IMPACT OF FARMING SYSTEMS ON RIPARIAN VEGETATION OF LAKE MANYARA CATCHMENT AT CHEMCHEM AND ENDABASH RIVERS IN KARATU DISTRICT, TANZANIA

BY

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ABSTRACT

Highland catchments of Lake Manyara basin are undergoing degradation through human activities from the adjacent communities. This study was conducted to assess the impact of farming systems on vegetations in the highland catchments of Lake Manyara basin namely Chemchem and Endabash rivers. The specific objectives were to identify the farming systems used and their sustainability with regard to wetland conservation, assess and compare the plant species composition and diversity between degraded and non degraded riparian zones. Riparian forests were stratified into degraded and non degraded strata. One hundred twenty eight concentric circular sample plots (64 plots in each strata) were established laid along transects. The difference between the two strata in each catchment was assessed using Sorensen's similarity index and Shannon Wiener diversity index. All vascular plants were identified and DBH was measured for trees/shrubs in each plot. Monocroping and mixed farming systems are the major farming systems used, though both of them do not support conservation of pre existing riparian plants. Vegetation analysis revealed that plants dominating degraded riparian zones were different from those of non degraded riparian zones in both composition and diversity. The Shannon-Wiener diversity indices for trees ≥ 5cm dbh in the degraded and non degraded zone of Chemchem catchment were 2.9 and 2.6 respectively implying medium species diversity with higher diversity in the degraded zone. In the Endabash catchment the Shannon-Wiener diversity indices were 2.6 and 2.8 in the non degraded and degraded riparian zones respectively which imply moderate levels of diversity. All these may indicate medium disturbance which have not affected the areas very adversely. Sorensen's similarity

indices of 40.51 % and 45.8 % observed between degraded and non degraded zones in Chemchem and Endabash catchments respectively show that there are differences between degraded and non degraded though not very significant.

DECLARATION

I, ROBERT FAUSTINE do hereby declare to the Senate of the Sokoine University Agriculture that this dissertation is my own original work and that it has neither been published nor concurrently submitted for a higher degree award in any other University.

…………………………………..   ………………………

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The above declaration is confirmed

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To all of you, may God bless you so much.

DEDICATION

This work is dedicated to my parents Catherine and Faustine Faida who believed and still believe in the power of education. I wouldn't have accomplished all this if it wasn't for the grace of God and their support.

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LIST OF ACRONYMS

FAO	-	Food and Agriculture Organisation
IMWI	-	Intergrated Water Management Institue
MNRT	-	Ministry of Natural Resources and Tourism
NCSU	-	North Carolina State University
URT	-	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The Ramsar Convention (1971) defines wetlands as areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands incorporate riparian and coastal zones adjacent to the wetlands or bodies of marine water deeper than six meters at low tide lying within the wetlands (Hook *et al.,* 1988). Wetlands vary according to their origin, geographical location, water regime, chemistry and soil or soil characteristics (Hook *et al.,* 1988). Wetlands can be classified in various ways. Keddy (2000) classified wetlands into six basic types i.e. swamp, marsh, bog, fern, wet meadow and shallow water.

Wetlands occupy about 6 % of the world's land surface (Hook *et al.,* 1988) and about 10 % of Tanzania land surface (MNRT, 2004). According to MNRT (2004) Tanzania wetlands are of considerable ecological and social economic values. Ecologically, wetlands are instrumental in water storage filtration and supply, flood control, control sediments, nutrient and toxin retention functions, and are also important for biodiversity conservation both flora and fauna. Social economically, wetlands support family livelihoods as bases for crop production, grazing animals, fishing and harvesting medicinal plants among others. Wetlands are very important for the rural livelihood (IWMI, 2002). The economic valuation makes clear that, especially in the developing countries, wetlands produce goods that are very important part of the livelihoods of local communities (Bacon, 2007). FAO (2003) reported that the potential contributions of wetlands or inland valley to food security are vast and varied.

Most wetlands are potentially suitable for agriculture because of their available water and high soil fertility and can be among resources for poverty reduction in Tanzania (Kamukala and Crafter, 1993; Keddy, 2000; Munishi and Kilungu, 2004; Munishi *et al*., 2003; MNRT, 2004). Farming activities are the major economic pursuits around wetlands with the cultivation of crops such as paddy, maize and various types of vegetables and fruits (Omari, 1990). However, before subjecting wetlands to any uses that can alter wetland ecosystem, proper plan that integrates the intra and inter dependence of the wetland ecosystems had to be developed. Bush (2000) observed that natural wetlands had distinct ecosystem functions in which alteration of any physical function such as hydroperiod or water quality had repercussions on other functions and this chain of reactions affect the values attributed to wetlands. We therefore need to be conscious of the sustainability of the wetland plants and animals when subjecting wetland to different uses such as agricultural activities.

Tanzania has officially ratified the Convention on wetlands (Ramsar Convention on Wetlands, 1971) in August 2000, thereby demonstrating her commitment towards sustainable wetland management. In supporting wetland conservation efforts the ministry of agriculture recommends that agriculture should make a positive contribution towards conservation of wetlands (FAO, 2003). However, in Tanzania agriculture seems to be a threat to wetland conservation (FAO, 2003). The need to expand agriculture to feed a growing population has in many places led to a major conversion of wetlands into farmlands (MNRT, 2004). Moreover, inappropriate farming methods are reported to result in degradation of wetlands (Hilhorst and Rohde, 2001; Ngana *et al.,* 2002). For example, inappropriate farming methods, clearing of vegetation, poor land husbandry practices and overgrazing in the upper catchments of Lake Manyara have lead to siltation of the Lake Manyara basin (Hilhorst and Rohde, 2001; Ngana *et al.,* 2002; Sechambo, 2006). Cultivation that involves clearing of vegetation on steep slopes and riparian zones of highland catchments generally results in sedimentation of the lowland wetlands. MNRT (2004) reported that cultivation on steep slopes and riparian ecosystems without proper conservation measures accelerates soil erosion and wetland sedimentation.

Given the fragility of wetlands, their importance for water supply and the growing pressures to convert them to agricultural uses, there is an urgent need for interventions which ensure sustainable use of wetlands. This requires introduction of management regimes which help maintain some of the natural characteristics of wetlands while also allowing partial conversion to allow activities which can meet the economic needs of communities. Dixon and Wood (2003) argued that although wetland utilization can make a key contribution to food security and livelihood security in the short term, in the long run there are concerns over the sustainability of this utilization and maintenance of wetland benefits. It is therefore necessary to carry out constant assessment of environmental condition as is critical to wise environmental management and policy decisions (Dana *et al.,* 1998).

1.2 Problem Statement and Justification

Unsustainable agricultural practices are one of the major environmental issues that call for attention in wetland utilization (MNRT, 2004). It has been observed that small scale farmers in Tanzania make the largest portion of inhabitants in the wetland areas where they practice unsustainable agriculture and when their farms become degraded, new ones are opened through clearing nearby natural vegetation in those wetlands (MNRT, 2004).

These unsustainable farming practices have resulted into degradation of many wetlands. For example, the degradation of the famous Ihefu-Usangu wetlands in Mbeya and Iringa (Majule and Mwalyosi, 2003). In Lake Manyara basin, siltation has been reported due to these malpractices practiced in the upper catchments (Hilhorst and Rohde, 2001; Ngana *et al.*, 2002; Sechambo, 2006). Various studies reported by MNRT (2006) show that cultivation on steep slopes and riparian ecosystems without proper conservation measures accelerates soil erosion and wetland sedimentation. Although many researches on land use found existence of inappropriate farming practices involving clearing of vegetation cover in highland catchments of Lake Manyara, little is known on the extent of degradation of plants as a result of the existing farming systems. Thus this study aims at finding out the extent of degradation of riparian vegetation of upper catchments of Lake Manyara basin in Monduli district as impacted by the existing farming methods in highlands catchments that are in Karatu District. The results of this study will provide the baseline information for wetland conservation, management and restoration.

1.3 Objectives of the study

1.3.1 Overall objective

The overall objective of this study was to assess the impact of farming systems on riparian vegetation in Chemchem and Endabash rivers of Lake Manyara basin.

1.3.2 Specific objectives

The specific objectives were to:

i. Assess plant species diversity in degraded riparian zones

ii. Assess plant species diversity in intact riparian zones

iii. Compare plant diversity of the degraded riparian zone against the intact riparian zone

iv. Identify the farming systems used and evaluate their impact on conservation of native species

1.4 Guiding Hypotheses

H_o: Existing farming systems have no significant impact on conservation of riparian native species

Ho: Plant species diversity in non degraded area is not significantly different to that of degraded area

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Wetland Management and Utilization

Plants and animals living in wetlands exhibit evolutionary adaptation to such habitat condition such as low oxygen availability, thus alteration of any physical function such as hydroperiod or water quality has repercussions on other functions and this chain of reactions affect the values attributed to wetlands since most wetlands have some standing water covering the soil surface for at least part of the year (Bush, 2000). According to MNRT (2004) thorough management of wetlands depends on the knowledge of the individual components and the interaction among/between them. Disregard of proper management plans will threat the sustainability of these wetlands.

Wetlands play a fundamental ecological role and have potential and are resources of great economic, cultural and scientific value (MNRT, 2006). Bush (2000) summarizes the common functions and uses of wetland ecosystems to be nutrient storage, accumulation of organic material for fuel or agriculture, filtering solids from waters, animal habitats, plant habitats and regulating water outflow. Though wetlands can be subjected to the uses above, the sustainability of these wetlands have to be considered first. Dana *et al.* (1998) argued that, disregard for sustainability may reduce long-term economic productivity and encourage environmental and ecological losses.

