnant acacias can be found. Whereas in the following deeper lying areas sparse water groves of the genus *Aeschynomene* form, that are important nestling sites and resting place for waterfowl (darter, cormorants, African fish eagle and kingfisher). Under undisturbed development the formation of gallery forests, that are supposed to have a much broader distribution, is assumed.
On the northern shore of the lake is the former mentioned natural dynamic already destroyed to a large extent.
Sand deposits are eminently seldom due to the geological preconditions.
That’s why the sandy terraces existing mainly on the northern shore are important sand mining areas with appropriate interventions on those ecosystems. Sand mining is a serious threat for the wetlands along the shoreline. At the northern shoreline black sand is found and excavated on a grand scale for building purpose (especially road construction) which is resulting in the total degradation of the shore and wetland areas and which can cause erosion. Wetlands and shoreline habitats, before used as spawning and

breeding grounds of the endemic and vulnerable fish stock in Lake Tana and important to the avifauna, are irreversible destroyed and ecological degraded as a consequence of the sand mining.

In general the river estuaries are among the most productive wetlands due to constant sedimentation and the relatively high oxygen content of the river water. Accordingly, huge bird accumulations, especially of migratory birds, can be found. It is worth pointing out that especially at the estuaries in the southeast huge accumulations of Collared Pratincole, Palla´s gull, Black-headed Gull, Common Stilt, Pied Avocet, Black-tailed Godwit, terns, herons, storks, geese, pelicans and ducks can be seen.

Each form of artificial river regulation has to be prevented as the increase of the flow velocity would shift the sedimentation processes and hence restrict the land reclamation.

The river estuaries are outstanding nursery sites of fry and juvenile fishes and, hence, require special protection.

Naturally stagnant water zones should form along the in the lake growing river courses, which play a vital role for the establishing of Papyrus. However the grazing pressure during the dry season leads to a high interference/devastation of this vegetation settlement.

Selected shallow water areas of estuaries should be secured as core zones for the establishing of papyrus, especially areas in the south east of Lake Tana.

The estuaries play only a minor role as carbon sinks. All half-way intact estuaries are settlement areas for hippos.

The river estuaries with their heavy nutrient load are very productive sites and continuously growing new ground areas. In general they are areas of the commons. Totally undisturbed areas nowadays are found solely in the huge delta of the Gilgel Abay with only extensive grazing and the highest degree of naturalness. This is the only area to define large core zones, whereby there are continuous changes of the location that have to be taken into consideration.

We recommend a very generous zonation that reaches far into the open water, to already protect future protected areas. The demarcation should widely surpass the current first vegetation outposts (aquatic plants/isolated reed plants). Our recommendation is to include areas with a water level of less than one meter during the dry season.

Regarding all other estuary areas, the intention to demarcate them as core zones due to their high biological productivity and their high biodiversity is not realistic (first concept by the Ethiopian side), thus they underlie a very high agronomic pressure due to their variety of locations.

In general they should be demarcated as buffer zones due to their high ecological value and their ecological sensibility.

3.9 Combretum-Terminalia-Woodland

Prior to the anthropogenic utilization of the lake, this vegetation has been the natural vegetation form on the dry mineral soils in the whole shore area of Lake Tana. Those agronomic very productive locations are generally under farming utilization. Merely in rocky and remote, scarcely settled areas they are partly in near-natural state.

The most valuable areas of this dry forest are found at the south eastern shore, for example close to church forests (see POI 5 and POI 10), at the north-eastern shore, but especially at the northern shore west of Gorgora, with the most significant extent (see POI 25,26,27,28), and at the south-western shore (see POI 41,42) (see Figure 21).

In those remnants of dry forests grivets and squirrels are common. Small antelopes, for example Dik-diks, are expected to live in those forests. As predators might sporadically exist Serval, African Civet and perhaps the Striped Hyena. The Warthog has been proven in remnant forests in the south-west of the lake. Sporadic Porcupines and Aardvarks exist, isolated burrows are found that are ascribed to them.

From the ornithological point of view those areas are very rich in birds, for example there are different Hornbill species, seldom Turacos, different Woodpecker, Barbets, Fruit Doves, Parrots, Kingfisher, Bee-eater, Hoopoes, Glossy starlings.

Those forests are sparse, with staggered deciduous trees, with tall high grass vegetation (*Hypharenia panicum,* and *H. pennisetum*) with minor/missing grazing pressure.

Those high grasses can grow up to 2m in height. The main tree species are Combretum and Terminalia (Combreaceae), in conjunction with Acacia species (*Perocarpus lucens*, *Dalbergia melanoxylon, Piliostigma thonningii* und *Lonchocarpus laxiflorus*) and *Candelaber euphorbia*. The soils of those communities are red soils and partly vertisols in small sinks with higher clay contents.

Fire risk is increased for those forests, but they are little damaged by fire under natural conditions (no grazing). The fire front is fed by dry grasses. The grass layer is able to burn repeatedly during the dry season. Those fires are obviously caused and encouraged by humans.

In general those forests have a height of 10-15m, solely huge sycamores can become 25-30m in height.

At the moment most of former forested areas are used as fertile peasant farming areas with *Eragrostis teff*, *Zea mais*, *Guisotia abyssinica*, *Cicer arietinum*,recently also *Brassica napus* and *Helianthus annuus* being the main crops.

The destruction of this vegetation type apparently started with the relatively late settlement of the area around Lake Tana, after the downfall of the city of Gondar. The dry forest region with its easy cultivability (slash-and-burn) and the fertile red soils was rapidly transferred into farming land. In the beginning of the settlement the production of charcoal and timber was likely to be one of the most important source of income, that virtually contributed to the vanishing of hardwoods, whilst the softwoods survived longer. On the other hand the parallel increase of grazing destroyed the high grass vegetation and thereby prevented the regeneration of trees. This led to light primary forests and in the end only remnant holy sycamores, that characterize the landscape scenery today.

These forests render important ecological services under natural conditions. The dominance of nitrogen attracting trees by a root symbiosis, the humus accumulating foliage and the naturally closed grass cover prevent any form of soil erosion.

Lutz Fähser (pers. comm..) suggests the productivity (increase) of the existing near-natural forests, with roughly estimated 4000 ha in size, to be 4 m^3 per hectare (=16.000 m^3/a). Eucalypt plantations might produce 20 m^3/ha, which would result in a productivity of 200.00 m^3/a with an estimated size of 10.000 ha of eucalypt plantations. But the actual consumption is higher. Although state forests and church forests are protected, they are often used illegally. Lutz Fähser estimates that the utilization of near-natural and natural forests is twice as high as the yearly productivity (~ 30.000 m^3/a).

The dry forests are generally characterized by tree species that develop a deep root system and thereby store a high proportion of underground dendromass.

The light forests offer shade and the natural microclimate of forests (evaporation/cooling). The high percentage of flowering trees is an important source for honey production and the high percentage of fruiting trees (especially sycamores) exhibits a remarkable diversity of frugivorous birds, mammals and insects. Those forests are valuable habitats with markedly high biodiversity, as long as they are natural.

Breeding birds as well as migrating birds (Hoopoe, Bee-eater, Swallows, Chats, Redstarts) and inner African migrants (Northern Carmine Bee-eater) have their habitat in those forests.

Partly big old sycamores can be found. Agroforestry with high wood inventory should be strived to. Benefit effects would be 1) wind breaking, thereby reduction of evaporation 2) shady trees for livestock 3) foliage fertilization 4) biodiversity (sycamores as fruit trees, attracting many bird species) 5) for legumes nitrogen fixation (acacia) 6) important trees for honey production.

