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TOPIC: DETERMINING VEGETATION COMPOSITION AND SOIL CHARACTERISTICS IN OHANGWENA REGION.

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DECLARATION

I Ndunge Cecilia I. H, hereby declare that this study is my own work. I grant the University of Namibia the right to reproduce this thesis in whole or as part by electronic or any other means that the University of Namibia think is best fit for any institution or individuals requiring them for any research purposes. I Ndunge Cecilia I. H declare that this work is my very own and it has not been submitted for any honors degree in any institution. Other works done by other people or from various sources have been referenced.

…………………………………….Date………………………………..

DEDICATION

This thesis is dedicated to generous, hardworking and loving women; my 97th year old Grandmother Teodensia and my mum.Without you two I could not have reached this level where I am now. Thank you for all that you have done for me, if it was not for your encouragement and support I could not be where I am today. May God continue to bless you and give you more years.

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Finally, for everyone that assisted me in one way or another thank you very much and may God bless you.

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ABSTRACT

Currently there is limited well documented on the vegetation composition and soil characteristics in Ohangwena region and this study will contribute to the understanding of soil properties and species composition and its importance in the Ohangwena region. Different types of soils support different types of vegetation. Soils are very important components of the ecosystem because they enable the plants to stay firm and help the plant species with water and nutrients retention from the soil. A line transect was used to determine the species composition and soil sample were taken along the vegetation transect at 10m and 20m.Soil samples were analysed for grain size, pH, electrical conductivity and moisture content in selected villages in Ohangwena region. The results shows that Oshikunde and Ongalangombe have 60% woody species composition because they all plants species such as *Combretum collinum* ,*Terminalia sericia* and *Burkea africana* that do well in a soil pH range of 5.5 to 7.5 that is mostly found in the plains. Although a causal relationship between species composition and soil characteristics cannot be inferred with certainty, most plant species seems to be related to a positive relation with soil characteristics.

CHAPTER 1

1.1 Introduction and literature review.

In the northern part of Namibia problems such as land degradation occur due to population pressure, livestock pressure, seasonal rainfall and erosion hazards (Klintenberg & Seely, 2004).Namibia has an increasing population hence the pressure put on the natural resources resource also increase non-adaptive management in Namibia is seen as the major cause of land due to a reduction in vegetation cover and subsequent soil denudation after intensive grazing has taken place (Klintenberg & Seely, 2004).

Vegetation is a group of plants growing together at local scales arranged in the form of plant communities (Southern Domain, 2010). A community is a congregation of two or more populations of different species that are interacting with each other as well as the environment and occupying the same habitat (Krebs, 1994). It can also be the local plant life of an environment, usually organized into populations and communities. Vegetation is regarded as a self-organizing system that came about due to the responses to biotic and abiotic factors and it represents a great proportion of biodiversity of an area (Barbour, Burk and Pitts, 1987).

Namibia has a broad variety of vegetation due to different factors such as climate, rainfall and soil characteristics. This vegetation ranges from desert vegetation to woodland vegetation (Southern Domain, 2010).

Soils are the top layer that covers large areas of the earth crust comprising of mixed that consist of mineral particles (Brandy & Weil, 1996). Soils can also be mixtures of solids, air and water and are mostly transported by water and wind (Price, Jackson and Parker, 2010). Soil characteristics such as pH and electric conductivity can affect the distribution of vegetation.

<u>**Vegetation**</u>

Community ecology is the branch of ecology studies which deals with interactions that affect community structure such as species richness, species diversity, species abundance, composition, species dominance (Barbour *et al.,* 1987).They further stated that structure of communities can be described using growth forms characteristics such as tall or short, evergreen or deciduous, herbaceous or woody plants and shrubs or trees. Numerous techniques have been used to obtain vegetation data such as measuring quantities which includes density, cover (crown & shoot area or basal area), height, stem diameter and biomass (Southern, 2010).Vegetation types are defined using dominant species such as perennial or annual species. Data collected in vegetation studies can be used in mapping of vegetation and can identify rare and sensitive species which can be included in the conservation efforts. Ultimately the vegetation data it contributes to baseline biodiversity data (Barbour *et al.*, 1987).

Plants are major sources of consumption for animals that is why it is important to study vegetation to determine which type of vegetation is palatable or not (Strohbach, 2000b). Vegetation composition can be influenced by disturbances such as land use and also cutting down of trees in certain areas (Mannheimer and Curtis, 2009). Since little vegetation information is known in Namibia (which includes Ohangwena region), this can affect decision making in ecological problems such as grazing and land uses (Kangombe, 2012).

Widespread species have a tendency to occur in higher densities compared to species restricted in their geographic distribution. The vegetation in Namibia is influenced by factors such as rainfall and soil types and land use. Namibia on average has a low fertility of soil due to the low organic matter in the soils (Petersen, 2008). Different types of soil support different types of vegetation. Generally the north eastern Namibia consist of Arenosols due to soil being formed from blown wind sand and are more prone to wind and soil erosion. Soils in Namibia are classified to be structurally poor leading to plant species being found on wide ranges of soils (Mannheimer and Curtis, 2009). According to Petersen (2008), among the roles of vegetation is to protect the land by covering hence it prevents land from soil erosion and it can affect soil characteristics including soil chemistry and texture.

Vegetation is the main basis for nature conservation and it provides habitats for animals and other plants. It helps with the modification of the local climate .Vegetation mapping & dynamics is important since it can provide the carrying capacity and succession of a particular community. Vegetation helps with the understanding the relationships between the species distribution and the environment (Barbour *et al.*, 1987).

Soil availability plays a vital role in determining the pattern of vegetation but soil characteristics such as moisture content, soil pH, and Electrical conductivity plays also a role in vegetation pattern (Cleland, 2012) . Vegetation in a region can depend on the soil characteristics and water availability.

Growth form and structure (composition), relative abundance and dominance are some of the characteristics of a community that have been measured and studied (Whittaker, 1962). Species composition is a very important component of a vegetation community. It's the identity of all the different organisms that make up a community and it is also the different types of organisms that affect the ecosystem in different ways (Barbour *et al.*, 1987). Knowing the identity of the species in a community allows biotic & abiotic interactions to be determined and it makes an ecosystem unique.

The distribution of species is non-random in space and usually aggregated as a result of many environmental factors both biotic and abiotic (Roxburgh and Chesson, 1998). This can be due to factors such as competition, light, nutrient, soil moisture, space; predation and parasitism between ecologically equivalent species.

Woody plants such as *Combretum collinum* are used for fences and fuel in the northern part of Namibia. Woodlands in Ohangwena region support many animals and have high biodiversity hence its management and conservation is a critical tasks. Vegetation support people with benefits such as providing goods and services (Mannheimer and Curtis, 2009.

Soil

According to Petersen (2008), soil is the most important nonrenewable resource for humans. It has many purposes such as holding the plant roots, cleaning ground water, enables the plants to stay firm and retain water for plants. Soil plays a major role in determining the type of land use in a certain region (Price et al, 2010).