In Tanzania as in most developing countries, the productive nature of wetland ecosystems has not been valued forcing them into a threatened category (Munishi and Kilungu, 2004). MNRT (2006) reported that high demand for wetland products and services had pushed towards unplanned and subsequent over harvesting/utilization of wetland resources and services leading into degradation of most wetland ecosystems. Bernard *et al.* (2002) also observed that the mechanistic view applied to wetlands has led to their destruction by the inability or unwillingness to see and try to understand their importance for the function of the whole system. However, Munishi and Kilungu (2004) argued that, when wetlands are wisely managed they can continue to provide support to poverty alleviation and human well being sustainably.

2.2 Impact of Agriculture and other human activities on Wetlands

It has been reported that in Africa most of the wetland areas are experiencing immense pressure from human activities, the most important being drainage for agriculture (Bernard *et al.,* 2002). Rijsberman and Sanjini (2004) reported that agriculture and wetlands have not had a very harmonious relationship. It has been observed that wetlands are lost or reduced in size through human processes, namely agricultural activities, over harvesting of wetland products, overgrazing, unsustainable fishing practices, use of agrochemicals, pollution by domestic sewage and industrial effluents, developmental activities, introduction of exotic species, poaching of wildlife and river diversions in unconfined irrigation (Kamuakala and Crafter, 1993).

In North America, over 90 % of riparian habitats have been lost during the past 200 years mostly due to agricultural intensification (Benoit *et al.*, 2003). Agriculture has been observed to be a major threat to wetlands since in many cases it involves conversion of wetlands into farmlands (Rijsberman and Sanjini, 2004). Bernard *et al.* (2002) reported that agriculture practiced in highland catchments results in siltation to the wetlands of low lands. He also rep orted of the changes in water quality due to agricultural pesticides. More over Bernard *et al.* (2002) reported of the introduction of alien species of flora and fauna due to agricultural activities. Drainage, land reclamation, overgrazing, eutrophication of inland waters are among the impacts of agriculture on Kenya's wetlands (Ironga, 2005).

Consequently besides threatening of the provision of clean water and introduction of alien species, degradation of the wetlands also negatively influences agriculture (MNRT, 2004). Therefore wetlands need to be conserved in order to enjoy their goods and services such as water purification, water supply during the dry season, natural resources supply, and flood mitigation during heavy storms as well as coastal erosion control during high tides storm (Bush, 2000). This can only be achieved through wise utilization of wetland resources.

2.3 Sustainable Wetland Utilization

The Ramsar Convention (1971) defines wise use as sustainable utilization of wetlands for the benefit of human kind in a way compatible with the maintenance of natural properties of the ecosystems. The Convention further defines sustainable utilization of wetlands as human use of wetland so that they may yield the greatest continuous benefit to present generations while maintaining their potential to meet the needs and aspirations of future generations. It defines natural properties of the ecosystem as those of physical, biological and or chemical components such as soil, water, plants, animals, nutrients and the interactions between them. Sustainable management generally involves activities that can be conducted within, and around wetlands, both natural and man-made, to protect, restore, manipulate, or provide for their functions and values (NCSU, 2006).

The interest in sustainable use and adaptive management of tropical wetlands has increased in recent years (Finlayson, 2002). However, in Tanzania the sustainability of these wetlands when subjected to different economic uses is not considered as in most cases people use their own knowledge in utilizing these resources. Sustainability of the production process requires that inputs from natural resources be given equal consideration to outputs or consumption because resources provide more services to society than simply producing goods (Dana *et al.*, 1998). Conversely, it is difficult to assess environmental sustainability because it involves disparate social objectives and an understanding of complex ecological systems (Dana *et al.*, 1998).

2.4 Farming Systems in Tanzania

Tanzania is well endowed with variety of farming systems with variations in agro ecological conditions of which crops can be grown. Farm families grow many crops, some in monoculture, some intercropped as well as undertaking other activities such as raising livestock or engaging in petty trade (Due and Anandajayasekam 1984). Differences in farming systems used were influenced by local conditions. For example in Southern Tanzania traditional farming system used involves slash and burn cultivation in which mounds of vegetation cuttings are formed and burned on mountain slopes (Koizuni, 2007). Clearing of vegetation for agricultural practices results in soil erosion and is one of the most serious problems in mountain areas where there are frequent heavy rain. Itani (1998) argued that when woodlands on slopes are cleared for cultivation, unless measures to stop soil erosion are taken, fertile surface soils may erode with heavy rain and the land becomes barren within only a few years.

2.5 Different Farming Systems and their impacts in Wetlands

The most used farming systems in Tanzania are monoculture and mixed farming (URT, 2002). On the basis of ecological principles sustainable agricultural systems are those whose productivity can continue indefinitely without undue degradation of other ecosystems. However, little is known on farming systems used in wetland areas of Tanzania and their ability in conservation of wetland native species. Many studies (Belanger and Greiner, 2002) have revealed that agriculture intensification lead to the degradation of original forests. Farming practices adopted by farmers are governed by farm traditions and economics (Belanger and Greiner, 2002), but their attitude and behavior towards conservation are dictated by their knowledge and level of information (Lichtenberg and Zimmeman, 1999). In highlands catchments of Lake Manyara basin, the knowledge associated with small scale irrigation agriculture is not well appreciated (Hilhost and Rhode, 2001). Furthermore, Hilhost and Rhode (2001) reported on the increased in runoff and hence siltation in low lands due to clearing of the vegetation in the upper catchments of Lake Manyara basin. This implies that, probably farming systems that do not conserve the existing plant species have been adopted. It has been reported that, in monoculture, plant diversity in is nill and below ground plant diversity is reduced via management. However there is little information on the adopted farming systems and their ability to conserve native species in highland catchments of Lake Manyara basin.

2.6 The role of riparian vegetation

Riparian habitats situated between crop fields and watercourses are of prime importance for the maintenance of water and soil quality, for their role in filtering out pesticides and fertilizers thus preventing excessive leaching directly into water, and for trapping eroding soil particles (Celin *et al.,* 2003). Loss of any link in the web of biodiversity will reduce the goods, functions and attributes of a wetland site (Bernard *et al.,* 2002). It is not sufficient just to protect the populations of plants and animals that are directly exploited as their health and survival, or sustainability, depends on maintaining the whole complex of biodiversity that characterizes the whole ecosystems. Wetlands loss of diversity often signals ecosystem degradation and a major task in applied ecology is to predict the impact of different scenarios of human impact (including land management) on the plants and animal communities of ecosystems (Wilson *et al.,* 2002). This is useful as it helps in developing sustainable plans on how wetlands can be wisely utilized.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Description of the Study Area

The study was conducted in two villages of Karatu Distrct namely Chem chem and Endabash adjoining Lake Manyara national park forest. In these villages there are Chemchem and Endabash rivers that run from these villages to the Lake Manyara basin (Fig. 1). The study area is located between latitudes 35°45’- 35°50’S and longitudes 3°25`-3°35’E. The area covers about 8990 ha. The area receives bimodal rainfall ranging from 700 to 1000 mm per year divided over short rainy seasons (November and December) and a long rainy season (March to April). The mean annual temperature is in the range of 18° C to 35° C. Soils vary from fertile highly erodible volcanic material to a variety of moderate to low fertility sedimentary and basement soils. Vegetation of the area can be classified as wooded grasslands, woodlands and forests. Population density ranges from 75-150 people per square kilometer. Crop cultivation is one of the main economic activities of the people living in these villages whereby major grown crops are maize/beans/pigeon peas in rotation with wheat/barley. Livestock farming is also practiced in these villages.