We recommend the protection of the last natural remnants as core zones by all means. Necessarily the natural potential of autochthonous trees and shrubs should be taken into consideration while conducting reforestation.

The system of church forests offers most valuable prerequisites to guarantee the success of reforestation within the landscape. Area closures should be included within those concepts.

The natural resettlement of such dry forests on volcanic ash hills, rocky hillsides, and basalt streams, by the restriction of use (grazing), will be with probably granted success.

The still humid forest climate is the basis for natural reforestation. The existing church forest as well as the still existing forest related birds are capable to distribute the available seed potential within the landscape.

Man-made reforestation is advisable on heavy degraded locations. Plantations during the rainy season guarantee a high success for taking roots.

3.10 Gallery forests / flooded forests

At few locations small remnants of flooded forests have been preserved. Those are very productive high forests with trees of 30 to 40 m height. Generally those are used as grazing areas, but are obviously conciously protected by the communities. Normally they are very small in size and due to grazing without natural rejuvenation.

Gallery forests serve as important filter areas during the rainy season and at the moment are sedimentation areas. Besides that carbon is sequestered as well.

Often they act as habitats for small remaining populations of squirrels and guneons. African Fish Eagle, Hornbill species, pigeons and barbets are breeding within the forests.

Currently they are threatened due to overgrazing and the increasing use of wood.

We recommend the implicit preservation of remnant gallery forests, what seems to be impossible by core zones, but possible by the declaration as buffer zones. One approach could be a rotation system of 5 to 10 years without use to allow regeneration, followed by years of sustainable use. Additionally, plantings with autothonous species are recommended. Plantations of eucalyptus have to be prohibited.

Besides gallery forests along the lake shore, all rivers were equipped with gallery forests, at least in downstream sections with accordingly slight inclines and strong meandering. Due to the high population pressure within this preferred settlemenat area, natural / near-natural gallery forests along river midcourse and downstream sections are no longer present.

Pressure on these productive fresh water ecosystems is highest, due to constantly present livestock and the human setlements linked to water. This led to the destruction of riparian forests and today only remnant trees can be found, with additionally cutted crowns. A natural forest rejuvenation is practically eliminated.

In intensive discussions local communities must be convinced of the reforestation of remote locations along the rivers with implicit fencing and initial plantings as prerequisites. Here again the orientation on natural species, with their high productivity and the provisioning of shadow and other ecological services (see above), is essential. The restoration of gallery forests in this intensive settled area is of crucial importance due to the following indispensable ecological services: fixing of riverbanks (bioengeneering), nutrient fixation capability of the roots thereby huge cleaning potential for river water and increase of habitat quality (microclimate), natural increase of water quality (self-purifying ability of the water).

4 CARBON SEQUESTRATION POTENTIAL

4.1 Introduction

Tropical Wetlands provide a wide range of ecosystem services such as supporting services (nutrient cycling, soil formation, Primary production), provisioning services (food, fiber and fuel), regulating services (pollution, flood and erosion control, carbon/climate), and cultural services (education and recreational) (CIFOR, 2012).
Wetlands store carbon in many different ways, e.g. in form of evergreen plants that sequester carbon; dead, not decomposed plant material (litter, peat, organic soils, sediments) formed over thousands of years under anaerobic conditions (oxygen deficiency). Wetlands and peat lands in particular account for 35-40 % of the global terrestrial carbon pool, thereby exceeding both the total agro-ecosystems and forests systems. (zur Heide, 2012)

4.2 Results of the fieldwork

The first transect is located in the south-west of Lake Tana, close to the Gilgel Abay in the so called wetland “Chimba”. The transect is following the main ecological gradient (water depth) running from the dryer border to the wetter core of the papyrus stand. Local farmers suggested the area to be 4ha in size.

At this transect site three drilling locations were choosen. In the following the findings for each location will be explained. A profile of the transect can be seen in Figure 19. The observed bird species can be seen in Annex 3.

Location 1

- Oscillating/floating reed infront of the *Cyperus papyrus* – Reed, ca. 80m in width
- Apparently originated from a former *Cyperus papyrus*-Reed, due to overgrazing
- Heavily oscillating/floating, but accessable by human and cattle
- 70cm sink down into the oscillating reed
- Closed reed-vegetation
- Reed-grases with a height up to 50cm, partly cutted by farmers
- Cover of vegetation 100%
- Main species & coverage:
    - *Echinochloa spec.*
    - *Cyperus cf. digitatus*
    - *Polygonum senegalensis*
    - *Hydrocotyle spec.*
    - *Ludwigia stolonifera*
- In front of the oscillating/floating reed lies an open water body with *Nymphaea lotus*
- water above surface level

Table 3: findings at Chimba location 1

Depth in dm	Sample number	Description of soil sample
3-4	3.4	Oscillating/floating root felt
3 /4 -11		water body
11-13	3.1	organic gyttja/sapropel
13-22	3.2 3.3	Radicell peat H 3-4 with muddy strips, strongly clayey peat in this layer/horizon
22 - ?		Clay sapropel

Location 2

- 20m within *Cyperus papyrus* reed
- Stationary mire
- Water at surface level
- GPS: N 11.67933 E 037.15428
- Height of Cyperus papyrus 3-4m
- Main species & coverage:
    - *Cyperus papyrus, 50%*
    - *Thelypteris sepc., 15%*
    - *Polygonum senegalensis, 15%*
    - *Hydrocotyle spec., 5%*
    - *Calamagrostis/Agrostis spec., 10%*

Table 4: findings at Chimba location 2

Depth in dm	Sample number	Description of soil sample
0-4/5		Root felt, solid, containing clay and silt
5-10		Peat, very rich in mineral matter With silt, clay and living roots Mineral matter input by sedimentation through water
10-15	1.1	Radicell peat, H 3-5
15-21	1.1	Radicell peat with clay deposits, >80% peat, muddy strips
21-27	1.2	organic gyttja/sapropel, clayey with peat strips, K3
27-31	1.3	Clay sapropel with organic strips
31-34	1.4	Basin clay

Location 3

- stationary mire
- water above surface level
- *Cyperus papyrus* reed, ca. 4ha in size
- N 11.67888, E 037.15407
- Main species & coverage
    - *Cyperus papyrus*, alive, 60%
    - *Cyperus papyrus*, dead, 30%
    - *Polygonum senegalensis*, 25%

Table 5: findings at Chimba location 3

Depth in dm	Sample number	Description of soil sample
4-5		Root felt
4/5-11		strongly watery, highly decomposed peat, scarcely material in soil driller
11-14		Radicell peat with clay sediment, muddy, H5
14-16		organic gyttja/sapropel with clay strips?, still peat
16-18		Heavy clay sapropel
18-?		Basin clay with plant remains

The *Cyperus papyrus* – Reed, that is classified as stationary mire, is flooded at the climax of the rainy season up to height of 1 1/2 - 2 m. At that time only the upper tips of the *Cyperus papyrus* stand out of the water body and assimilate. Farmers indicated that the tips of the papyrus are harvested with the use of tankwas and are used as fodder.

The floating reed mats at the fringe of the *Cyperus papyrus* – Reed oscillate according to the water table.

According to the drilling it is hypothesized that the *Cyperus papyrus* originally lasted up to the mineral-fringe of the wetland. This fact would explain the peat layers found in the deeper horizons of the wetland. According to this the floating reed mats found at this time are the result of grazing within the *Cyperus papyrus* – Reeds. Furthermore we assume that with the growing grazing pressure the *Cyoerus papyrus* stands will be destroyed and become smaller and even may become open water bodies due to overgrazing.