Degradation of soil and vegetation is increasing and this pose threats to biodiversity and local livelihoods (Burke and Strohbach, 2000). Loamy soils are rare leading to Namibian soils being structurally poor and this eventually leads to plant species being found on wide ranges of soil (Mannheimer and Curtis, 2009).According to Petersen (2008), different types of soils supports different types of vegetation and soil can also help to determine the ground water recharge. In order to study plant communities, vegetation data is needed to be able to obtain information that can help in decision making of plants and ecological problems (Kent 2003; Kangombe, 2012). Soil moisture content can affect root growth, nutrient uptake and plant survival and productivity.

Some soils can contain more salt than others and these soils usually occur in depressions and this can results in the land being unsuitable for cultivation (Zandler, 2011). Therefore, salinity plays a major role in determining the patterns of vegetation (Mayr, 2012). Few vegetation (forest inventory) studies were done in Namibia after independence and this led to few information of vegetation being known for northern central Namibia (Burke and Strohbach, 2000).According to Mendelssohn *et al* (2000), Namibia on average has low fertility soils and due to low content of organic matter in the soils. Despite that soil can supports subsistence farming in the northern Namibia.

Soil texture is the relative proportion of sand, silt, and clay in a soil; it is measured by carrying out the process called sedimentation among other methods (Bormann and Klaassen, 2008). For example sandy soil is mostly dominated by large soil particles therefore it has a relatively small total surface area and large pore spaces between soil particles and this can cause plants to absorb more water for their growth even though the soil does not hold water for a very long time compared to a clay soil which consists of tiny particles and has a large total surface area but have small pore spaces.

Electrical conductivity (EC) is a measurement of the dissolved material in an aqueous solution, which shows the ability of the material to conduct electrical current through it. EC is measured in Seimens per unit area (Brandy and Weil, 1996).

Soil pH is defined as the measure of acidity or alkalinity of the soil and it ranges from pH 0 to 14, with pH 7 as the neutral point (Brandy and Weil, 1996). With an increase in the amount of hydrogen ions in the soil the pH decreases hence the soil is more acidic resulting in poor plant growth (Petersen, 2008). Vegetation vary in their tolerance to soil acidity .Soil acidity often causes yellowing of leaves, resulting in the decrease in growth and yield of crops as the pH levels decreases. Additionally, vegetation that grows in adverse pH conditions may be more prone to disease such as fungal attacks. In general, the most favorable pH range for vegetation growth is 5.5 to 6.5.High vegetation diversity is usually associated with areas that have good soils (Cleland 2012). Together with other factors such as fire and climatic, soil characteristics are the main determinant of changes and vegetation structure in an ecosystem (Dantas and Batalha, 2011).

1. 2 Statement of the problem.

Ohangwena is among the most densely populated region in Namibia and there are challenges of high population growth leading to more pressure being put on the vegetation and soil. The vegetation and soil in this region is affected by human activities such mass clearing of land to create land for cultivation. Activities such as continuous grazing and cultivation practices that are not best suited for the area affect the soil and eventually degrade the lands quality and it tend to become less productive. Currently there is limited well documented information and knowledge on plant composition and associated soil characteristics in Namibia. Most studies on vegetation and soil in Namibia have been done in other regions but not that much has been done in Ohangwena region (Petersen, 2008).

1.3 Objectives

Vegetation

The main objectives were to determine:

1. The plant species composition in selected villages in Ohangwena region.

2. The Crown covers of plant species in selected villages in Ohangwena region.

Soils

The main objectives were to determine:

1. The soil color in selected villages in Ohangwena region.

2. The Grain size distribution (soil texture), pH, electrical conductivity in selected villages in Ohangwena region.

1.4 Relevance and Significance of the study

Results from this study can inform conservation and management measures. It can provide data that can be used in rangeland management to ensure sustainable animal production. It can also identify priorities for future research. This study can help to identify land use influence on various aspects of the ecological community investigated. This study will contribute to the understanding of soil properties and its importance in region.

The study allows for indicator species to be identified and these can be used to provide clues about the environment conditions in the area .Some vegetation aspect of species such as life histories and successional status can be used as indicators of degradation, calcrete and groundwater level. As an example, species such as bitterbrush, *Pechuel-Loescha luebnitziae* is commonly known as an indicator of land degradation in northern Namibia and is consequently associated with degraded lands or soils (Kangombe, 2010).

Species composition in this study can be used as an attribute in rangeland inventory and monitoring and it is regarded as an important indicator of ecological and management processes at a site. It can reveal proportion of annual to perennial grass cover in an area thus providing information on the proportion of palatable vs. unpalatable species

1.5. Limitations of the study

The main limitation of the data collection was that the time allocated was little to get all the soil samples and sample more villages. Limitations occurred due to the rainfall that was too high during some sampling periods. Some villages were not sampled due to the headmen that did not allow us to sample.

Chapter 2

MATERIALS AND METHODS

Villages were selected on the basis of underground water potential of areas called hydrotopes (table 1).

These areas have been pre-selected as focal research areas by the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) programme (task 007) which funded this study.

The SASSCAL programme is focused on problem-oriented research in the area of adaptation to climate and change and sustainable land management and provide evidence-based advice for all decision-makers and stakeholders to improve the livelihoods of people in the region and to contribute to the creation of an African knowledge based society (http://www.sasscal.org/).

Table 1: Some of the selected villages location in Ohangwena region with the respective hydrotopes.

Hydrotope	Villages
River	Omulonga, Epumbalondjaba, Onambaladi
Depression	Okamanya (Okamanya), Ohameva, Ongalangobe, Oshana-shiwa, Oluwaya.
Pan	Omboloka, Omundaungilo, Oshikunde.
Dune	Omboloka, Oshuuli.
Sandfield	Still to be chosen.

2.1 Study area

2.1.1 Location

Ohangwena region is situated in the north eastern of Namibia; it extends east to west along the Angolan border. It’s one of the most populated regions in Namibia .Its population density is 21.0 persons per square kilometers, which is the highest among the 13 regions of Namibia (Ministry of Environment & Tourism, 2011). Its geographical coordinates are 17° 34' 0'' South, 17° 13' 0'' East).