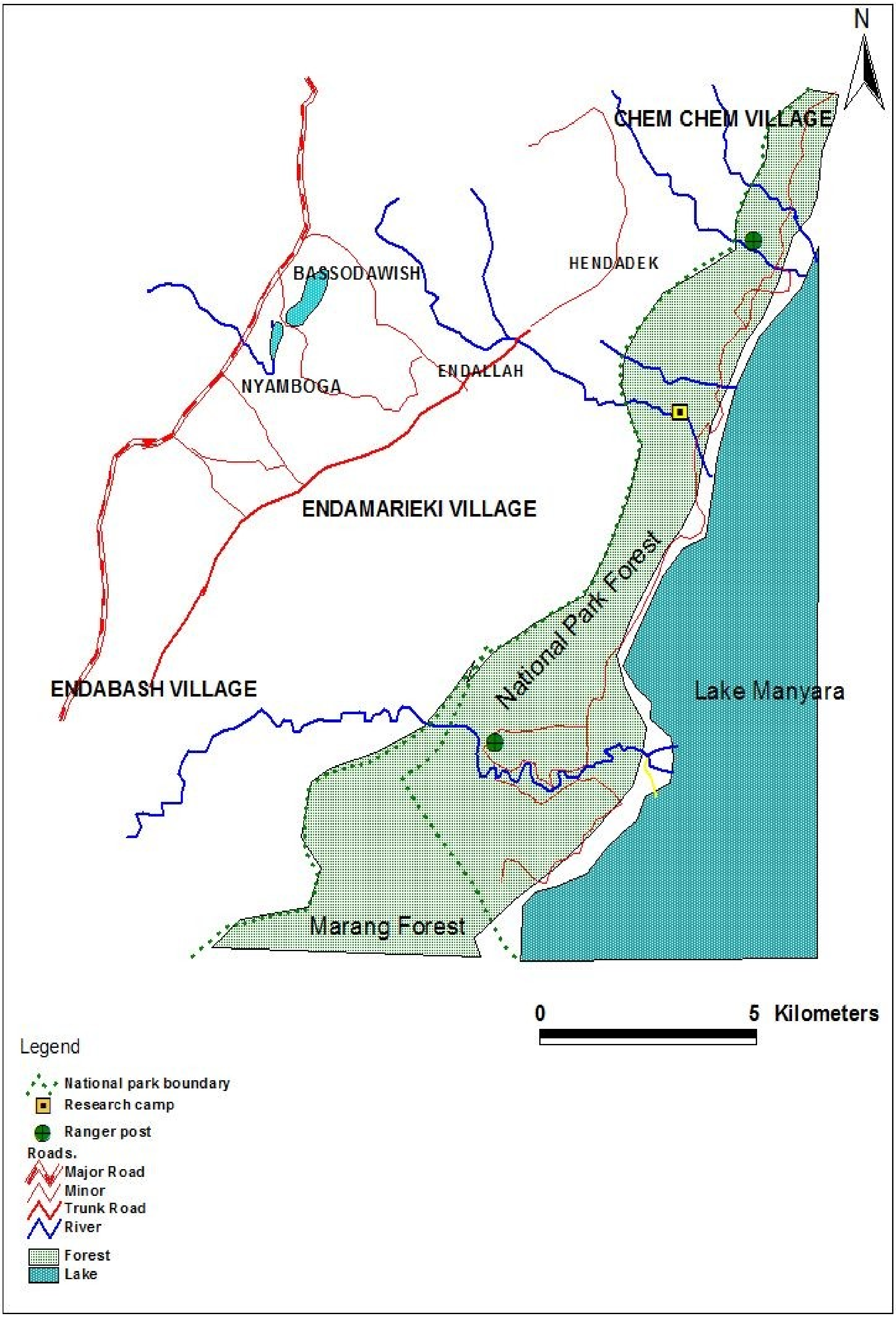

Figure 1: Map showing upper catchments of Lake Manyara National park

3.2 Data Collection Methods

Data collection involved identification and measuring of plants DBH in degraded and non degraded riparian zones of Chemchem and Endabash Rivers of Lake Manyara basin as well as identification of farming systems used in degraded riparian zones of these rivers. The riparian zones of Chemchem and Endabash rivers were stratified into two zones, the degraded and non degraded riparian zones. Riparian zones inside the national park was considered as non degraded riparian zone while that of outside the national park was considered as degraded riparian zone.

3.2.1 Plant diversity in degraded and non degraded riparian zones

Reconnaissance survey

Reconnaissance survey was done to get the insight of the actual field situation. The work involved observation of the actual field situation and determination of how transects will be laid. Using maps, transects and sample plots were established on the ground.

Sampling for ecological data

Stratified sampling was adopted where the area was stratified into the degraded riparian zones and non degraded riparian zones. Two transects 20m apart were laid parallel in both sides of the rivers within each zone. The distance between plots was 200m. Transects were laid in such a way that they covered as much variations as possible in the riparian zones including highly disturbed area, partially disturbed area and intact area.

Data collection

The required number of sample plots was 633 (at sampling intensity of 0.5 %). However, due to limited finances and time to conduct research this was not possible. Therefore, a total of 128 plots, which is 20 % of the required number of sample plots were laid out along the transects at an interval of 50 m apart with the first plot at half way distance of 25 m from the starting point.

Sampling was done in temporary concentric sample plots of 15 m, i.e. 0.071 ha with subplots of 10 m and 5 m radii established systematically along transects that run parallel to each other.

In each plot, the following were assessed;

- Within the 15 m radius, all trees/shrubs with dbh ≥10 cm were identified and DBH measured
- Within the 10 m radius, all trees/shrubs with dbh ≥ 5 and <10 cm were identified and DBH measured
- Within the 5 m radius, all other species not identified in the 10m were identified and recorded. These were categorized as all vascular plants.

In additional to the above, the following information was recorded in each sample plot in degraded riparian zones;

- Basal diameter of stumps
- Names of the cut trees and their condition (new i.e. fresh stumps or old i.e. dry stumps).
- Counts of the cut trees.

3.2.2 Farming systems in degraded riparian zones

The farms adjoining the riparian zones of the Chemchem and Endabash rivers were subjectively visited and the adopted farming system was identified. Circular plots were established in the visited farmlands within transects.

In each plot, the following were assessed;

- Within the 15 m radius, all trees/shrubs with dbh ≥10 cm were identified and DBH measured
- Within the 10 m radius, all trees/shrubs with dbh ≥ 5 and <10 cm were identified and DBH measured
- Within the 5 m radius, all other species not identified in the 10m were identified and recorded. These were categorized as all vascular plants.

3.3 Data Analysis

Microsoft Excel program was used to analyse ecological data. Species richness, diversity and similarity between the two zones (i.e. degraded riparian and non degraded riparian zones) were calculated using the Simpson and Shannon diversity indices as well as the Sorensen’s similarity index.

3.3.1 Species richness

The number of species as per sample is a measure of species richness. The more species present in a sample the richer the sample. It is one of the most important elements in biodiversity because the number of species existing at a site is a quantitative measure of biodiversity and allows comparison with other sites (Hayat *et al.*, 2010). Species richness was computed as the total number of species in each zone/strata. The species Importance Value Index (IVI) for trees/shrubs with dbh ≥10 cm was used in computation based on relative basal area, density and frequency.

3.3.2 Species diversity

Plant species diversity refers to the number of different species in a particular area (i.e. species richness) and their relative abundance (evenness) within a defined area. Diversity indices (DI) provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. Simpson and Shannon-Wiener's indices were used to measure the species diversity (Magurran, 1988).

3.3.2.1 Simpson's index of diversity

The Simpson's index reflects dominance because it weighs the most abundant species more heavily than the rare species. It considers the number of species, the total number of individuals and the proportion of the total found in each species. The index expresses the probability that the next species encountered will be a different species. It ranges from 0 to 1, with values near zero corresponding to highly diverse or heterogeneous ecosystems and values near one corresponding to more homogeneous ecosystems (Simpson *et al.,* 1986). A perfectly homogeneous population would have a diversity score of 0. A perfectly heterogeneous population would have a diversity score of 1 (assuming infinite categories with equal representation in each category). This index was used to reflect if there were dominating species.

It is computed as

$$C = \sum_{i=1}^{S} (p_i)^2$$

Where

C = the index number (diversity index)

S = total number of species in the sample

p_i = the proportion of all individuals in the sample that belong to species i.

3.3.2.2 Shannon–Wiener index

The index represents the “uncertainty” or “information” of a community. The Shannon-Wiener measures (H’) increases with the number of species but for biological communities H’ does not seem to exceed 5 (Hayat *et al.*, 2010) The more variable its composition the more uncertain or unpredictable each sample of it would be.

$$H' = -\sum_{i=1}^{S} (p_i)(\ln p_i)$$

Where pi = the proportion of all individuals in the sample that belong to species i.

*In*pi = Natural logarithm of pi

S = total number of species in the sample

3.3.3 Similarity between the two zones

Similarity between the two zones (degraded and non degraded riparian zones) was measured using Sorensen Index of Similarity (Magurran, 1988).

Similarity coefficient Cs = (2j/(2j+a+b))*100

Where: **j** is the number of species found in each pair of sites taken at a time,

a is the number of species found in site A

b is the number of species found in site B.

3.3.4 The Impact of Anthropogenic disturbance to Riparian Vegetation

Ecologically, disturbance is defined as a short lived event that causes a measurable change in the properties of an ecological community. It is judged by severity of its effects upon a wetland. To reflect the impact of anthropogenic disturbances to riparian vegetation, average live trees per ha, average old cut trees per ha, and average new cut trees per ha was calculated (MNRT, 2005). Average live trees per ha was calculated as total count of all trees (live trees and cut trees) less the cut trees divided by the total area in ha. Average old cut per ha was calculated as total old cut trees divided by the total area in ha. Average new cut per ha was calculated as total new cut trees divided by the total area in ha. The results were used to reflect the contribution of the other human activities in degradation of riparian plants.

3.3.5 Farming Systems and Conservation of Local Riparian Vegetation

The percentage of the adopted farming system was calculated by summing similar farming systems divided by total observed farming systems. Plants existing in the observed farming systems were compared to those in intact riparian zone to find their similarity. The results reflect the farming systems used and their ability to conserve the existing riparian local species.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Plant Species Composition and Diversity in Riparian Zones of Chem chem

4.1.1 Plant species composition in degraded and non degraded riparian zone of Chemchem river

A total of 49 plant species belonging to 32 families were identified in the degraded riparian zone. There were 19 species of shrubs, 14 tree species, 14 species of herbs and 2 species of grass (Appendix 1). Most of plant species in this area were commonly found in riverine with exception of few plant species such as *Combretum molle* which were mainly found in the woodlands.

In the non degraded riparian vegetation, a total of 45 plant species belonging to 27 families were obtained. Among these 16 plant species were shrubs, 14 trees, 13 herbs and 2 grasses (Appendix 1). Species found in this zone were riverine species.