The flood plain of the Gilgel Abay is principally a wall-net-floodplain due to strongest sedimentation during the flood. Close to the river the sedimentation rate is highest, with fast sediment particle size (sand, silt). The attached floodplain is growing more slowly, due to the feeding of clay sediments, and therefore stays much deeper.

To put it in a nutshell on both sides of the river cultivation is realized close to the river during the dry season. The deeper-lying clay sedimentation areas become important grazing areas during the dry season and the papyrus stands in remote areas might have the chance to survive.

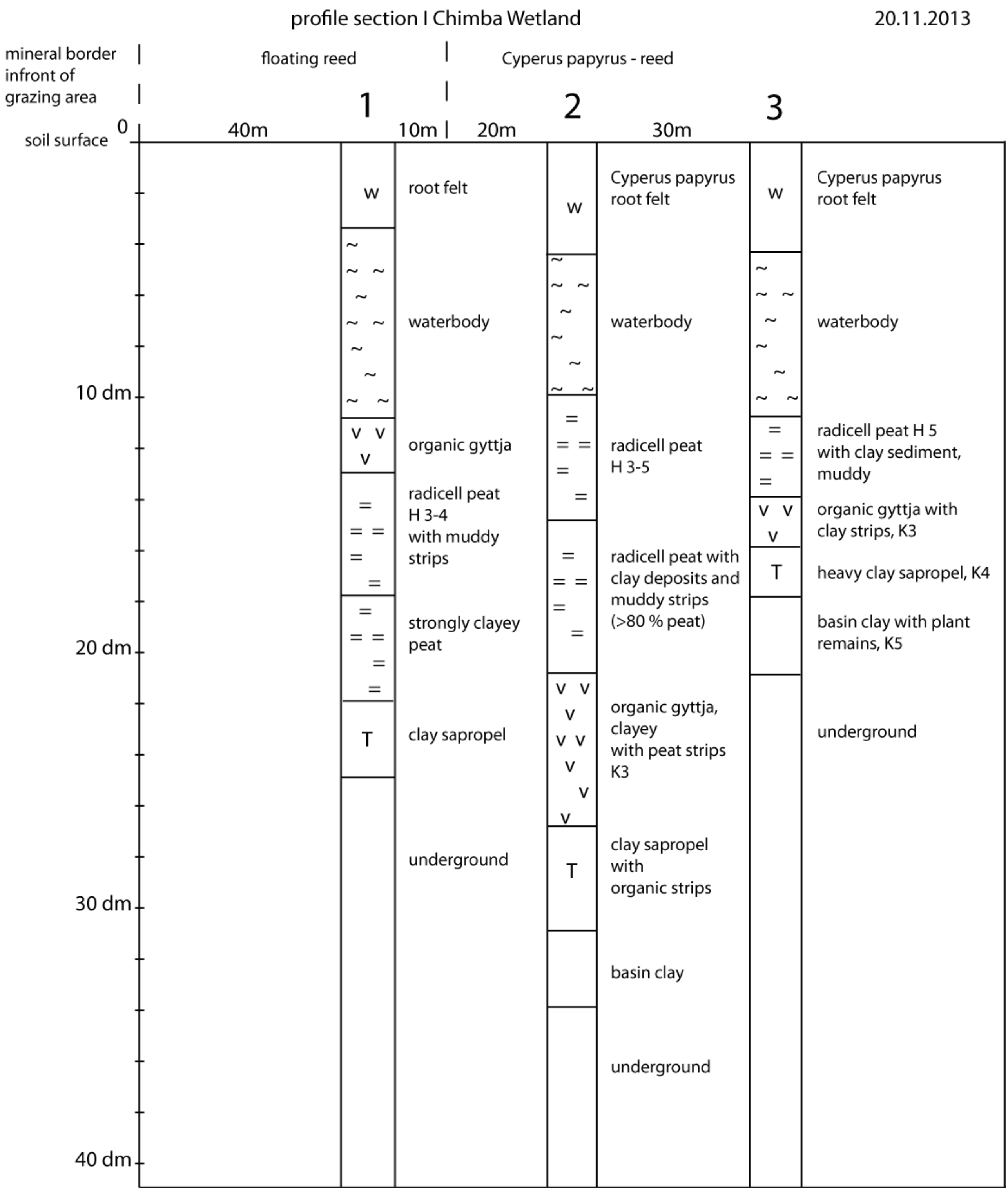

Figure 19: profile section I of Chimba Wetland by Succow & Mundt

We suggest that under natural conditions *Cyperus papyrus* would be the dominating natural vegetation in the deeper-lying area of clay sedimentation. The higher located riverbanks may have carried gallery woods/riparian forests. In areas further away from the river, dominated by mineral soils, may forests dominate the natural vegetation, characterized by different phases of flooding according to the altitude. Exemplary, one can see the two remaining church.

forests close to Chimba as examples of highly inundated forest vegetation.
The never flooded locations (red soils/chromic luvisols with lava flows) should have been dominated by natural forest vegetation, characterized by *Acacia spec*. (hardwoods).

The second transect is located at the south-western shore of Lake Tana, north of the peninsula Zeghe, within the wetland named “Yganda”. The stony shoreline of Zeghe is in estimated 300 m distance. The transect is following the main ecological gradient (water depth) running from the border to the core of the papyrus stand. At this transect site two drilling locations were choosen.
In the following, the findings for each drilling site will be explained.

Location 1

- *Cyperus papyrus* stand directly at the water border
- Drillig within the *Cyperus papyrus* – Reed
- Distance to open water: 8m
- Closed *Cyperus papyrus* stand, height 3-4m, coverage 80/90%, 1/3 dead *Cyperus papyrus* plants
- Main species & coverage
    - *Cyperus papyrus*, alive, 70%
    - *Cyperus papyrus*, dead, 30%
    - Coverage herbs: 30% (*Ludwigia stolonifera, Cyperus cf. digitatus, Pychnostachis spec., Polygonum senegalensis, Agrostis/Calamagrostis spec., Tradescantia spec*.),
- *Cyperus papyrus*-Reed drawn through with water veins with *Phragmites karka* that are hardly passable

- Water at surface level, while drilling forming of water body of 30cm depth
- Overgrowing floating mire with forming of secondary sedimented peat (Sinktorf) and with sapropel/gyttja sedimentation at the water base. In the dry season probably connection of the overgrowing peat with the sapropel/gyttja sediment of the underground. The thickness of the overgrowing floating mire gives the impression of being in a stationary mire.
- GPS N 11.71414, E 37.32244, altitude 1810m

Table 6: findings at Yganda location 1

Depth in dm	Sample number	Description of soil sample
0-4/5		Living root felt, hard to drill
5-11	4.1	Rough watery radicell peat, H3-4, with clay strips,rich in clay
11-24		Water body
24-35	4.2	Organic gyttja/sapropel, slightly gel like, green-grey, pulpy up to 32dm (K3),
35-41	4.3	Fine detrital gyttja K 3-4 , grey-black, firmness 3-4
38-41	4.4	Dense organic gyttja/sapropel, clayey
41		underground