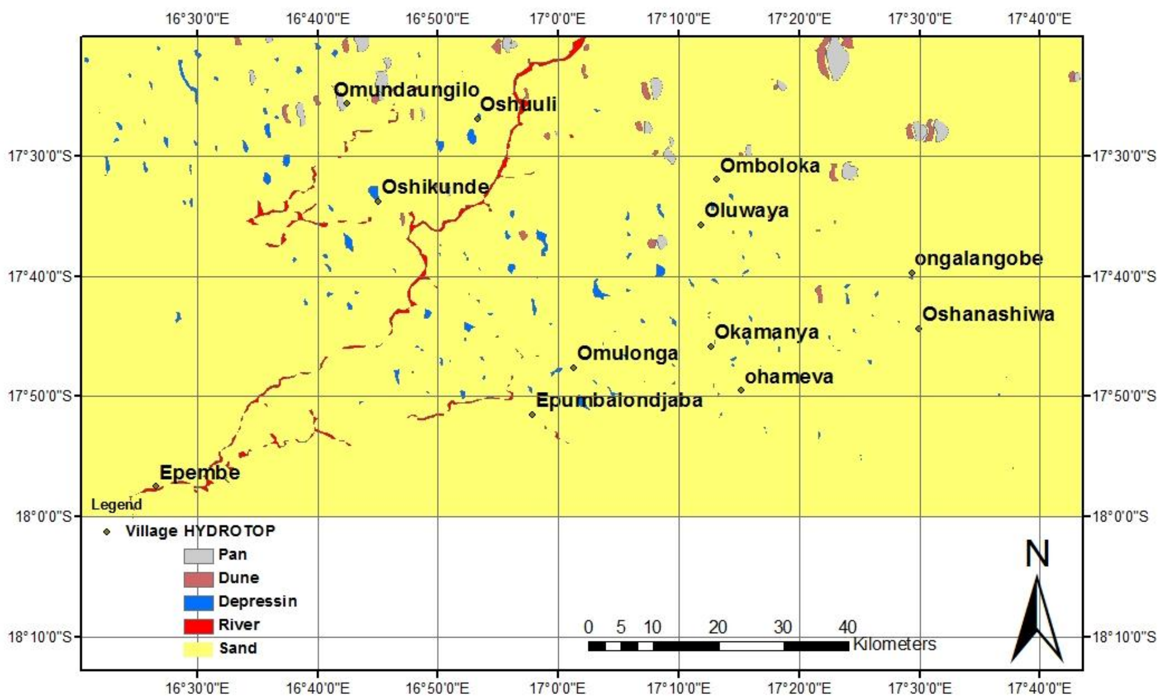

Figure 1: Some of the selected villages location in Ohangwena region with the respective Hydrotope.

2.1.2 Climate and rainfall

According to Cheikhyoussef and Embashu (2013), the annual temperature range of Ohangwena is between 23-34°C and the annual rainfall varies between 480 mm and 600 m. Annual rainfall ranges from 480 mm in the west to 600 mm in the east. The rainfall normally starts from the end of October and ends early in April. Average winter temperatures are just below 20C and summer temperatures around 28°C (Mendelsohn, Jaruis, Roberts & Robertson, 2002). Average maximum temperatures reach around 35°C in summer and recorded average lows are around 8°C in winter (Ministry of Environment & Tourism, 2011).

2.1.3 Land use and vegetation

Majority of people living in Ohangwena, Oshana and Oshikoto regions depend on small-scale rain fed subsistence farming, either with livestock or crops or both, for their daily livelihoods (Mendelsohn., *et al*,2002). Land use in the study area is generally influenced by soil and vegetation patterns due to activities such as human settlement. Most lands have been transformed from forest to arable lands and grazing areas for the livestock (Ministry of Environment & Tourism, 2011). Most households in this region use wood as fuel, building materials and fencing Agricultural activities are dominated by livestock farming with goats, cattle and donkeys and crop farming such as mahangu, sorghum and maize.

In the west, the ephemeral wetlands of the Oshanas support an open landscape with *Hyphaene digitata* (palm tree) and *Scelerocarya birrea* (marula trees) while the eastern parts comprise woodlands. Rainfall in the Ohangwena Region supports dry land cropping, especially of pearl millet (mahangu) in western parts of the region, and grazing of livestock extending into the eastern woodlands. Use of non-timber forest products such wild fruits, medical plants and livelihoods as supplements farming (Ministry of Environment & Tourism, 2011). This vegetation type is typical of the “forest savanna” and woodland that is mostly dominated by tress such as *Burkea africana*, *Terminalia sericea*, *Baikiaea plurijuga*, various *Combretum* and *Grewia* species (Giess, 1971 as cited in Strohbach, 2000).

Sampling procedures

Sampling was done in March 2014 in the selected villages in Ohangwena region

2.2.1 Vegetation

The line intercept method was used to determine vegetation composition (types of species present) and aerial cover (%).At each site, a 50 m transect was outlined on the ground & the distance covered for each woody plant intercepting the line was recorded, while taking note of that plant's scientific identification.

To estimate herbaceous vegetation cover, four 1mx1m plots were demarcated on the transect (at 10m interval), the aerial/crown cover was then visually estimated while taking note of the top two dominant species. The herbaceous vegetation cover was then averaged for each transect. The method estimates vegetation cover of woody species (trees and shrubs) from distance. Herbaceous vegetation (grasses and herbs) cover was visually estimated, expressed as a fraction of the plot.

Plant species which could not be identified in the field were collected labeled and given provisional names according to their physical appearance for later identifications. Plant species were identified with the help of field guides of Namibian plants.

2.2.2 Soil

The soil sampling was also done along the vegetation transect in Ongalangobe, Onambaladi, Omboloka and Oshikunde on the surface for all the sites and 20cm where possible using a hand auger. At 0m and 20m along the vegetation transect if the soil texture and color differed more samples were taken to capture variation The sampling on the surface was done by pushing cylinders into the soil and closing the top surfaces and the cylinders were removed from the soil and cover under surfaces. All samples were collected in Plastic bags and labeled.

Fresh (wet) soil color was determined by using a Munsell soil color chart (Figure 2).

Figure 2: Soil color Munsell chart was used to determine soil color

2.3 Analytical laboratory methods

2.3.1 Soil

The soil samples were analyzed at the University of Namibia, geology department laboratory. Firstly, the moisture content of the samples was determined by weighing the mass of the soils before and after drying them in the oven at 105^{o}C for 24 hours down (figure 3). The moisture content was then determined as wet mass (g) dry mass (g).

Figure 3: Soil sample on weighing balance (a) and soil samples in the oven (b).

After drying the samples were analyzed for grain size distribution using dry sieving and sedimentation (see figure 5). For non-cohesive soils, sieving was used to separate soils into different fractions according to their grain size. Five sieves were used, >2 mm, >1 mm, >500 µm, >250 µm, >63 µm and <63µm (figure 4) .The sieves were fitted on a pan (sample tray) with mesh size decreasing from top to bottom. The sample was passed through the 2 mm sieve into the tray without pushing it through the opening and the sieve was covered. The electrical stirrers were then switched on for 3 minutes at an amplitude of 0.45 mm/g. The mass of soil retained on each sieve was determined including the mass that retained in the pan.

Figure 4: The sieving plates (a) and the materials (b) used during sedimentation.