4.1.1.1 Dominant vascular plants in degraded riparian zones of Chemchem river

With regard to all vascular plants, degraded riparian zone of Chemchem river was dominated by *Acacia mellifera, Cynodon dactlyon, Pavonia gallaensis, Acacia elatior, Deolonix elata, Tabernaemontana stapfiana, Hypoestes triphylla*, *Croton dichogamus* and *Maerua triphylla* (Table 1). It was observed that, the degraded riparian zone vegetation was mainly dominated by shrubs (38 %), followed by trees (28 %), grasses (20 %) and herbs (14 %). These results were in agreement with those of Mishra *et al.*, (2004), where by shrubs were found to dominate agricultural managed land. The higher light levels and more open canopy in this degraded riparian zone favored the growth of shrubs, grasses as well as other herbaceous plants. Hubbell *et al.* (2007) found that canopy opening creates light gaps which markedly increases sapling densities because pioneer species successfully germinated and survived.

Table 1: Vascular Plants Species Dominance in degraded riparian zone of Chemchem river

Species	Species Life form	Frequency	% Composition
Acacia mellifera	S	15	13.9
Cynodon dactylon	Gr	15	13.9
Pavonia gallaensis	H	14	13.0
Solanum incanum	S	12	11.1
Acacia elatior	T	11	10.2
Delonix elata	T	10	9.3
Tabernaemontana stapfiana	T	9	8.3
Hypoestes triphylla	H	8	7.4
Croton dichogamus	S	7	6.5
Maerua triphylla	S	7	6.5
Total		**108**	**100**

* S=Shrub, Gr=Grass, H=Herb, T=Tree

4.1.1.2 Dominant trees/shrubs species in degraded riparian zones of Chemchem river

When considering trees and shrubs with DBH ≥ 5cm, the most dominant species in the degraded riparian zone were *Acacia mellifera*, *Acacia elatior, Ficus sur, Croton dichogamus, Rhus natalensis,* and *Celtis africana* (Fig. 2 below). With exception of *Acacia mellifera*, all dominant tree and shrub species were riverine species. Among other dominant species in degraded riparian zones of Chemchem, *A. mellifera* which is mainly a woodland species was observed to be the most dominant species (Fig. 2). Presence of a woodland species such as *A. mellifera* portrayed that this riparian zone might be degraded or unhealthy. These results are in agreement with the findings of Bellows (2003) who argued that degraded/unhealthy riparian areas have vegetation dominated by upland plants and noxious weeds. Furthermore, the decrease in water levels might allow woodland species to grow in the riparian zones. Presence of *A. mellifera* in this zone might also be a result of decrease in water levels because Hines and Eckman (1993) observed that *A. mellifera* is also found along seasonal water courses mixed with other trees. Therefore presence of *A. mellifera* might be a sign of degradation of the earlier existed wetland vegetation or decrease of water level in this riparian zone. Both of above implies that the zone exhibit one of signs of degraded riparian zone.

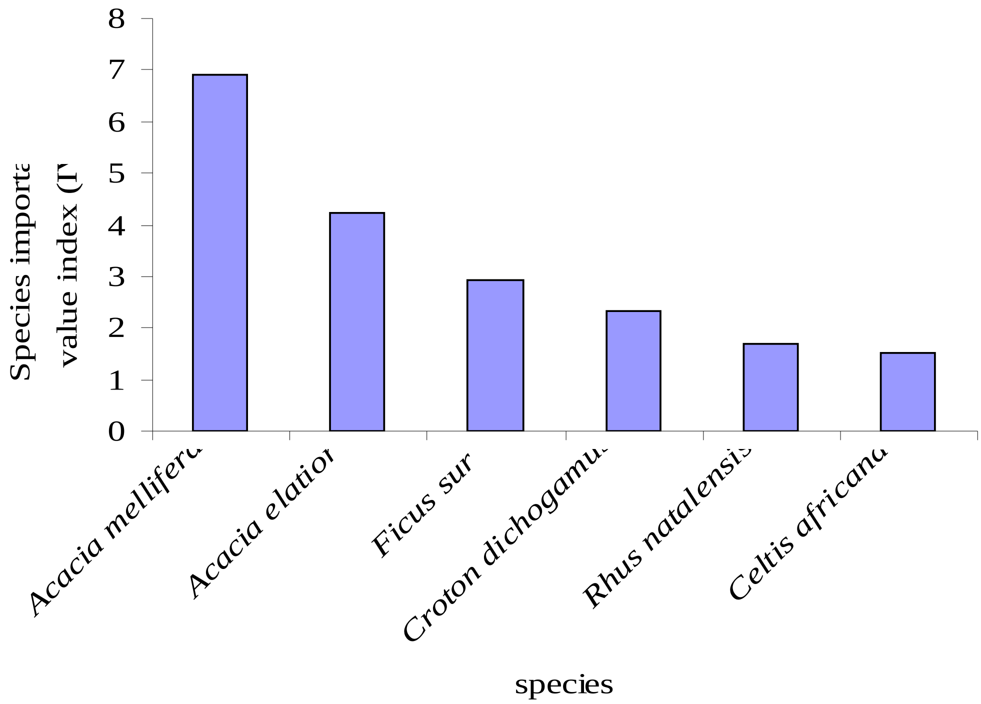

Figure 2: Dominant tree/shrub species based on Species Importance Value Index in degraded riparian zone of Chemchem river

4.1.1.3 Dominant vascular plant species in the non degraded riparian zones of Chemchem river

The most dominant vascular plants species in non degraded riparian zone of Chemchem were *Maerua triphylla, Acacia elatior, Barleria ramulosa, Commelina petersii, Kigelia africana* and *Acacia tortilis* (Table 2). Trees make the largest proportion of the life forms (46 %) followed by herbs (32 %) and shrubs (23 %). These results are in agreement with those of Behera and Mishra (2005) who found lower number of herbaceous species in non degraded stands of Eastern Ghats of India. The lower proportion of herbs and shrubs can be attributed to higher canopy cover as they are suppressed by trees and shrubs due to competition for light and nutrients. A study conducted by Behera and Mishra (2005) revealed negative relationship between canopy cover and herbaceous plant density.

Table 2: Vascular Plants Species dominance in non degraded riparian zone of Chemchem

Species	Species Life form	Frequency	% Composition
Acacia elatior	T	14	17
Acacia tortilis	T	11	13
Barleria ramulosa	H	13	16
Commelina petersii	H	13	16
Kigelia africana	T	13	16
Maerua triphylla	S	19	23
Total		**83**	**100**

* S=Shrub, Gr=Grass, H=Herb, T=Tree

4.1.1.4 Dominant trees/shrubs species in non degraded riparian zones of Chemchem river

The most dominant trees and shrubs with DBH ≥ 5cm in non degraded riparian zone were *Acacia elatior, Acacia tortilis, Acacia mellifera, Terminalia brownii, Cordia* *ovalis, Chorisia speciosa, Celtis africana and Ficus sur* (Fig. 3). These results are similar to those of Loth and Herbert (1986) who observed that *Terminalia brownii, Ficus sur* and *Acacia tortilis* were dominant trees along the upper catchments of Lake Manyara basin. This indicates that the riparian zone is not significantly disturbed as the area is under total protection.

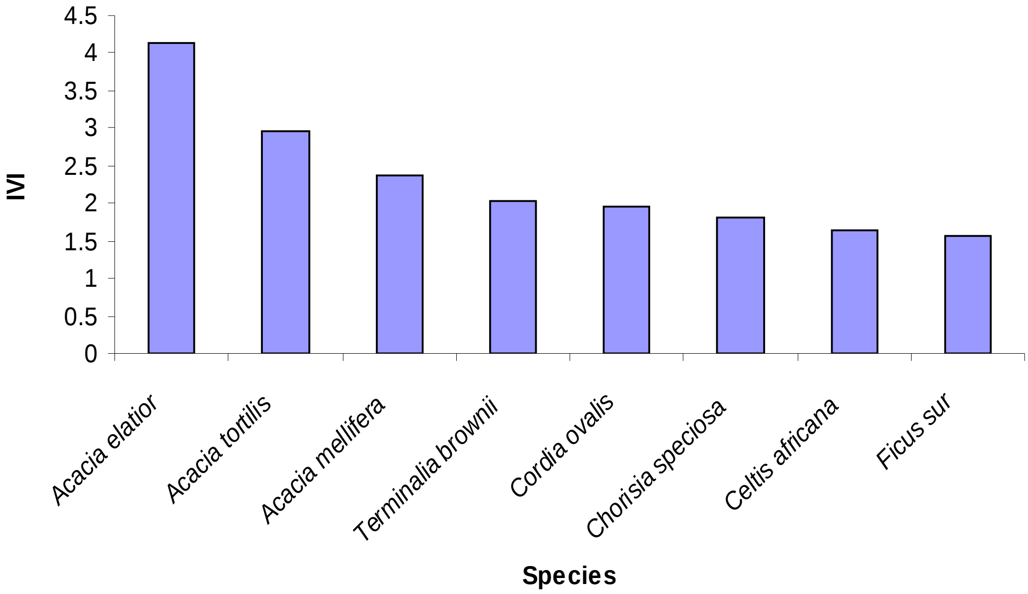

Figure 3: Dominant tree/shrub species based on Importance Value Index (IVI) in the non degraded riparian zones of Chemchem river catchment in Karatu district

4.1.2 Vascular plant species diversity in degraded and non degraded riparian zones of Chemchem river

The Shannon-Wiener index of all vascular plants was 3.6 for the degraded riparian zone while it was 3.5 for non degraded riparian zone (Table 3). Furthermore, the Simpson index of all vascular plants was 0.03 while in non degraded riparian zone was 0.03 (Table 3). The observed Shannon index suggest that the habitat is highly diverse. Moreover, the observed Simpson indices suggest that the species are more heterogeneous because their values approach zero. Both indices of diversity suggest that there was species diversity for all vascular plants and the species were more heterogeneous. This showed that the regeneration potential for all vascular plants in degraded and non degraded riparian zones is high and there was low competition that inhibits germination and survival of these vascular plants. This is because species diversity is dependent on the regeneration potential of various species and the presence of competitors that may either inhibit or promote regeneration (Aparajita, 2007). However, the diversity indices show that vascular plants in degraded riparian zone were more diverse compared to non degraded riparian zone. The higher species heterogeneity and diversity of vascular plants in the degraded zone may be attributed to forest clearance and disturbance as it has been argued that medium disturbance increases species diversity (Mishra *et al.,* 2004). The observed disturbances might also be periodical because disturbances which occur periodically determine a higher species diversity than in communities where species can exist under competitive equilibrium (Sala *et al.,* 1986).