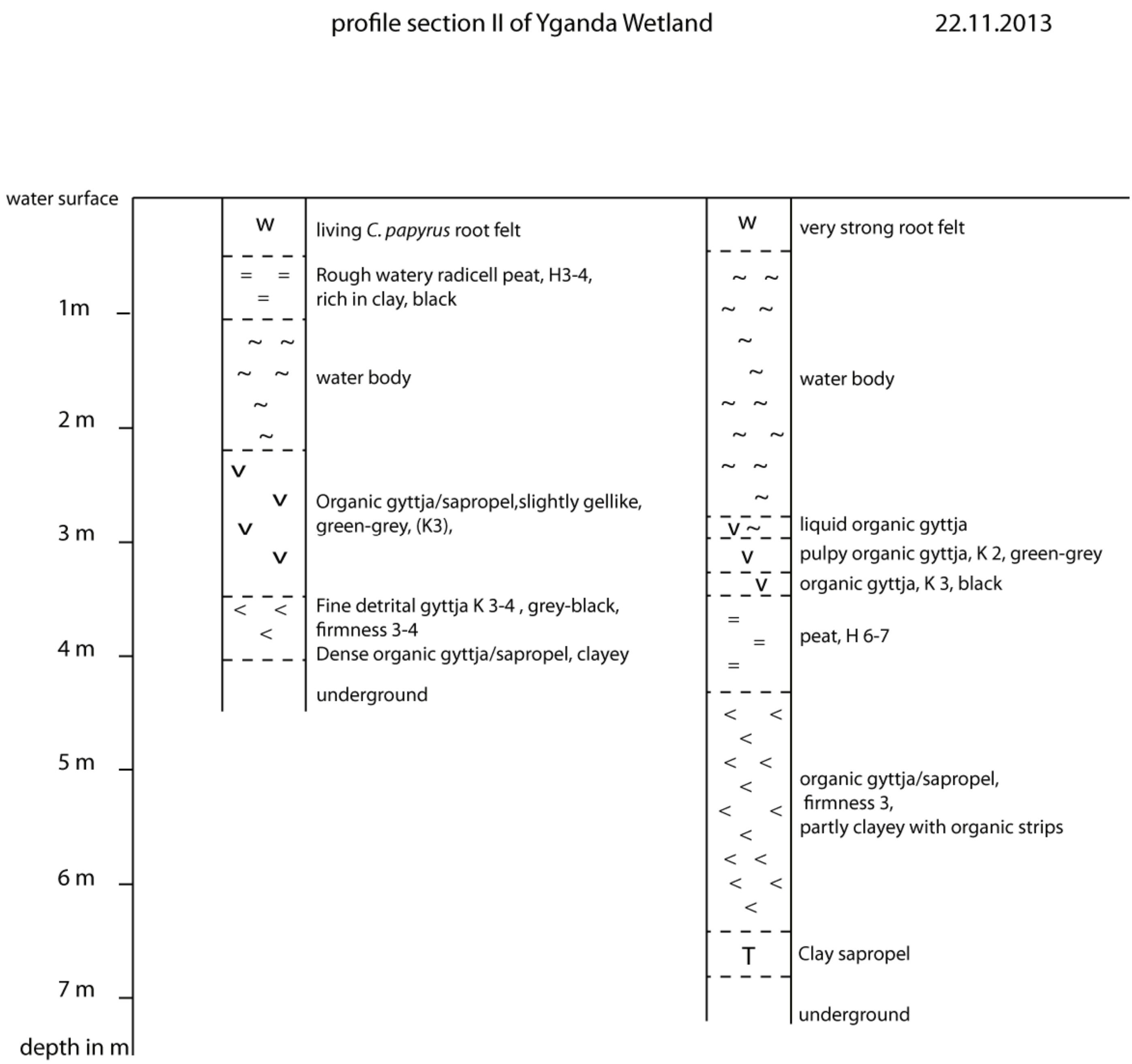

Figure 20: profile section II of Yganda Wetland by Succow & Mundt

Location 2

- 35 m distance to the former drilling site, towards the center of the papyrus reed
- Height of *Cyperus papyrus* 3 – 3 1/2 m
- Old stock of *Cyperus papyrus*, coverage of living papyrus 80-90%
- Main species & coverage
    - *Cyperus papyrus*, alive, 80-90%
    - *Ludwigia stolonifera,*
    - *Pychnostachis spec.*
    - *Polygonum senegalensis,*
    - *Agrostis/Calamagrostis spec.*
    - *Typha domingensis vel latifolia*
- Stationary mire, but while working sinking into the water up to 40/50cm
- Location was separated from location 1 by an overgrown current of water (*Phragmites karka* overgrowing)
- N 11.71406, E 037.32254

Table 7: findings at Yganda location 2

Depth in dm	Sample number	Description of soil sample
0-5		Very strong root felt
5-28		Water body
28-30		Liquid organic gyttja/sapropel
30-33	5.1	Pulpy organic gyttja/sapropel, green-grey, firmness 2
33-35	5.2	organic gyttja/sapropel, black, no clay, detrital gyttja/sapropel, firmness 3
35-43	5.3	peat, highly decomposed, H6-7
43-64	5.4	organic gyttja/sapropel, firmness 3, partly clayey with organic strips
64-67		Clay sapropel

4.3 Carbon Sequestration Potential of Papyrus-Reeds

The anthropogenically caused climate change, which is induced by the usage of fossile fuels, draws special attention on carbon sequestration to safeguard the future. Within terrestrial ecosystems and according to the latest results, though few, African papyrus-reeds are among the ecosystems to be the most capable of binding carbon dioxide. A first short overview of the carbon-cycle and carbon-fixing in Papyrus-swamps in tropical regions of Africa is given by Saunders, Kansiime, & Jones (2013) whose work is a first summary of publicated studies by governmental and non-governmental organisations. This review shows how papyrus-reeds, with their partly unusual high productivity, are some of the most important carbon-sinks, if not the most important.

According to Saunders et al. (2013) the netto primary production fluctuates between 51 – 190t of dry matter per hectare and year. Comparising, highly productive Glyceria maxima/Phalaris arundinacea-reeds only come up to 11 t per hectare and year. Reedbeds in the Danube delta[1] reach up to 43t / ha and year while reedbeds in wetland water treatment systems in Oman[2] can produce 40-80t of dry matter in perfect conditions.

These are the highest measured values in reed stocks.

The comparatively and uncommonly high productivity of Papyrus results from the following facts:

1) the permant possibility of assimilation (lacking winter)
2) evenly high thermal capacity
3) a long-term, high-quality water supply of the papyrus swamps

These factors are generally often found in humide regions that show heavy rainy seasons. Papyrus is mainly found in river systems with a high water exchange coming from larger catchment areas, guaranteeing a constant sedimentary load with a high supply of nutrients. The general eutrophication of wetland ecosystems, wether induced by human drainage inflow or by processes of siltation after forest clearing, topically leads to nutrient intakes that often exceed those of a natural landscape (process of rapid eutrophication). This

[1] Rodewald-Rodescu, L. (1974): *Das Schilfrohr.* In: Die Binnengewässer, Band XXVII. Schweitzerbartsche Verlagsbuchhandlung. 302 S. plus Anhang

[2] Schriftliche Mitteilung Bauer Gruppe: Vergleiche: http://www.bauer.de/de/press/press_articles/2010/2010_07_19_reed_bed.html

framework causes papyrus-reeds to grow up to 5m with a straw concentration of 80-130 straws per m² (*Phragmites australis* reachs max. 40-50 straws per m^2) under the given polytrophic circumstances (Saunders et al.,2013) which shows that *Cyperus papyrus* within tropical Africa is by far the most productive wetland-plant.

There are only few references regarding the subterranean biomass. Saunders et al. (2013) estimate the carbon stock of the upper more or less living rhizome and root-layer, which can have a thickness of 3-5 dm, to be 5,9 - 32,4 t carbon per hectare an year (correspondingly 13 – 72 t dry matter) (measures from Uganda). This yearly formed subterranean biomass is after die off and partly mineralization of the biomass the base for the longtime peat accumulation.