Sedimentation

This process allowed soil particles to settle from suspension. The size of the soil particles and their density determines their speed to settle down. A 500 ml cylinder was filled with tap water and the temperature of the water was measured. The temperature recorded determines how long it took for the clay sample to be taken. A 20 g soil sample was added to the cylinder and well shook until the samples mixed completely. Then the first sample 25 ml which determined the amount of clay and silt is taken after 56 seconds with only 10 cm of the pipette going in the solution. Then the only clay content sample was at taken after 7 h 34 min 04 s. The samples were then heated in the oven at 205 °C (Figure 5) until all water had evaporated and were weighed.

Figure 5: The soil samples in the oven after sedimentation was done.

The soil pH and electrical conductivity.

Twenty (20) grams of soil was weighed on the scale balance and put in 250ml bottles. 50ml of de-ionized water was added to the bottle with 20g of soil. The bottles were shaken thoroughly to mix the soil and the de-ionized water well. The solutions were allowed to stand for 2 hours and the pH was then measured using a pH meter. The Electrical Conductivity was also measured in this solution of the pH using the Electrical Conductivity meter.

2.2 Data analysis

Woody vegetation

The Hierarchical Cluster analysis (HCA) was used to determine the villages with similar species composition (see appendix for the list of species surveyed in different villages). This technique classifies vegetation clusters based on species composition. For this dataset, analysis was based on the woody component of the data.

HCA is a multivariate test that groups observations by similarity and dissimilarity (Gouch, 1986). Using the Bray Curtis similarity analysis in primer 5 a dendrogram was created to show similarities and dissimilarities in the vegetation composition data in the selected villages. The data were log transformed due to no zeros being present and to normalize the data.

For herbaceous vegetation, the data collected from the four 1×1m plots on the transect was averaged to get the overall cover for the layer of vegetation per transect surveyed.

Soil

Grain size have not been analyzed yet, this means that the results and discussion won't incorporate it

Chapter 3

RESULTS

Vegetation

Woody Species composition

The dendrogram (cluster diagram) reveals four main clusters as indicated, with about 20% similarity in species composition. This further suggests 80% of heterogeneity in the data.Onambaladhi2 (outlier) is evidently composed of a more unique combination of plant species (figure 6).

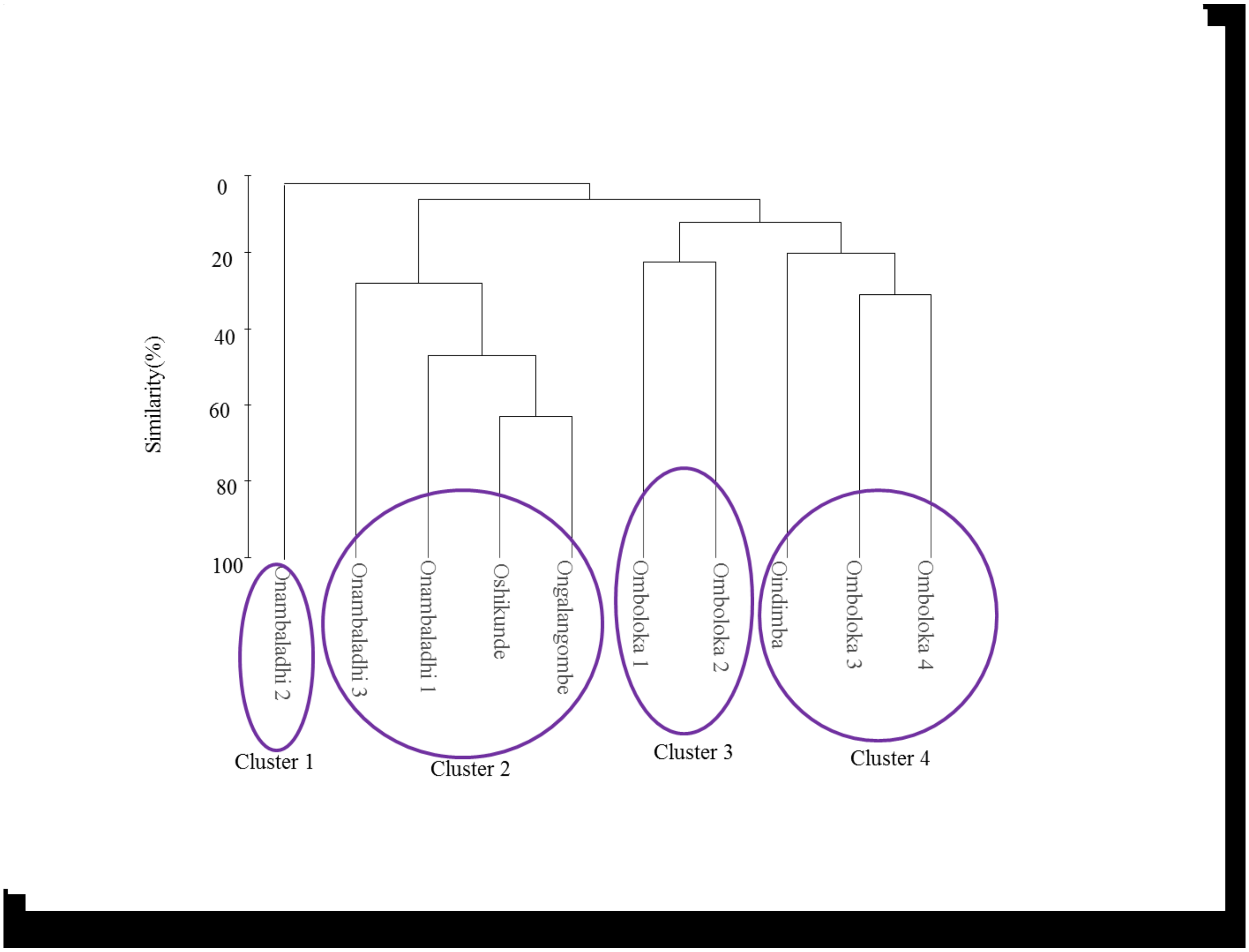

Fig 6: Hierarchical Cluster Analysis (HCA) dendrogram illustrating the classification of vegetation into 4 main clusters based on species presence/absence data in the selected villages in Ohangwena region.

Table 2: The two dominant woody species in the each of the clusters.