4.1.3 Trees/shrubs species diversity in degraded and non degraded riparian zones of Chem chem river

The Shannon-Weiner index for trees and shrubs was 2.6 in the degraded riparian zone while in non degraded zone was 2.9 (Table 3). Further more Simpson diversity index was 0.06 and 0.10 for non degraded and degraded zones respectively. The observed Shannon-Wiener and Simpson indices suggest high species diversity in both zones. However, the species diversity in degraded riparian zone was lower. This may imply high disturbance for trees/shrubs in degraded riparian zones as it has been argued that high levels of disturbances reduce species richness (Mishra *et al.,* 2004).

Table 3: Species diversity in riparian zones of Chemchem river

Riparian zone status	Biodiversity index	Vegetation category	
		All vascular plants	Trees/Shrubs Dbh ≥ 5cm
Degraded	Shannon wiener	3	2.6
	Simpson	0.03	0.01
Non degraded	Shannon wiener	3.5	2.9
	Simpson	0.03	0.06

4.1.4 Comparison of plant species composition and diversity in riparian zones of Chemchem river

The results indicate that the degraded riparian zone is mainly dominated by shrubs 38 %, followed by trees (28 %), grasses (20 %) and herbs (14 %) (Table 1). Contrary to the above situation, non degraded riparian zone contains more trees (46 %) and herbs (32 %) (Table 2). The proportion of shrubs in the non degraded zone suggests that the area has been under agricultural practices. It has been argued that shrubs dominate agricultural managed land (Mishra *et al.,* 2004). The observed shift in species dominance between degraded and non degraded riparian zones might be a result of vegetation degradation due to agricultural activities as well as other anthropogenic disturbances in degraded riparian zone. Gaberscik (2007) argued that frequent and intense disturbances can lead to shift in vegetation dominance.

A Shannon and Wiener indices of 3.6 and 3.5 were recorded in degraded and non degraded riparian zones respectively for all vascular plants (Table 4). The difference is statistically significant at ($P < 0.05$). Though the difference between the Shannon values is small, it is evident that the value in degraded area is higher than that of non degraded riparian zones, suggesting higher diversity in the degraded areas possibly resulting from mild disturbances. Other studies e.g. of Mishra *et al*. (2004), revealed that mild disturbances favoured species richness, but with increased degree of disturbance, as in the case of highly disturbed stands, the species richness markedly decreased. On the other hand, the Shannon value for trees and shrubs with DBH ≥ 5cm in non degraded riparian zone (2.9) was higher than that of the degraded riparian zones (2.6) (Table 4). IVI was used to test for significance of the difference and the difference was found to be statistically not significant at ($P < 0.05$) This depict that the trees and shrubs in non degraded areas are more diverse than in degraded riparian zones implying high vegetation degradation in the degraded riparian zones. Selective cutting of trees/shrubs for different uses such as timber production, charcoal making, firewood and building poles might be the reason for the decreased tree/shrub species diversity in degraded riparian zones.

Table 4: Plant species composition and diversity in the Riparian zones of Chemchem river

Plant category	**Site**	
	Degraded	**Non degraded**
Species richness	50	46
Species diversity		
All vascular Plants		
Shannon	3.6	3.5
Simpson	0.03	0.03
Trees/Shrubs ≥ 5cm DBH		
Shannon	2.6	0.10
Simpson	2.9	0.06

4.1.5 Similarity between degraded and non degraded areas in the Chemchem river Catchment

The Sorensen similarity index in Chemchem river shows that the species in degraded and non degraded riparian zones were similar by 40.51 %. Mishra *et al*. (2004) observed a similarity of 33 % between undisturbed and highly disturbed stands in Maghalaya, Northern India. A 40.51 % similarity between the two sites suggests high degradation of some parts of the catchment which can signify a high pressure on the riparian zone of the catchment. The ongoing cultivation in the degraded riparian zones of Chemchem river might have resulted in alteration of species composition because it involves conversion of riparian forests to farmlands.

Argemone mexicana an exotic plant brought as wheat weed appears both in degraded and non degraded riparian zones of Chemchem river. Because these exotic species are aggressive and highly-tolerant species, they may out compete earlier indigenous species leading to a reduction in species diversity.

4.2 Farming Systems in Degraded Riparian zones of Chemchem

Monocropping and mixed cropping were the main farming systems in Chemchem river. These results agree with the findings of URT (2001) that monoculture and mixed farming are the main farming systems in Tanzania. Of the entire farms visited, 37.5 % in Chemchem river use monocropping. The observed monoculture farming system involved clearing of the existed vegetation at the expense of planting desired annual crops mainly maize and beans. When these annual crops were harvested the cultivated area became disposed to soil erosion. Itani (1998) argued that when woodland on the slopes are cleared for cultivation, unless measures to stop soil erosion are taken, fertile surface soils may erode with heavy rain and the land becomes barren within only a few years. In mixed farming fields it was observed that farmers cleared the existed vegetation and plant their intended perennial crops mainly trees for fruit production as well as annual crops such as maize, beans and vegetables.

4.2.1 Plant species found in different farming systems of Chemchem River Catchment

A total of 12 and 10 plant species were encountered in monocropping and mixed cropping systems respectively (Table 5).

The common plant species in monocropping systems were *Acacia melifera, Argemone mexicana, Amaranthus hybridus, Annona muricata, Commiphora Africana, Crabbea velutina, Jatropha curcas, Kigelia africana, Melia azedarach, Rauvolfia caffra, Ricinus communis and Solanum incunum*. Most of these trees were left in the fields for provision of shade and fruits. Moreover, *Argemone mexicana* and *Solanum incunum* occurred as weeds within the farmlands.

The common species in mixed cropping included *Amaranthus hybridus, Annona cherimola, Citrus limon, Citrus sinensis, Grevillea robusta, Mangifera indica, Melia azedarach, Persea americana, Psidium guajava, Rauvolfia caffra and Senna siamea*. These trees were mixed within the farm fields for different intentions i.e. production of fruits, timber and fodder.

Table 5: Species found in Farming systems of Chemchem river Catchment Karatu district

Species	Monocropping	Mixed farming
Acacia melifera	√	
Argemone mexicana	√	
Amaranthus hybridus	√	
Annona cherimola		√
Annona muricata	√	
Citrus limon		√
Citrus sinensis		√
Commiphora africana	√	
Crabbea velutina	√	
Grivelia robusta		√
Jatropha curcas	√	
Kigelia africana	√	
Mangifera indica		√
Melia azedarach	√	√
Persea americana		√
Psidium guajava		√
Rauvolfia caffra	√	√
Ricinus communis	√	
Senna siamea		√
Solanum incunum	√	

4.2.2 Farming systems and conservation of native riparian plants

Only 5 species out of 46 species found in non degraded area occurred in the farmlands practicing monocropping. These species included *Acacia mellifera, Argemone mexicana, Kigelia africana, Ricinus communis* and *Solanum incanum*. Similarity index of 14.5 % was observed between the non degraded riparian zone and the monocropping farming systems showing the species in monocropping highly differ from those in non degraded riparian zone. This may suggest high vegetation degradation in farmlands.

Further more only one species occurring in mixed cropping was found in non degraded riparian zone. A very low similarity index (3.3 %) was observed between the non degraded riparian zone and the mixed cropping farming systems. This is likely due to reduced plant species resulting from management as farmers plant species of their preference.

The low similarity between farming systems and natural riparian habitats showed that the two farming systems do not support the conservation of the original plant species.

4.4 Plant Species Composition and Diversity in Endabash river riparian zones

4.4.1 Plant species composition in riparian zones of Endabash river

The degraded riparian zone had a total of 53 plant species belonging to 28 families. There were 21 shrubs species, 19 trees species, 9 herbs species and 4 grasses species (Appendix 2). Most of plant species in this area were riverine species.

In the non degraded a total of 56 species which belonged to 22 families were identified. Among these 23 species were shrubs, 20 trees, 9 herbs and 4 grasses (Appendix 2). Plant species encountered in this zone were riverine species.

4.4.1.1 Dominant vascular plants in degraded riparian zones of Endabash river

With regard to all vascular plants recorded in degraded riparian zone of Endabash river, it was observed that the area was mainly dominated by (44.4 %) trees, (20.9 %) grasses, (10.4 %) shrubs and (24.4 %) herbs respectively (Table 6). Behera *et al.* (2007) argued that, opening of the canopy favors invasion of grasses and sedges. Moreover, annuals and short lived perennials are favoured by disturbance. Thus the observed high contribution of grasses, herbs and shrubs can be attributed to be a result of various anthropogenic disturbances mainly clearing of vegetation for farming.