The aerial in relation to the subterranean biomass features a ratio from 1:0.3 to 1:1.5 after latest studies. This means that subterranean carbon sequestration in fact is able to exceed aerial biomass production. Examinations of peat-forming ecosystems in Central Europe (Succow & Joosten, 2001) show that reed beds can store between 0.5-2t of peat per hectare and year whereas alder swamp forests reach a peat storage of 0.5-1.3t/ha and year which is 5 – 10% of the annually formed subterrestrial biomass. Because of the high nutrient content and tropical climate the storage rates of papyrus will rather be situated in the lower range.

The attempt to gain first values of peat formation during our peat-drilling at Lake Tana in Ethiopia unfortunately failed as the samples, analysed by the recommended laboratory Amhara Supervison Design Center, for some uncomprehensible reason did not provide any results. As shown the description of the deposition in the field is in contradiction to the given results from the laboratory. This is valid for the carbon content that identified the assumed peat deposits as humus soils, as well as for the organo-mudd-samples that clearly show high clay content. However, after the results these were accounted with a high sandfraction though not detectable during field work. Unfortunately it has not been possible to gain information about laboratory methods, however, a current examination with reliable results is needed to manifest the ecological importance of papyrus-reeds. The papyrus stocks at Lake Tana are supposed to exhibit one of the highest productivities as they feature a high nutrient supply due to soil erosion (following the clearing) of the primary very fertile soils of volcanic origin. The removal of these locations, which are said to have the most fertile tropical soils, has reached dimensions that highly question the continuance of arable crops in the Ethiopean highlands. The shown results especially apply to papyrus-reeds in the downstream section of the Gilgel Abay and the estuaries into Tana Lake. Also the nutrient supply of Papyrus on the silted shores of Lake Tana is very high (supply from melioration areas in the north, unpurified wastewater from Bahir Dar and surrounding settlements and Gondar) and leads to the enormous productivity of the reedbanks. To summarize, the current nutrient supply of the papyrus-reeds leads to a productivity comparatively high to African ratios (Saunders et al., 2013). The height of the papyrus-reeds in central Africa is said to be 2.5-5m, our research showed general heights of 3.5-5m and thereby presents papyrus-reeds as the most productive ecosystems regarding CO_2-fixation.

At the moment there is an area of about 8400 ha of papyrus-reeds. With a roughly estimated primary production of 100 t dry matter per hectare and year this would lead to a carbon fixation and additionall subterrestrial carbon sequestration of peats and organic muds.

5 MEASURES THAT NEED TO BE TAKEN FOR THE RECOVERY OF THE ECOSYSTEM LAKE TANA

- Reforestation of the mountain catchment area. Due to centuries of farming the soil surface is totally eroded. The resumption especially on slopes reaches its limits and is neither economically nor ecologically justifiable. Under the still prevailing humid conditions a reforestation with autochthonous pioneer species has to be initiated. One possibility would be jointly plantings during the rainy season. The planting species have to be grown in local nurseries. The planted areas must under no circumstances be subject to grazing. The still “forest-friendly” climate admits the development of forest in a little while.
- The lava-flows in the agricultural landscape, especially in the southern and western part of Lake Tana, should in the sense of area closure

generally be planted with autochthonous trees and be kept free of grazing within the first ten years after planning. This lately agriculturally used landscape exhibits partly a high primary tree population. In the sense of agroforestry the goal must be the preservation and development of an open woodrich agricultural landscape, which offers a lot of ecological services.

- Sediment traps – woody strips at slopes; application all around
- Unconditional continuation of traditional farming practices within the fogera plain (recession farming), thereby nutrient deposition and sedimentary deposition
- Discharging rivers with their enormous sediment load should have a natural vegetation development, in order to capture nutrients and sediments by the vegetation
- Natural gallery forests need to be preserved and increased, especially along the rocky shore at the western edge (important nutrient removal out of the water body)
- Topic of water hyacinths (see above)
- Preservation and increase of papyrus reeds as important CO_{2}-, sediment- and nutrient sinks
- Orientation on ecotourism: the high natural wealth especially of the wetlands of Lake Tana represent an important touristic centre of attraction; the construction of observation platforms and educational nature trails under inclusion of the local communities could be an appropriate instrument for a sustainable nature integrating tourism
- The area of the 44 springs at Infranz River, at the western edge of the rapid growing city of Bahir Dar, owns highest priority for the future drinking water supply. As has been emphasized several times, a spacious protected area has to be designated. It is urgently advised not to deforest the remnant forest as well as not to practice farming. Within this spring area any human activity must be prohibited. Even grazing has to be prohibited. It has to be designated as strictly drinking water protection area.
- Aquaculture (fish farming) must be prohibited within the lake
- River regulation, dyke construction and “modern” agriculture with

agricultural chemistry must be prohibited

- Prohibition of discharging urban waste water to reduce the rapid eutrophication of Lake Tana
- For the protection of the exceptional high biodiversity (especially bird life), with its extraordinary familiarity as result of the religious motivated nature worship, has in the future furthermore any form of hunting of birds to be prevented. The same applies to the collection of eggs (especially within wetlands), what is been reported recently.
- Gratifying is the obviously slight increase of the hippopotamus population, at actual 12 sites. The prevention of their feeding habitats is mainly done by the designation of the proposed core zones. Equally the protection of the so far not hunted nile monitor has to be assured. The up to now not performed hunting by humans of the monitors has led to the deep familiarity and the experiencing of those animals with their high population density.

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Annex 1: List of bird species occuring at Lake Tana

Scientific Name:	Common Name:	Season:	IUCN Category:
Acrocephalus gracilirostris	Lesser Swamp Warbler	resident	Least Concern
Acrocephalus schoenobaenus	Sedge Warbler	wintering	Least Concern
Acrocephalus scirpaceus	Eurasian Reed Warbler	wintering	Least Concern
Actitis hypoleucos	Common Sandpiper	wintering	Least Concern
Actophilornis africanus	African Jacana	resident	Least Concern
Alcedo cristata	Malachite Kingfisher	resident	Least Concern
Alopochen aegyptiacus	Egyptien Goose	resident	Least Concern
Amandava subflava	Orange-breasted (Zebra) Waxbill	resident	Least Concern
Amaurornis flavirostris	Black Crake	resident	Least Concern
Anas acuta	Northern Pintail	wintering	Least Concern
Anas clypeata	Northern Shoveller	wintering	Least Concern
Anas crecca	Common Teal	wintering	Least Concern
Anas erythrorhyncha	Red-billed Teal	resident	Least Concern
Anas penelope	Eurasian Widgeon	wintering	Least Concern
Anas querquedula	Garganey	wintering	Least Concern
Anastomus lamelligerus	African Openbill	resident	Least Concern
Anhinga rufa	African Darter	resident	Least Concern
Anthus campestris	Tawny Pipit	resident	Least Concern
Anthus cervinus	Red-throated Pipit	wintering	Least Concern
Anthus leucophrys	Plain-backed Pipit	resident	Least Concern
Anthus richardi	Richard´sPipit	resident	Least Concern
Aquila clanga	Greater Spotted Eagle	wintering	Vulnerable
Ardea cinerea	Grey Heron	Wintering & resident	Least Concern
Ardea goliath	Goliath Heron	resident	Least Concern
Ardea melanocephala	Black-headed Heron	resident	Least Concern