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Acacia herbaclada *Boscia albitrunca*	*Terminalia sericea* *Combretum collinum*	*Baikiaea plurijuga* *Euclea divinorum*	*Euclea divinorum* *Ziziphus mucronata*

Herbaceous cover

Omboloka 2 had the highest herbaceous crown cover and Ongalangobe had the lowest herbaceous crown cover (figure 7)

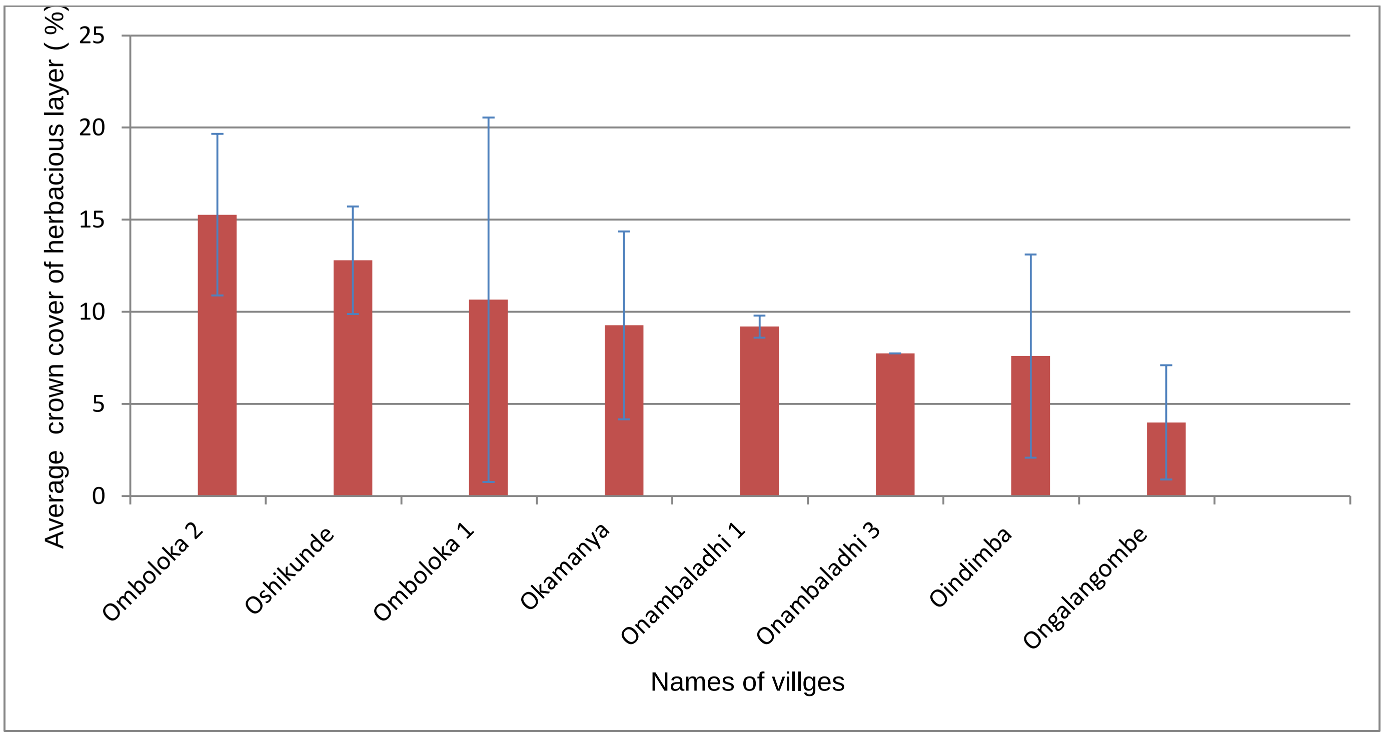

Figure 7: The Herbaceous plant crown cover (%) of selected villages in Ohangwena region.

The woody vegetation cover was the highest at Omboloka2 and the lowest at Oshikunde (figure 8)

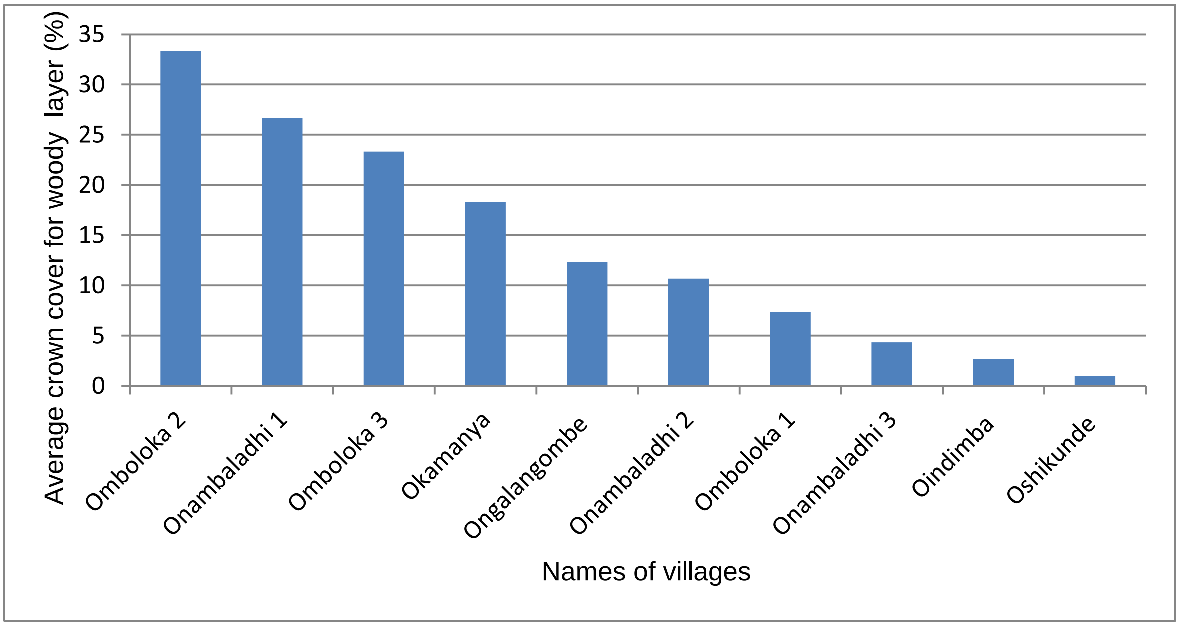

Figure 8: The woody plant crown cover (%) of selected villages in Ohangwena region.

Soils

Table 3: The top soil color of selected villages in Ohangwena region.

Village name	Soil color	Interpretation in general
Onambaladi	10YR 3/3	Dark and more fertile
Omboloka 1	5YR 4/6	Red and less fertile
Omboloka 2	5YR 3/4	Dark and fertile
Omboloka 3	5YR 3/2	Dark and fertile

Onambaladi 1 is slightly acidic (5.2) and Ongalangobe has soil that is neutral (7.0). Onambaladi 2 had the lowest pH value while Omboloka 3 had the highest pH value (figure 9).