Table 6: Dominant Vascular Plants in Degraded riparian zone of Endabash river

Species	Species life form	Frequency	% composition
Terminalia brownii	T	18	15.7
Dalbergia melanoxylon	T	13	11.3
Hyparrhenia rufa	Gr	13	11.3
Conyza pryrrhopappa	S	12	10.4
Combretum molle	T	11	9.6
Crabbea velutina	H	11	9.6
Penisentum purpureum	Gr	11	9.6
Azanza garckeana	T	9	7.8
Hypoestes triflora	H	9	7.8
Commelina petersii	H	8	7.0
Total		**115**	**100**

S=Shrub, Gr=Grass, H=Herb, T=Tree

4.1.2 Dominant trees/shrubs in degraded riparian zones of Endabash river

The most dominant tree/shrub in degraded riparian zone of Endabash river were *Terminalia brownii, Combretum molle, Dalbergia melanoxylon, Rhus natalensis, Acacia mellifera, Albizia grandibracteata, Tamarindus indica, Commiphora africana and Acacia nilotica* (Figure 4). Except *Combretum molle* and *Acacia mellifera* all dominant trees and shrubs were riverine species. Bellows, (2003) argued that presence of woodland species in riparian zone is an indicator of degraded riparian zone. Moreover, decrease in water level might allow woodland species to grow in the riparian zones. Therefore the presence of *Combretum molle* and *Acacia mellifera* as dominant species implies that the zone is degraded since both species are woodland species.

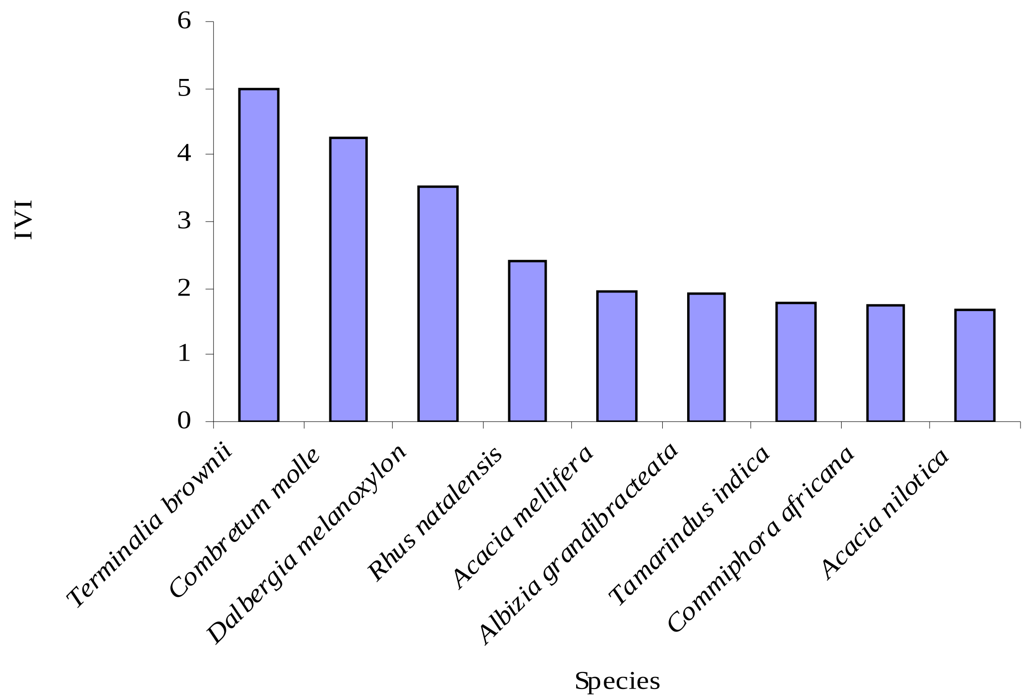

Figure 4: Dominant tree/shrub species based on Species Importance Value Index (IVI) in the degraded riparian zone of Endabash river Catchment Karatu District

4.4.1.3 Dominant vascular plants in non degraded riparian zones of Endabash river

With regard to all vascular plants observed in non degraded riparian zone of Endabash river, trees make the largest portion of the life forms (54.9 %), followed by grasses (23.5 %), shrubs (10.8 %) and herbs (10.8 %) (Table 7). These results are in agreement with the findings of Behera and Mishra., (2005) who found lower number of herbaceous species in non degraded stands of Eastern Ghats of India. Moreover, the study revealed negative relationship between canopy cover and herbaceous density (Behera and Mishra, 2005). The lower number of herbaceous species in this non degraded riparian zone was possibly due to competition for space, light, soil moisture and nutrients among species.

Table 7: Dominant vascular plant species in non degraded riparian zone

Species	Species life form	Frequency	% composition
Terminalia brownii	T	20	19.6
Commiphora africana	T	16	15.7
Hyparrhenia rufa	Gr	13	12.7
Conyza pryrrhopappa	S	11	10.8
Crabbea velutina	H	11	10.8
Pennisentum purpureum	Gr	11	10.8
Albizia grandibracteata	T	10	9.8
Commiphora eminii	T	10	9.8
Total		**102**	**100**

S=Shrub, Gr=Grass, H=Herb, T=Tree

4.4.1.4 Dominant trees/shrubs in non degraded riparian zones of Endabash river

The most dominant trees and shrubs with DBH ≥ 5cm in non degraded riparian zone were *Terminalia brownii, Commiphora africana, Albizia grandibracteata, Combretum molle, Commiphora eminii, Tamarindus indica, Dombeya goetzei, Ziziphus abyssinica* and *Albizia gummifera* (Fig. 5). Hoorman and McCutcheon, (2005) urged that, presence of upland vegetation often serve as indicators of disturbed or degraded riparian areas. Existance of bushland and woodland species such as *Combretum molle, Commiphora eminii, Tamarindus indica* and *Ziziphus abyssinica* suggest that the riparian zone is in degraded state because the area is dominated by the upland plants. This might be a result of severe decrease in water level for long period of the year.

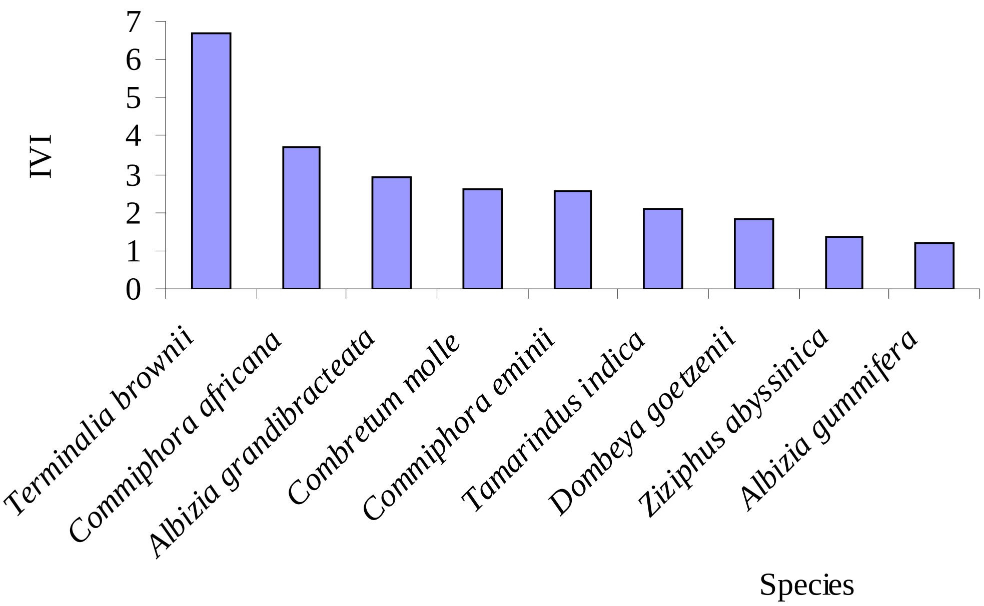

Figure 5: Dominant tree/shrub species based on Species Importance Value Index (IVI) in the on degraded riparian zones of Endabash river Catchment Karatu District

4.4.2 Vascular plant species diversity in degraded and non degraded riparian zones of Endabash river

The Shannon Wiener diversity index for all vascular plants was 3.6 (Table 6) for both degraded and non degraded riparian zones of Endabash river. The Shannon and Wiener index observed suggest that there was high diversity. The Simpson index for all vascular plants in the degraded zone was 0.03 while in non degraded zone was 0.06 (Table 6). The Simpson index ranges from 0 to 1, with values near zero corresponding to highly diverse or heterogeneous ecosystems and values near one corresponding to more homogeneous ecosystems. The observed Simpson index suggest that there was high plant species heterogeneity in this zone. Both indices reported suggest that there was high diversity for all vascular plants implying that species diversity was high. The higher species heterogeneity and diversity for vascular plants might be a result of medium disturbance.

4.4.3 Trees/shrubs species diversity in degraded and non degraded riparian zones of Endabash river

The Shannon Wiener index for trees/shrubs was 2.8 in degraded riparian zone while in non degraded riparian zone was 2.6 (Table 8). Further more, the Simpson diversity indices were 0.08 and 0.06 for degraded and non degraded riparian zones respectively (Table 8). The observed Shannon and Simpson indices suggest high plant species diversity and heterogeneity in both zones. However, species diversity in degraded riparian zone (2.8) was higher than that of non degraded riparian zone (2.6) implying mild degradation of trees/shrubs as it has been argued that mild disturbance favored species richness, but with increased degree of disturbance, as was the case in the highly disturbed stand, the species richness markedly decreased (Lite *et al.*, 2005). The increase in tree/shrubs species diversity may be attributed to canopy opening which allows pioneer species to germinate and survive.