Ardea purpurea	Purple Heron	Wintering & resident	Least Concern
Ardeola ralloides	Squacco Heron	Resident & wintering	Least Concern
Balearica pavonina	Black Crowned Crane	resident	Vulnerable
Bostrychia hagedash	Hadeda Ibis	resident	Least Concern
Bradypterus baboecala	Little Rush Warbler	resident	Least Concern
Bubulcus ibis	Cattle Egret	Resident & wintering	Least Concern
Bugeranus carunculatus	Wattled Crane	resident	Vulnerable
Burhinus senegalensis	Senegal Thick-Knee	resident	Least Concern
Butorides striata	Green-backed Heron	resident	Least Concern
Calidris ferruginea	Curlew Sandpiper	wintering	Least Concern
Calidris minuta	Little Stint	wintering	Least Concern
Calidris temminckii	Temminck's Stint	wintering	Least Concern
Casmerodius albus	Great White Egret	Resident & wintering	Least Concern
Centropus monachus	Blue-headed Coucal	resident	Least Concern
Ceryle rudis	African Pied Kingfisher	resident	Least Concern
Charadrius dubius	Little Ringed Plover	wintering	Least Concern
Charadrius hiaticula	Common Ringed Plover	wintering	Least Concern
Charadrius pecuarius	Kittlitz's Plover	resident	Least Concern
Charadrius tricollaris	Three-banded Plover	resident	Least Concern
Chlidonia hybrida	Whiskered Tern	wintering	Least Concern
Chlidonia leucopterus	White-winged Tern	wintering	Least Concern
Ciconia ciconia	White Stork	wintering	Least Concern
Ciconia episcopus	Woolly-necked Stork	resident	Least Concern
Ciconia nigra	Black Stork	wintering	Least Concern
Circus aeruginosus	Eurasian Marsh-Harrier	wintering	Least Concern
Circus pygargus	Montagu's Harrier	wintering	
Cisticola eximius	Black-backed Cisticola	resident	Least Concern
Cisticola juncidis	Zitting Cisticola	resident	Least Concern
Cisticola lugubris	Ethiopian Cisticola	resident	Least Concern
Corvus capensis	Cape Crow	resident	Least Concern

Coturnix coturnix	Common Quail	Wintering & resident	Least Concern
Dendrocygna bicolor	Fulvous Whistling Duck	resident	Least Concern
Dendrocygna viduata	White-faced Whistling Duck	resident	Least Concern
Egretta garzetta	Little Egret	wintering	Least Concern
Ephippiorhynchus senegalensis	Saddle-billed Stork	resident	Least Concern
Estrilda astrild	Common Waxbill	resident	Least Concern
Euplectes afer	Yellow-crowened Bishop	resident	Least Concern
Euplectes axillaris	Fan-tailed Widowbird	resident	Least Concern
Euplectes capensis	Yellow Bishop	resident	Least Concern
Euplectes orix	Red Bishop	resident	Least concern
Falco tinnunculus	Common Kestrel	Wintering & resident	Least Concern
Francolinus erckelii	Erckel's Spurfowl	resident	Least Concern
Fulica cristata	Red-knobbed Coot	resident	Least Concern
Galerida theklae	Thekla Lark	resident	Least Concern
Gallinago nigripennis	African Snipe	resident	Least Concern
Gallinula angulata	Lesser Moorhen	resident	Least Concern
Gallinula chloropus	Common Moorhen	Resident & wintering	Least Concern
Glareola pratincola	Collared Pratincole	Resident & wintering	Least Concern
Grus grus	Common Crane	wintering	Least Concern
Gypaetus barbatus	Bearded Vulture	resident	Least Concern
Gyps africanus	White-backed Vulture	resident	Endangered
Gyps rueppellii	Rüppell's Vulture	resident	Endangered
Halcyon chelicuti	Striped Kingfisher	resident	Least Concern
Halcyon leucocephala	Grey-headed Kingfisher	resident	Least Concern
Halcyon senegalensis	Woodland Kingfisher	resident	Least Concern
Haliaeetus vocifer	African Fish-Eagle	resident	Least Concern
Himantopus himantopus	Black-winged Stilt	wintering	Least Concern
Hirundo aethiopica	Ethiopian Swallow	resident	Least Concern
Hirundo daurica	Red-rumped Swallow	resident	Least Concern
Hirundo fuligula	Rock Martin	resident	Least Concern
Hirundo rustica	Barn Swallow	resident	Least Concern

Hirundo senegalensis	Mosque Swallow	resident	Least Concern
Hirundo smithii	Wire-tailed Swallow	resident	Least Concern
Indicator minor	Lesser Honeyguide	resident	Least Concern
Ixobrychus minutus	Little Bittern	wintering & resident	Least Concern
Kaupifalco monogrammicus	Lizard Buzzard	resident	Least Concern
Lagonosticta senegala	Red-billed Firefinch	resident	Least Concern
Lamprotornis chalybaeus	Greater Blue-eared Starling	resident	Least Concern
Laniarius aethiopicus	Tropical Boubou	resident	Least Concern
Lanius collaris	Common Fiscal	resident	Least Concern
Lanius excubitoroides	Grey-backed Fiscal	resident	Least Concern
Lanius isabellinus	Red-tailed Shrike	wintering	Least Concern
Lanius nubicus	Masked Shrike	resident	Least Concern
Lanius senator	Woodchat Shrike	wintering	Least Concern
Larus fuscus	Lesser Black-backed Gull	wintering	Least Concern
Larus ichthyaetus	Greater Black-headed Gull	wintering	Least Concern
Leptoptilos crumeniferus	Marabou Stork	resident	Least Concern
Limosa limosa	Black-tailed Godwit	wintering	Near threatened
Lonchura cucullata	Bronze Mannikin	resident	Least Concern
Lophaetus occipitalis	Long-crested Eagle	resident	Least Concern
Lybius bidentatus	Double-toothed Barbet	resident	Least Concern
Lybius guifsobalito	Black-billed Barbet	resident	Least Concern
Lybius undatus	Banded Barbet	resident	Least Concern
Megaceryle maxima	Giant Kingfisher	resident	Least Concern
Melaenornis edolioides	Northern Black Flycatcher	resident	Least Concern
Melierax metabates	Dark Chanting Goshawk	resident	Least Concern
Merops nubicus	Northern Carmine Bee-Eater	resident	Least Concern
Merops pusillus	Little Bee-Eater	resident	Least Concern
Merops variegatus	Blue-breasted Bee-Eater	resident	Least Concern
Mesophoyx intermedia	Yellow-billed Egret	resident	Least Concern

Mesopicos goertae	Grey-headed Woodpecker	resident	Least Concern
Microparra capensis	Lesser Jacana	vagrant	Least Concern
Milvus migrans	Black kite	resident	Least Concern
Mirafra rufocinnamomea	Flappet Lark	resident	Least Concern
Monticola rufocinereus	Little Rock-Thrush	resident	Least Concern
Monticola semirufa	White-winged Cliff-Chat	resident	Least Concern
Motacilla aguimp	African Pied Wagtail	resident	Least Concern
Motacilla alba	White Wagtail	wintering	Least Concern
Motacilla clara	Mountain Wagtail	resident	Least Concern
Motacilla flava Motacilla f. feldegg	Yellow Wagtail	wintering	Least Concern
Muscicapa adusta	African Dusty Flycatcher	resident	Least Concern
Muscicapa striata	Spotted Flycatcher	wintering	Least Concern
Mycteria ibis	Yellow-billed Stork	resident	Least Concern
Myrmecocichla melaena	Rueppell's Chat	resident	Least Concern
Necrosyrtes monachus	Hooded Vulture	resident	Endangered
Nectarinia senegalensis	Scarlet-chested Sunbird	resident	Least Concern
Nectarinia tacazze	Tacazze Sunbird	resident	Least Concern
Neophron percnopterus	Egyptian Vulture	resident & wintering	Endangered
Netta erythrophthalma	Southern Pochard	resident	Least Concern
Nettapus auritus	African Pygmy Goose	resident	Least Concern
Nycticorax nycticorax	Black-crowned Night Heron	resident	Least Concern
Oena capensis	Namaqua Dove	resident	Least Concern
Oenanthe bottae	Botta's Wheatear	resident	Least Concern
Oenanthe cypriaca	Cyprus Wheatear	resident	Least Concern
Oenanthe hispanica	Black-eared Wheatear	resident	Least Concern
Oenanthe isabellina	Isabelline Wheatear	resident	Least Concern
Oenanthe lugens	Mourning Wheatear	resident	Least Concern
Oenanthe oenanthe	Northern Wheatear	wintering	Least Concern
Oenanthe pleschanka	Pied Wheatear	wintering	Least Concern
Onychognathus	White-billed Starling	resident	Least Concern