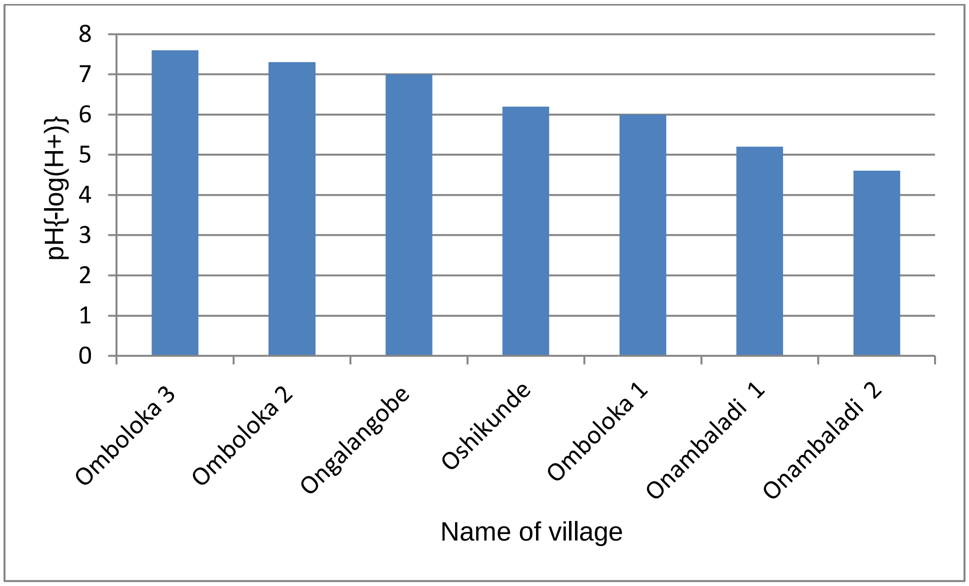

Figure 9: The pH {-log (H+)} of the selected villages in Ohangwena region.

Onambaladi 1 had the highest electrical conductivity of 1.03ms/cm whereas Oshikunde had the lowest electric conductivity of 0.0bms/cm (figure 10).

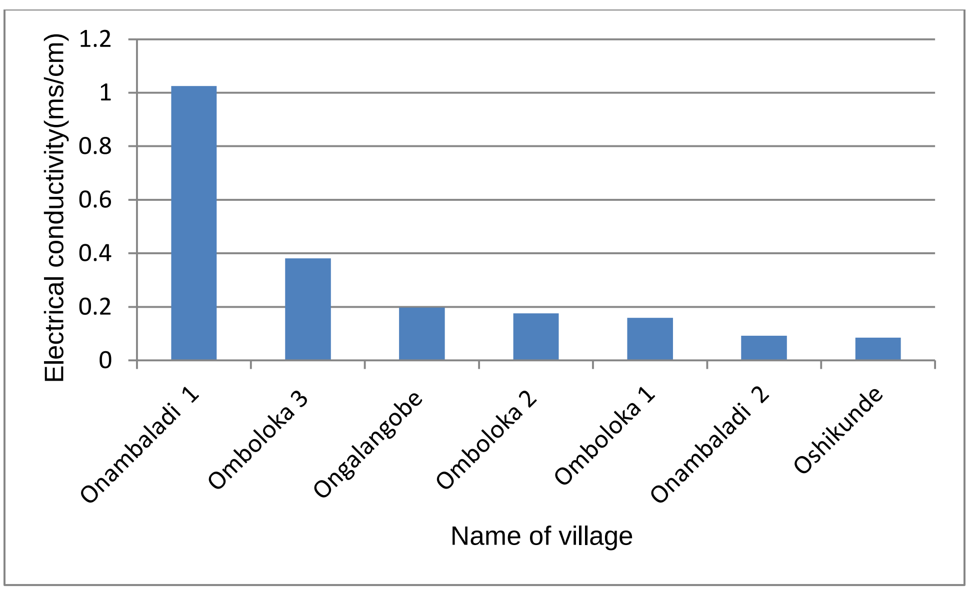

Figure 10: The electrical conductivity of the selected villages in Ohangwena region.

Ongalangobe had the highest moisture content and Oshikunde had the lowest moisture content (figure 11)

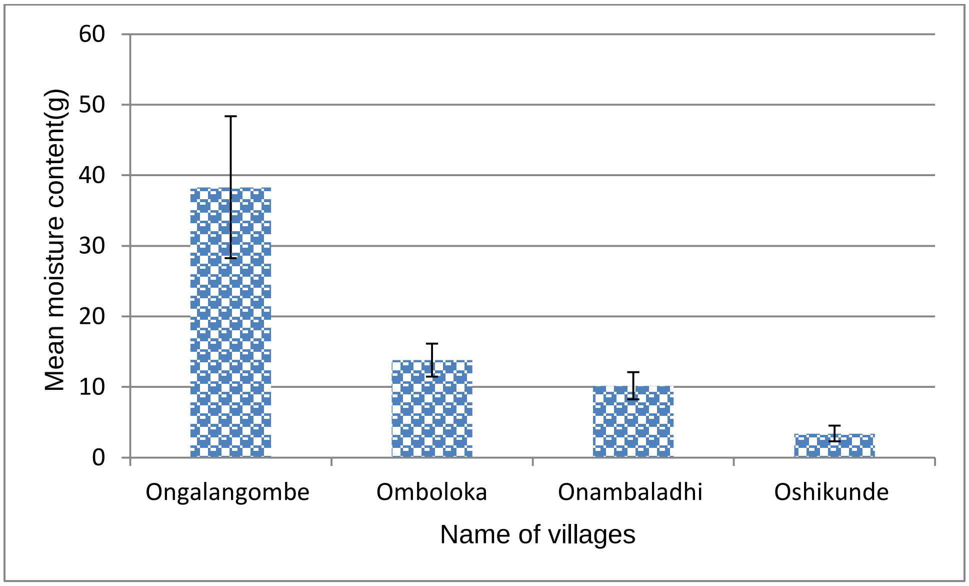

Figure 11: The moisture content (g) in the selected villages of Ohangwena region.

CHAPTER 4

Discussion

Vegetation

The 20% similarity reflects the degree to which the villages have plant species composition in common and 80% suggests that woody plant composition in the clusters is different. According to figure 6, Oshikunde and Ongalangobe have 60% similar woody vegetation with reference to woody plant species composition because these two villages may reflect similarities in the physical (abiotic) components of the environment, to which vegetation responds as it develops into populations and communities (Barbour *et al.*, 1987).

Although the herbaceous vegetation was relatively high at some villages for example Omboloka 2 and Oshikunde ;most of the species encountered such as Aristida species ,*Megaloprotachne albescens*, *Tribulis zeyhri* ,*Sedera cordifolia* and *Chamaecrista absus* includes annual herbs and grasses such as (Appendix). This may suggests that disturbances possibly livestock production are persistent in the villages. Furthermore, this indicates poor grazing condition with very limited perennial grass cover and composition in the villages.

Another reason why Oshikunde and Ongalangobe have 60% similarities is because they have a pH of 6.2 and 7 respectively. Generally, many plants such as *Combretum collinum* ,*Terminalia sericia* and *Burkea africana* do well in a soil pH range of 5.5 to 7.5but some plants require low soil pH because it leads to an increase in nutrient plant availability (Curtis and Mannheimer,2005).

With a plant species composition similarity of about 30% between Omboloka 3 and 4 as indicated by species such as Ximmenia *americana, Combretum heroensis, Ziziphus mucronata, Euclea divinorum*; the two villages were correctly classified under the same hydrotope (pan; Ehenene).It can be inferred that these species require and tolerate more or less the same soil properties and environmental conditions for their growth and development (Strohbach, 2000b).