Table 8: Plant Species Diversity in Riparian zones of Endabash river

Riparian zone status	Biodiversity index	Vegetation category	
		All vascular plants	Trees and Shrubs Dbh ≥ 5cm
Degraded	Shannon wiener	3.6	2.8
	Simpson	0.03	0.08
Non degraded	Shannon wiener	3.6	2.6
	Simpson	0.03	0.06

4.4.4 Similarity between degraded and non degraded areas in the Endabash river Catchment

The Similarity between degraded and non degraded areas in the Endabash river catchment was 45.8 %. Other studies e.g. Mishra *et al.* (2004) reported a similarity index of 71 % between undisturbed and moderately disturbed stand in Meghalaya, northeast India. Yadav and Gupta (2007) reported a similarity index of 68 % between the undisturbed forest and highly disturbed forest in Sariska, India. 45.8 % similarity observed between the two sites suggests moderate degradation of vegetations which might have altered both species diversity and composition. The ongoing cultivation in the degraded riparian zones of Endabash river have resulted in altering species composition because it involves complete change of land use.

4.4.5 Comparison of plant species diversity in degraded and non degraded riparian zones of Endabash river

The Shannon index of diversity of degraded and non degraded riparian areas were 3.6 and 3.6 while Simpson indices were 0.03 and 0.04 for all vascular plants in degraded and non degraded riparian zones (Table 9). The results indicate that Shannon index in degraded area is almost similar to that of non degraded riparian zones implying that with regard to all vascular plants, the degraded riparian zone is as diverse as non degraded zone. More over, Simpson index suggest that the species are more heterogeneous in degraded zone compared to non degraded riparian zone. The Shannon index of diversity of degraded and non degraded areas were 2.8 and 2.6 while the Simpson index were 0.07 and 0.03 for trees and shrubs with DBH ≥ 5cm were reported in degraded and non degraded riparian zones of Endabash river respectively (Table 9). The Shannon index obtained in degraded riparian zones (2.8) was higher than that of the non degraded zone (2.6). Lite *et al.* (2005) revealed that mild disturbance favored species richness, but with increased degree of disturbance as was the case in the highly disturbed stand, species richness markedly decreased. These results depict that trees and shrubs in degraded riparian zones are more diverse than in non degraded riparian zones implying that there is mild disturbance of vegetations in degraded riparian zones. Increase in species richness might be due to invasion by open woodland species and shrubs resulting from disturbances such as clearing of riparian forests for farming. Moreover, the observed result indicate that the tree species in non degraded riparian zones are more heterogeneous compared to degraded riparian zone. This implies that, in degraded riparian zone there might be high cut of preferred trees/shrubs in degraded riparian zone because there were few species which dominated more than the others. This is probably because of selective cutting of preferred trees/shrubs for different uses such as extraction of charcoal, timber and building poles.

Table 9: Plant species composition and diversity of the riparian zones of Endabash river catchment Karatu district

Plant category	**Site**	
	Degraded	**Non degraded**
Species richness	53	56
Species diversity		
All vascular Plants		
Shannon	3.6	3.6
Simpson	0.03	0.04
Trees/Shrubs ≥ 5cm DBH		
Shannon	2.8	2.6
Simpson	0.7	0.03

4.5 Farming Systems in Degraded Riparian zones of Endabash river catchment

The results show that monocropping is the main farming system adopted in Endabash river. 100 % of the visited farms in Endabash river practice monocropping. Maize and beans are the main crops grown. The practiced monoculture involved clearing of existed vegetation at the expense of planting maize and beans.

4.5.1 Species found in monocropping farming systems of Endabash river catchment

A total of 15 plant species were encountered in monocropping farming system containing shrubs (33.3 %), herbs (33.3 %), grasses (20 %) and trees (13.3 %). The common plant species in monocropping farming systems were *Acacia mellifera, Argemone mexicana, Amaranthus hybridus, Bidens pilosa, Combretum molle, Commelina petersii, Conyza spp, Crabbea velutina, Cynodon dactylon, Hyparrhenia rufa, Pavonia gallaensis, Pennisentum purpureum, Solanum incanum, Tagetes minuta, Terminalia brownii*. Higher proportion of shrubs, herbs and grasses can be attributed to the nature of management of monocropping farming systems whereby after harvesting of annual crops, the farms remain uncovered by vegetation and therefore open space for germination of seeds from the soil seed bank and other wind dispersed seeds.

4.5.2 Farming systems and conservation of native riparian plants

Only 11 out of 53 species found in non degraded area existed in farmlands practicing monocropping. These species included *Acacia mellifera, Combretum molle, Commelina petersii, Conyza pryrrhopappa, Cynodon dactylon, Hyparrhenia rufa, Pavonia gallaensis, Pennisentum purpureum, Solunum incanum and Terminalia brownii.* A low similarity index of 24.4 % was observed between the non degraded riparian zone and the monocroping farming systems. This may be due to reduced plant diversity resulting from management of monocropping as farmers plant species of their preference. The low similarity between monocropping farming systems and natural riparian habitats show that monocropping farming system do not support conservation of the original plant species.

4.6 Anthropogenic Disturbances and Plant Diversity loss in Chemchem and Endabash river Catchments

In Chemchem, the percentage contribution of human disturbance is low as shown by extraction percent per ha of old cut trees of 2.8 % and new cut trees of 2.3 % (Table 9). The same situation was observed in Endabash river were by extraction percentage per ha of old cuts and new cuts were 7.1 % and 5.4 % respectively (Table 9). The species mainly cut in Chemchem river were *Acacia elatior, Acacia mellifera, Acacia nilotica, Afzelia quanzensis, Albizia gummifera, Cordia ovalis, Dombeya goetzenii, Exomolus monospora, Rhus natalensis, Terminalia brownii, Ziziphus* and *Ziziphus mucronata* while in Endabash river species most extracted includes *Acacia nilotica, Azanza garckeana, Combretum molle, Commiphora africana, Dalbergia melanoxylon, Lonchocarpus capassa, Rhus natalensis* and

Terminalia brownii. Similar studies in Chambongo forest reserves revealed a fairly high percentage of old cut of 18 % (MNRT, 2005). Moreover extraction percent of 2.5 % new cut was observed in Ihanga forest reserve (MNRT, 2005). It was observed that trees were cut mainly for charcoal production. Therefore decreased percent of new cut compared to old cut might be attributed to absence of preferred tree species

Table 10: Showing old and new cut trees in Chemchem and Endabash river Catchments

Catchments	Stocking (Total number of stems encountered)	% old cut	% new cut
Chemchem	467	2.8	2.3
Endabash	168	7.1	5.4

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The species composition and diversity in Chemchem and Endabash rivers is generally high. However, in the degraded riparian zones, there is alteration of species due to farming systems and other anthropogenic activities.

The degraded riparian zone of Chemchem river has high diversity of vascular plants. When consider only trees and shrubs with DBH ≥ 5cm high diversity has also been observed. However, the diversity index shows that vascular plants are more diverse as compared to only trees and shrubs of DBH ≥ 5cm. This is because the trees and shrubs with DBH ≥ 5cm might have been cleared due to opening of new farms. More over, the area is mainly dominated by shrubs, followed by trees, grasses and herbs depicting that it is agricultural managed land. An upland plant (*A. mellifera*) being most dominant species in this zone implies that the riparian zone is unhealthy or degraded riparian zone. In the non degraded riparian zone of Chemchem river, species diversity is high and species are more heterogeneous. The zone is dominated by trees, followed herbs and shrubs. The lower proportion of herbs and shrubs can be attributed to high canopy cover. The most dominant trees in this area include *Terminalia brownii, Ficus sur, Acacia tortilis*. The similarity (41.51 %) between species in the degraded and non degraded riparian zone of Chemchem river depict unsustainable conservation of the earlier existing riparian zone plants in degraded zone because the large number of species in original forest did not survive. The ongoing cultivation in the degraded riparian zones of

Chemchem river might have resulted in alteration of species composition because it involves conversion of riparian forests to farmlands. Although not highly spread, *Argemone mexicana* (exotic species) has spread in both degraded and non degraded riparian zones. Because these exotic species are aggressive and highly-tolerant species to survive in different environmental conditions, may out compete earlier existing species leading to a reduction in species diversity. Furthermore, there is shift in vegetation dominance between the two zones. Vegetation degradation due to agricultural activities and other human activities such as charcoal burning, timber tree harvesting and grazing in degraded riparian zone might be a result of the shift in dominance.

Diversity indices show that in degraded riparian zone of Endabash river, the species are heterogenous and diverse. However, the zone is unhealthy/degraded because it is dominated by woodland species such as *Combretum molle* and *Acacia mellifera*. With regard to all vascular plants, the area is highly dominated by grasses, herbs and shrubs which can be a result of converting riparian forest to farmlands as well as other anthropogenic disturbances. In non degraded riparian zone, the species are also heterogeneous and diverse. However, the zone is in degraded state as it is dominated by woodland species such as *Combretum molle* and *Commiphora africana*, *Tamarindus indica* and *Ziziphus abyssinica*. High canopy cover has resulted in lower number of herbs, grasses and shrubs in this zone. Domination of woodland plants in non degraded zone can be attributed to seasonal drying of river which has resulted to loss of original riparian forest. The similarity (45.8 %) between species in degraded and non degraded riparian zones of Endabash river depicts that the ongoing practices in degraded riparian zone do not support conservation of the original plant species.

It was observed that both farming systems do not support the presence of original plant species as it alters the structure and composition of the original plants species. Moreover, the farming practices have resulted in introduction of alien exotic species such as *Argemone mexicana* which is a weed in wheat. The species is now spread and found both in degraded and intact riparian zones.