albirostris			
Onychognathus tenuirostris	Slender-billed Starling	resident	Least Concern
Oriolus monacha	Dark-headed Oriole	resident	Least Concern
Oriolus monacha	Ethopian Oriole	Resident, Endemic to Eitrea & Ethiopia	Least Concern
Ortygospiza atricollis	African Quailfinch	resident	Least Concern
Pandion haliaetus	Osprey	resident	Least Concern
Parus leuconotus	White-backed Tit	resident	Least Concern
Passer swainsonii	Swainson's Sparrow	resident	Least Concern
Pelecanus onocrotalus	Great White Pelican	Resident & wintering	Least Concern
Pelecanus rufescens	Pink-backed Pelican	resident	Least Concern
Petronia dentata	Bush Petronia	resident	Least Concern
Phalacrocorax africanus	Long-tailed Cormorant	resident	Least Concern
Phalacrocorax carbo	Great Cormorant	Wintering & resident	Least Concern
Philomachus pugnax	Ruff	wintering	Least Concern
Phoeniconaias minor	Lesser Flamingo	wintering	Near Threatened
Phoenicopterus roseus	Greater Flamingo	Wintering & resident	Least Concern
Phoeniculus purpureus	Green Wood-Hoopoe	resident	Least Concern
Phoeniculus somaliensis	Black-billed Wood-Hoopoe	resident	Least Concern
Phoenicurus phoenicurus	Common Redstart	wintering	Least Concern
Phylloscopus collybita	Common Chiffchaff	wintering	Least Concern
Platalea alba	African Spoonbill	resident	Least Concern
Platysteira cyanea	Brown-throated Wattle-eye	resident	Least Concern
Plectropterus gambensis	Spur winged Goose	resident	Least Concern
Plegadis falcinellus	Glossy Ibis	Resident & wintering	Least Concern
Ploceus baglafecht	Baglafecht Weaver	resident	Least Concern
Ploceus cucullatus	Village (Black-headed)	resident	Least Concern

	Weaver		
Ploceus melanocephalus	Black-headed Weaver	resident	Least Concern
Ploceus ocularis	Spectacled Weaver	resident	Least Concern
Pogoniulus chrysoconus	Yellow-fronted Tinkerbird	resident	Least Concern
Poicephalus flavifrons	Yellow-fronted Parrot	resident	Least Concern
Polyboroides typus	African Harrier-Hawk	resident	Least Concern
Porphyrio alleni	Allen’s gallinule	resident	Least Concern
Porzana parva	Little Crake	resident	Least Concern
Prinia subflava	Tawny-flanked Prinia	resident	Least Concern
Pseudhirundo griseopyga	Grey-rumped Swallow	resident	Least Concern
Psophocichla litsitsirupa	Groundscraper Thrush	resident	Least Concern
Pycnonotus barbatus	Common Bulbul	resident	Least Concern
Rallus caerulescens	African Rail	resident	Least Concern
Recurvirostra avosetta	Pied Avocet	wintering & resident	Least Concern
Rhinopomastus cyanomelas	Common Scimitarbill	resident	Least Concern
Rhinopomastus minor	Abyssinian scimitarbill	resident	Least Concern
Riparia cincta	Banded Martin	resident	Least Concern
Riparia paludicola	Brown-throated Martin	resident	Least Concern
Riparia riparia	Sand Martin	wintering	Least Concern
Rougetius rougetii	Rouget's Rail	resident	Near Threatened
Sarkidiornis melanotos	Knob-billed Duck	resident	Least Concern
Saxicola torquatus	Common Stonechat	resident	Least Concern
Scopus umbretta	Hamerkop	resident	Least Concern
Serinus citrinelloides	African Citril	resident	Least Concern
Serinus nigriceps	Ethiopian (Black-headed) Siskin	resident,endemic	Least Concern
Serinus striolatus	Streaky Seed-Eater	resident	Least Concern
Serinus tristriatus	Brown-rumped Seed-Eater	resident	Least Concern
Serinus xanthopygius	(Abyssinian) Yellow-rumped Seed-Eater	resident, Endemic to N-	Least Concern

		Ethiopia and Eritrea	
Sterna caspia	Caspian Tern	Resident & wintering	Least Concern
Sterna hirundo	Common Tern	Wintering & resident	Least Concern
Sterna nilotica	Gull-billed Tern	Wintering & resident	Least Concern
Sterna sandvicensis	Sandwich Tern	wintering	Least Concern
Stigmatopelia senegalensis	Laughing Dove	resident	Least Concern
Streptopelia decipiens	African Morning Dove	resident	Least Concern
Streptopelia lugens	Dusky Turtle-Dove	resident	Least Concern
Streptopelia semitorquata	Red Eyed Dove	resident	Least concern
Streptopelia semitorquata	Red-eyed Dove	resident	Least Concern
Streptopelia vinacea	Vinaceous Dove	resident	Least Concern
Sylvia atricapilla	Eurasian Blackcap	wintering	Least Concern
Sylvia curruca	Lesser Whitethroat	wintering	Least Concern
Sylvia lugens	Brown Parisoma	resident	Least Concern
Tachybaptus ruficollis	Little Grebe	Wintering & resident	Least Concern
Tauraco leucotis	White-cheeked Turaco	resident	Least Concern
Tchagra senegalus	Black-crowned Tchagra	resident	Least Concern
Terathopius ecaudatus	Bateleur	resident	Near Threatened
Terpsiphone viridis	African Paradise Flycatcher	resident	Least Concern
Thalassornis leuconotus	White-backed Duck	resident	Least Concern
Thamnolaea cinnamomeiventris	Mocking Cliff-Chat	resident	Least Concern
Threskiornis aethiopicus	African Sacred Ibis	resident	Least Concern
Threskiornis aethiopicus	Sacred Ibis	resident	Least Concern
Tockus hemprichii	Hemprich's Hornbill	resident	Least Concern
Tockus nasutus	African Grey Hornbill	resident	Least Concern
Torgos tracheliotos	Lappet-faced Vulture	resident	Vulnerable

Treron waalia	Bruce's Green Pigeon	resident	Least Concern
Trigonoceps occipitalis	White-headed Vulture	resident	Vulnerable
Tringa erythropus	Spotted Redshank	wintering	Least Concern
Tringa glareola	Wood Sandpiper	wintering	Least Concern
Tringa nebularia	Common Greenshank	wintering	Least Concern
Tringa ochropus	Green Sandpiper	wintering	Least Concern
Tringa stagnatilis	Marsh Sandpiper	wintering	Least Concern
Turdus olivaceus	Olive Thrush	resident	Least Concern
Turtur afer	Blue-sptotted Wood-Dove	resident	Least Cooncern
Turtur tympanistria	Tambourine Dove	resident	Least Concern
Tyto alba	Barn Owl	resident	Least Concern
Upupa epops	Eurasian Hoopoe	wintering	Least Concern
Uraeginthus bengalus	Red-cheeked Cordonbleu	resident	Least Concern
Vanellus melanopterus	Black-winged Lapwing	resident	Least Concern
Vanellus senegallus	African Wattled Lapwing / Senegal Wattled Plover	resident	Least Concern
Vanellus spinosus	Spur Winged Lapwing	resident	Least Concern
Vidua chalybeata	Village Indigobird	resident	Least Concern
Vidua macroura	Pin Tailed Whydah	resident	Least Concern
Zosterops abyssinicus	Abyssinian White-eye	resident	Least Concern
Zosterops poliogastrus	Montane White-eye	resident	Least Concern

Annex 2: List of observed plant species

Agrostis/Calamagrostis spec.