Onambaladi 2 consisted mostly of species such as *Acacia hebaclada* and *Boscia albitrunca.* These plant species require large amounts of water to survive hence they are found in the hydrotope (river) (Curtis, & Mannheimer, 2005). These species are mostly restricted to these areas due to their dispersal mechanisms which require water (Rankin, Semple, Murphy and Koen, 2007).

According to figure 7, Omboloka 2 had the highest herbaceous crown cover. This can be due to Omboloka 2 consisting of grass species such as some Eragrotis species which tend to grow on alkaline soils which are mostly disturbed and they have an overall low grazing value hence most animals tend to avoid it allowing it to be abundant in this village and some when wilted they can cause acid poisoning of stock hence selective grazing take place (Mannheimer and Curtis, 2009).

Some tree species found in Omboloka 2 such as the Zambezi Teak;*Baikiaea plurijuga* are threatened by over exploitation due to activities such as fencing and clearing of lands for homesteads and this tree is classified as near threatened according to the latest IUCN criteria(Loots,2005 as cited by Curtis, & Mannheimer, 2005).

Oshikunde it had a lower woody cover because tree species leaves such as *Croton gratissimus* are browsed by cattle and goats and it mostly found on rocky alkaline outcrops (Zandler, 2011). Oshikunde had the lowest woody cover and yet the lowest Electric conductivity because soils that have relatively low EC have a regular deep drainage of soils which does not allow accumulation of soluble salt hence plant lack some nutritious which affect their growth rates. Another reason can be due to heavy grazing. Oshikunde had a pH of 6.16 and low moisture content which means plant species found in this village will tend to have low ions exchange capabilities leading to slow growth (Petersen, 2008).

Most villages consisted of annuals (see appendix), this can because the plant species are generalists leading them to grow in any soil type and tolerate a wide range of environmental conditions for their survival. This can also be a clear indication that overgrazing is severe because the proportion of annual to perennial grasses is high (Mayr, 2012).

Soil

Oshikunde and Ongalangobe have a pH of 6.2 and 7 respectively. Generally, many plants such as *Combretum collinum* ,*Terminalia sericia* and *Burkea africana* do well in a soil pH range of 5.5 to 7.5but some plants require low soil pH because it leads to an increase in nutrient plant availability (Curtis and Mannheimer,2005).

According to figure 9, Omboloka 3 had the highest pH value (7.6) and the highest electric conductivity (EC) and it also have a less percentage similarity with the other villages. This can be because typically soils that have a deep drainage have a low EC which does not allow accumulation of soluble salts. Hence the vegetation is different from the other villages and this also allow less percentage cover due to permanent heavy grazing that leads to a decrease in the herbaceous layer and makes the village more prone to soil erosion due to additional heavy trampling that increase soil disturbance (Brandy and Weil,1996). In the long run, the herbaceous layer is reduced and eventually affects the soil seed banks which are very important for natural regeneration. Low values of pH also indicate leaching of nutrients from the soil. According to figure 7, Oshikunde had the lowest herbaceous percentage this can because there was heavy grazing but now it’s only few perennial grass that are indicating heavy grazing (Kangombe,2010).This can be because some species are could not be able to grow on low fertility soils which is determine by pH and the Electric conductivity (Petersen, 2008).

According to figure 11, Ongalangobe had the highest moisture content this can be due to rainfall that had occurred that day leading to the soil to retain more water leading to a high water holding capacity which influenced the amount of moisture in the soil (Zandler, 2011).

Onambaladi 2 was the only village in the cluster grouped alone this can be because it has a soil color of 10YR 3/3 , pH of 4.5 and high moisture content This soil color indicates that there is high nutrient content leading to the color being dark and more fertile which supports species like *Acacia herbaclada* and *Boscia albitrunca.* Therefore plants require different amounts of soil nutrients, water and light hence their ability to use these is dependent on the temperature, humidity, and pH and oxygen availability in the soil (Petersen, 2008).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Conclusion

Although soil characteristics were not directly related to the species composition in some villages ,similarity in soil properties example pH between Oshikunde (6.1) and Ongalangobe (7.0) could account for their 60% similarity in woody plant composition.

Although a causal relationship between species composition and soil characteristics cannot be inferred with certainty, most plant species seems to be related to a positive relation with soil characteristics.

Recommendations

This study was limited by low availability of data , permission not granted by headmen and time constraints

For further studies I recommend to that enough time be allocated for data collection meaning field work should be one of the main priority because enough time was not available to collect enough data.

And I would also recommend for permission to sample in the villages to be granted prior field work.

Chapter 6

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Appendix

<u>Appendix</u>

Appendix 1: The standard data sheet used to collect raw data for vegetation in the selected villages in Ohangwena region.

CANOPY COVER DATA (50m)
TRANSECT NUMBER (SAME AS SITE NUMBER):
DATE: …………………………………………………
USE LABEL AND COLLECT IF YOU DON'T KNOW THE SPECIESECIES
INCLUDE TREES AND SHRUB COVER
Every 20m sample (cover) herbaceous vegetation (1m x 1m) adjacent to transect = 5 samples. Number samples with transect no and sample no e.g. 1/1, 1/2, 1/3, OBSERVERS:

SPECIESECIES/SOIL/ROCK	GROWTH FORM	START (CM)	STOP (CM)	SPECIESECIES/SOIL/ROCK	START	STOP

Appendix 2: Distance covered by each woody species on the transect in the selected villages in Ohangwena region.

Site	Species name	Distance covered(cm)	%cover
Omboloka 1	Soil	12.7	25.4
	Commiphora angolensies	18	36
	Baikiaea pluijuga	13.7	27.4
	Rhus tenuinervis	1	2
	Combretum engleri	1.4	2.8
	Greuia flavescens	0.8	1.6
	Combretum collinum	1	2
	Combretum zeyheri	1.4	2.8
Omboloka 2	*Baikiaea plurijuga*	7.4	14.8
	Soil	19.7	39.4
	Bechemia discolor	12	24
	Croton gratissimus	5.1	10.2
	Euclea divinorum	5.8	11.6
Omboloka 3	rock and soil	7.5	15
	Acacia herbaclada	2.7	5.4
	Ximmenia americana	4.3	8.6
	Combretum heroensis	2.9	5.8
	Euclea divinorum	24.4	48.8
	Ziziphus mucronata	8.2	16.4
Omboloka	soil and rock	35.2	14.8