The contribution of human disturbance is generally low in riparian zones of Chemchem and Endabash rivers. However extraction percentage per ha of new cuts in Endabash river (5.4 %) is relatively high. This calls for immediate ecological intervention measures.

5.2 Recommendations

In order to ensure sustainable management and utilization of riparian zones of these rivers, proper farming systems e.g. home gardens and alley cropping agroforestry farming systems should be introduced.

- Ecological restoration of riparian vegetation projects have to be developed and enacted specifically those focusing on natural regeneration of riparian plants.

- Immediate control measure of exotic species especially *Argemone mexicana* has to be developed and enacted.

- There is a need to educate the people on importance of conserving water sources for sustainable agriculture production and poverty reduction. Public awareness programs have to be improved.

- There is a need to formulate local rules and regulation that support the existing environmental and forest policies on conservation of water catchments. Local watershed and soil conservation planning have to be developed and enacted e.g. clearance of wood and shrubs should not be allowed within 25 m at both sides of any waterway

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APPENDICES

Appendix 1: Species present as per stratification in Chemchem river

S/N	Species name	Species Family	Species life form	Riparian site found		
				Degraded	Non degraded	Both degraded and non degraded
1	*Abutilon grandiforum*	Malvaceae	S			√
2	*Acacia brevispica*	Mimosoideae	S	√		
3	*Acacia elatior*	Mimosoideae	T			√
4	*Acacia mellifera*	Mimosoideae	S			√
5	*Acacia tortilis*	Mimosoideae	T			√
6	*Acanthospermum hispidum DC*	Compositae	H		√	
7	*Achyranthes aspera*	Amaranthaceae	H			√
8	*Afzelia quanzensis*	Caesalpiniodeae	T	√		
9	*Agremone mexicana*	Papaveraceae	H			√
10	*Albizia gummifera*	Mimosoideae	T			√
11	*Albuca abyssinica*	Liliaceae	H			√
12	*Aneilema pedunculosum*	Commelinaceae	H	√		
13	*Apodytes dimidiate Arm*	Icacinaceae	T		√	
14	*Asparagus africanus*	Liliaceae	H		√	
15	*Aspillia mossambicensis*	Compositae	S		√	
16	*Azanza garckeana*	Malvaceae	T	√		
17	*Barleria ramulosa*	Acanthaceae	H			√
18	*Caesalpinia pulcherima*	Caesalpinoideae	S		√	
19	*Ceiba pentandra*	Bombacaceae	T	√		
20	*Celtis africana* Burn	Ulmaceae	T			√
21	*Chorisia speciosa*	Bombacaceae	H			√
22	*Clausena anisata*	Rutaceae	S	√		
23	*Combretum molle*	Combretaceae	T	√		
24	*Commelina petersii*	Commelinaceae	H			√
25	*Cordia ovalis*	Boraginaceae	S			√
26	*Cordia sinensis*	Boraginaceae	S		√	
27	*Crabbea velutina*	Acanthaceae	H	√		
28	*Croton dichogamus*	Euphorbiaceae	S			√
29	*Cynodon dactylon* (L) Pers	Gramineae	Gr			√
30	*Delonix elata*	Caesalpinoideae	T			√
31	*Dombeya goetzenii*	Sterculiaceae	T			√
32	*Dombeya kirkii*	Sterculiaceae	S	√		
33	*Euclea divinorum*	Ebenaceae	T		√	
34	*Euphorbia tirucalli* L.	Euphorbiaceae	S		√	
35	*Ficus sur*	Moraceae	T			√
36	*Ficus sycomorus*	Moraceae	T		√	
37	*Grewia bicolor*	Moraceae	S	√		
38	*Grewia similis*	Tiliaceae	S			√

39	*Hibiscus fuscus*	Malvaceae	S	√		
40	*Hibiscus vitifolius*	Malvaceae	S		√	
41	*Hypoestes triflora*	Acanthaceae	H			√
42	*Indigofera nairobiensis*	Papilionoideae	H	√		
43	*Indigofera arrecta*	Papilionoideae	S			√
44	*Justicia odora*	Acanthaceae	H			√
45	*Kigelia Africana*	Bignoniaceae	T		√	
46	*Maerua triphylla*	Capparaceae	S			√
47	*Ocimum hadiense*	Capparaceae	S	√		
48	*Pavonia gallaensi*	Malvaceae	H			√
49	*Pericentum purpureum*	Gramineae	Gr			√
50	*Phylanthus muellerianus*	Euphorbiaceae	H			√
51	*Rhus natalensis*	Anacardiaceae	S	√		
52	*Ricinus communis*	Euphorbiaceae	S		√	
53	*Salvadora persica*	Salvadoraceae	S			√
54	*Solanum incanum*	Solanaceae	S			√
55	*Tabernaemontana stapfiana*	Apocynaceae	T	√		
56	*Tamarindus indica*	Caesalpinoideae	T		√	
57	*Terminalia brownii*	Combretaceae	T			√
58	*Tribulus terrestris*	Zygophyllaceae	H			√
59	*Trichilia emetica*	Meliaceae	T			√
60	*Vangueria acutiloba*	Rubiaceae	S	√		
61	*Ximenia Americana*	Oleaceae	S	√		
62	*Ziziphus mucronata*	Rhamnaceae	S			√

Appendix 2: Species present as per stratification in Endabash river

S/N	Species name	Species Family	Species life form	Riparian site found		
				Degraded	Non degraded	Both degraded and non degraded
1	*Acacia hokii*	Mimosoideae	T		√	
2	*Acacia mellifera*	Mimosoideae	S			√
3	*Acacia nalotica*	Mimosoideae	T		√	
4	*Acacia tortilis*	Mimosoideae	T		√	
5	*Acacia xanthophloea*	Mimosoideae	T			√
6	*Albizia grandibracteata*	Mimosoideae	T			√
7	*Albizia gummifera*	Mimosoideae	S	√		
8	*Azanza garckeana*	Malvaceae	T			√
9	*Lantana camara*	Verbanaceae	S			√
10	*Bridelia micrantha*	Euphobiaceae	T		√	
11	*Caesalpinia pulcherima*	Caesalpinoideae	S			√
12	*Capparis tomentosa*	Capparaceae	S		√	
13	*Carissa edulis*	Apocynaceae	S			√
14	*Cassia singueana*	Caesalpinoideae	S			√
15	*Combretum molle*	Combretaceae	T			√
16	*Commelina petersii*	Commelinaceae	H			√
17	*Commiphora africana*	Burseraceae	T			√
18	*Commiphora eminii*	Burseraceae	T			√
19	*Conyza pryrrhopappa*	Compositae	S			√
20	*Cordia ovalis*	Boraginaceae	S			√
21	*Crabbea velutina*	Acanthaceae	H			√
22	*Croton dichogamus*	Euphorbiaceae	S			√
23	*Croton megalocarpus*	Euphorbiaceae	T	√		

24	*Cynodon dactylon*	Gramineae	Gr			√
25	*Cyphostemma orondo*	Vitaceae	H			√
26	*Dalbergia melanoxylon*	Papilionoideae	T			√
27	*Dichrostachys cinerea*	Mimosoideae	T			√
28	*Digitaria scalarum*	Gramineae	Gr			√
29	*Dombeya goetzei*	Sterculiaceae	T	√		
30	*Dombeya rotundifolia*	Sterculiaceae	T		√	
31	*Euclea divinorum*	Ebenaceae	T	√		
32	*Ficus sycomorus*	Moraceae	T		√	
33	*Ficus sur*	Moraceae	T			√
34	*Gardenia ternifolia*	Rubiaceae	S			√
35	*Grewia bicolor*	Tiliaceae	S		√	
36	*Grewia similes*	Tiliaceae	S			√
37	*Hibiscus fuscus*	Malvaceae	S			√
38	*Hyparrhenia rufa*	Gramineae	Gr			√
39	*Hypoestes triflora*	Acanthaceae	H			√
40	*Indigifera arrecta*	Papilionoideae	H			√
41	*Justicia flava*	Acanthaceae	S			√
42	*Kalanchoe densiflora*	Crassulaceae	H			√
43	*Lonchocarpus capassa*	Papilionoideae	T			√
44	*Lippia javanica*	Verbenaeae	H			√
45	*Maerua triphylla*	Capparaceae	S			√
46	*Ocimum hadiense*	Labiatae	H			√
47	*Ozoroa insignis*	Anacardiaceae	T		√	
48	*Pavonia gallaensis*	Malvaceae	S			√
49	*Pennisentum purpureum*	Gramineae	Gr			√
50	*Phyllanthus muellerianus*	Euphorbiaceae	S			√

51	*Rauvolfia caffra*	Apocynaceae	T	√		
52	*Rhus natalensis*	Anacardiaceae	S			√
53	*Sclerocarya birrea*	Anacardiaceae	T			√
54	*Sida ovata*	Malvaceae	H			√
55	*Solanum incanum*	Solanaceae	S			√
56	*Syzygium guineense*	Myrtaceae	T	√		
57	*Tamarindus indica*	Caesalpinoideae	T			√
58	*Terminalia brownie*	Combretaceae	T			√
59	*Triumfetta ?*	Tiliaceae	S			√
60	*Vangueria madagascariensis*	Rubiaceae	T	√		
61	*Ximenia caffra*	Olaceae	S		√	
62	*Zizyphus abyssinica*	Rhamnaceae	S			√
63	*Zizyphus mucronata*	Rhamnaceae	S			√