Ceratophyllum demersum

Cyperus cf. digitatus

Cyperus cf. distans

Cyperus papyrus

Echinochloa stagnina

Echinochloa spec.

Hygrophila auriculata

Hygrophila auriculata

Ipomoea aquatica

Ludwigia stolonifera

Nymphaea lotus

Nymphaea nouchali var. caerulea

Nymphoides brevipedicellata/brevipedunculata

Ottelia ulvifolia

Phragmites karka

Polygonum (Persicaria) senegalensis

Pycnostachys spec.

Sacciolepis africana

Sesbania sesban

Typha domingensis vel latifolia

Tradescantia spec.

Utricularia sp.

Annex 3: Birds observed at Chimba wetland

Latin	English	Number
Ciconia abdimii	Abdim´s Stork	~40
Bucorvus abyssinicus	Abyssinian Ground-hornbill	2
Anhinga rufa	African Darter	~5
Haliaeetus vocifer	African Fish Eagle	~10
Actophilornis africanus	African Jacana	~150
Anastomus lamelligerus	African Openbill	~250
Threskiornis aethiopicus	African Sacred Ibis	~40
Balearica pavonina	Black Crowned Crane	~300
Ardea melanocephala	Black headed Heron	~10
Limosa limosa	Black-tailed Godwit	>100
Himantopus himantopus	Black-winged Stilt	~200
Bubulcus ibis	Cattle Egret	>500
Tringa nebularia	Common Greenshank	>50
Alopochen aegyptiacus	Egyptian Goose	~80
Circus aeruginosus	Eurasian Marsh Harrier	~10
Dendrocygna bicolor	Fulvous Whistling Duck	~800
Plegadis falcinellus	Glossy Ibis	~300
Phalacrocorax carbo	Great Cormorant	~40
Casmerodius albus	Great White Egret	~50
Pelecanus onocrotalus	Great White Pelican	>300
Tringa ochropus	Green Sandpiper	~50
Ardea cinerea	Grey Heron	~10
Bostrychia hagedash	Hadada Ibis	~20
Sarkidiornis melanotos	Knob-billed Duck	~20
Merops pusillus	Little Bee-Eater	~50
Calidris minuta & *Calidris temminckii*	Little Stint & Temminck´s Stint	>300
Merops nubicus	Northern Carmine Bee-Eater	~20
Anas acuta	Northern Pintail	>1000

Ceryle rudis	Pied Kingfisher	~10
Philomachus pugnax	Ruff	>500
Ephippiorhynchus senegalensis	Saddle-billed Stork	~1
Plectropterus gambensis	Spur-winged Goose	~300
Vanellus spinosus	Spur-winged Plover	~40
Ardeola ralloides	Squacco Heron	~100
Bugeranus carunculatus	Wattled Crane	1
Ciconia ciconia	White Stork	~5
Chlidonia leucopterus	White-winged Tern	~200
Tringa glareola	Wood Sandpiper	>300
Mesophoyx intermedia	Yellow-billed Egret	~30
Milvus (migrans) aegypticus	Yellow-billed Kite	~20
Mycteria ibis	Yellow-billed Stork	~5
Motacilla flava Motacilla f. feldegg	Yellow Wagtail	>800

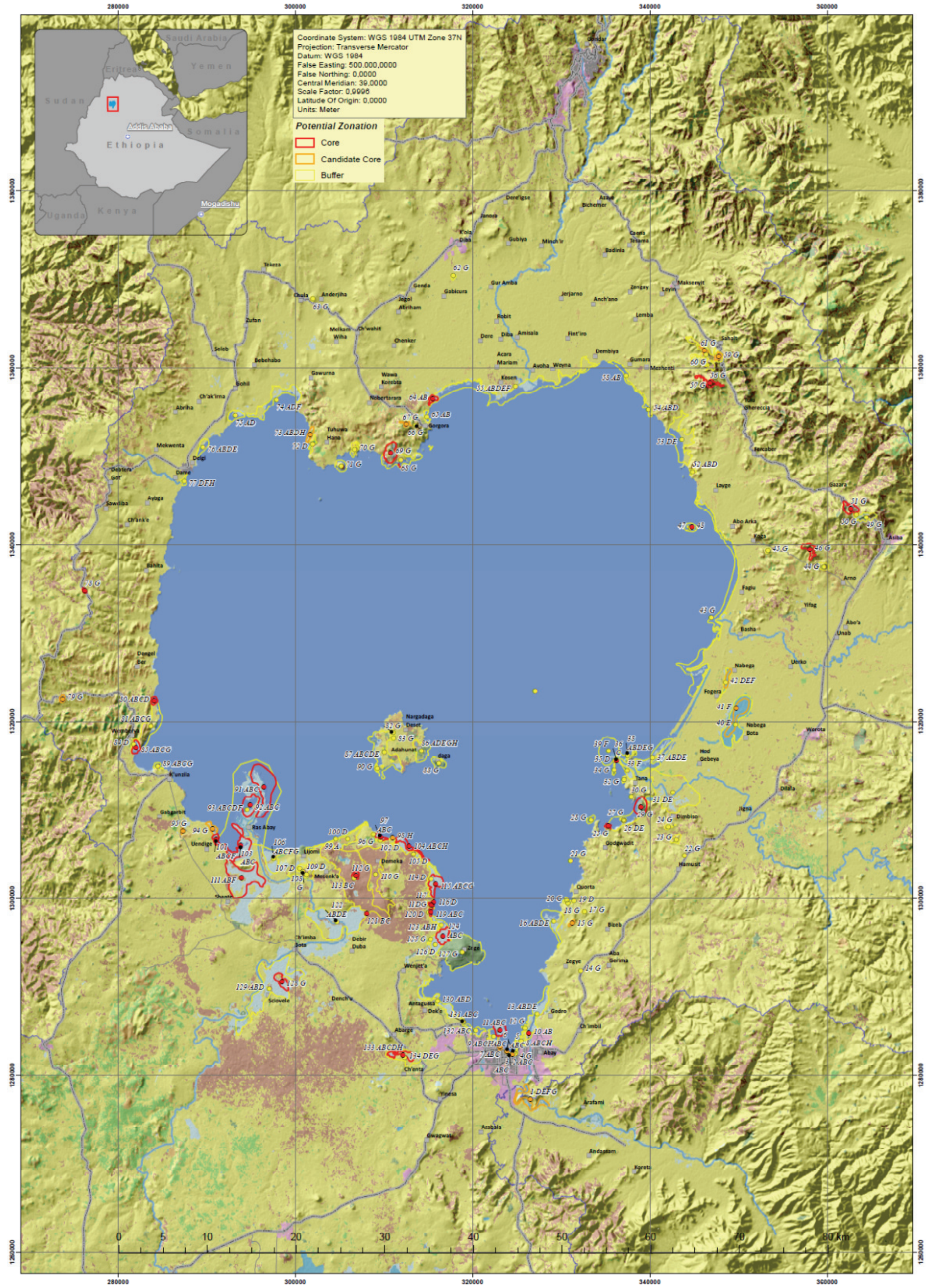

Figure 21: Map Overview 25000 (by Dresen, 2013)