(Okamanya)			
	Ziziphus mucronata	0.9	1.8
	Euclea divinorum	3.5	7
	Attached (Combretum hereroencis,Maytenus senegalensis ,Diospeciesyros lycioides)	9.5	19
	Rhus tenuinervis	0.9	1.8
Onambaladhi 1	*Acacia erioloba*	1.1	2.2
	Acacia herbaclada	1.5	3
	Combretum collinum	3.5	7
	Soil	30.5	61
	Terminalia sericea(omugolo)	8.4	16.8
	Ziziphus mucronata	5	10
Onambaladhi 2	Soil	28.2	56.4
	Acacia herbaclada	12.1	24.2
	Boscia albitrunca	9.7	19.4
Onambaladhi 3	*Acacia attaxaacantha*	22.3	44.6
	Acacia erioloba	8.3	16.6
	Combretum collinum	2.5	5
	Terminalia sericea	1.2	2.4
	Soil	12.2	24.4
	Dichrostachys cinerea	3.5	7
Oshikunde	Soil	29.5	59

	Salacia luebbertii (okandongondongo)	0.8	2.6
	Terminalia sericea	11.2	22.4
	Burkea Afrikaner	2.5	5
	Combretum colinum	5.5	11
Ongalangombe	*Combretum colinum*	26.1	52.2
	Terminalia sericia	2.3	4.6
	Burkea afrikana (omtundungu)	1.7	3.4
	Soil	19.9	39.8
Oindimba	*Combretum hereroense(*Schinz)	16.4	32.8
	Soil	18.4	36.8
	Gymnosporia senegalensis	2.1	4.2
	Peltophorum africanum	7.7	15.4
	Mundulea sericea	0.4	0.8
	Euclea divinorum	5	10

Appendix 3: The species composition and percentage cover of herbaceous species recorded along the line transect in the selected in Ohangwena region (with their growth forms A representing Annuals and P representing perennials)

Omboloka 1				
	10M	20M	30m	40m
	Oxygonum alatum (A)	*Vigna unguiculata (A)*	*Oxygonum alatum (A)*	*Oxygonum alatum(A)*
	Phyllanthus pentandrus (A)	*Oxygonum alatum (A)*	*Hemizygia bracteosa (A)*	*Bulbostylis hispidula(A)*

	Hibiscus mastersians (A)	*unidentifiable grass (A)*	*Phyllanthus pentandrus A*	*Phyllanthus pentandrus A*
	Chamecrista abus (A)	*Phyllanthus pentandrus (A)*	*Perotis patens (A)*	*Perotis patens(A)*
	Kylinga white (A	*Hibiscus mastersians A*	*Indigofera filipes (A)*	*Indigofera filipes(A)*
	Cyperus species		*Bulbostylis hispidula (A)*	*Ipomoea hackeliana (A)*
Percentage cover (%)	*2*	*3*	*7*	*12*
Dominant species	*Oxygonum alatum A*	*Vigna unguiculata (A)*	*Oxygonum alatum A*	*Oxygonum alatum (A)*
	Phyllanthus pentandrus (A)	*Oxygonum alatum (A)*	*Perotis patens A*	*Indigofera filipes (A)*
Omboloka 2				
	Senna ossidentalis (P)	*Eragrotis species (A)*	*Sedera cordifolia (A)*	*Chamaecrista absus (A)*
	Chamaecrista absus (A)	*Tribulis zeyhri(devils thorn) (A)*	*Chamaecrista absus(A)*	*Spermacoce sinencies(A)*
	Spermacoce sinencies (A)		*Tribulis zeyhri (devils thorn)(A)*	*Cleome hirta (A)*
	Tribulis zeyhri (A)		*Eragrotis A*	*Eragrotis lehmaniana (A)*
	Eragrotis species (A)		*Jacmontia* species (A)	*Sedera cordifolia (A)*
	Sedera cordifolia (A)			
Percentage cover	10	20	40	40
Dominant species	*Eragrotis species (A)*	*Tribulis zeyhri (A)*	*Sedera cordifolia (A)*	*Chamaecrista absus (A)*
	Chamaecrista absus A	*Eragrotis* species (A)	*Chamaecrista absus (A)*	*Cleome hirta (A)*
Omboloka 3	*Tribulis zeyhri(devils thorn)*	*Tribulis zeyhri (A)*	*Enneapogon desvauxii (A)*	Eragrotis species (A)

	(A)			
	Altenanthera pungen (A)	*Eragrotis pergerana (A)*	*Eragrotis pergerana (A)*	*Tribulis zeyhri (A)*
	Eragritis pergerana A		*Chamaseque inaquilatera (A)*	*Geigeria ornativa (A)*
	Setaria vertililata A G		Eragrotis species *(A)*	*Chamaecrista absus (A)*
	Stramonium inoxis (A)			
	Acanthospermum hispidum (A)			
	Docttlotenium aegyptum(A)			
Percentage cover	30	40	25	5
Dominant species	*Tribulis zeyhri(A)*	*Tribulis zeyhri (A)*	*Enneapogon desvauxii (A)*	Eragrotis species *(A)*
	Altenanthera pungen (A)	*Eragrotis pergerana(A)*	*Eragrotis pergerana(A)*	*Tribulis zeyhri (A)*
Omboloka 4	*Eragrotis lehmaniana(A)*	*Erneapogon desvauxii(A)*	*Hermania modesta(A)*	*Erneapogon desvauxii(A)*
	Eragrotis pergerana (A)	*Eragrotis pergerana A*	*Erneapogon desvauxii (A)*	*Eragrotis pergerana (A)*
	Cynodon dactylon (P)	*Eragrotis lehmaniana (P)*	*Bidens schimperi(A)*	*Chamaseque inaquilatera (A)*
	Chamaseque inaquilatera (A)	*Chamaseque inaquilatera (A)*	*Eragrotis pergerana (A)*	*Chamaecrista absus (A)*
	Chamaecrista absus (A)	*Aristida species (A)*	*Urochloa brachyra (A)*	*Polygala species (A)*
	Heliotropium species (A)	*Chamaecrista absus (A)*	*Indigofera filipes (A)*	*Lotononsis species (A)*
	Chamaseque inaquilatera	*Tribulis zeyhri(A)*	*Eragrotis lehmaniana (P)*	*Eragrotis species (A)*

		Sida ovata (A)	*Eragrotis species (A)*	*Vigna unguiculata (A)*
		Hermania modesta(A)	*Polygada species (A)*	*Urochloa brachyra (A)*
			Sida ovata (A)	
Percentage cover	35	20	20	15
Dominant species	*Eragrotis pergerana (A)*	*Chamaseque inaquilatera(A)*	*Hermania modesta(A)*	*Erneapogon desvauxii(A)*
	Chamaseque inaquilatera(A)	*Hermania modesta(A)*	*Erneapogon desvauxii(A)*	*Chamaseque inaquilatera(A)*
Onambaladhi 1	*Sedera cordifolia (A)*	*Sedera cordifolia (A)*	*Eragrotis lehmaniana (P)*	*Eragrotis lehmaniana (P)*
	Eragrotis lehmaniana (P)	*Eragrotis lehmaniana (P)*	*Zornia*	*Sedera cordifolia (A)*
	Cynodon dactylon (P0	Zornia species *(A)*		*Perotis vaginata (A)*
	Spermacoce sinesis A	*Orthatera jusminiflora (P)*		*Bulbostylis hispidula (A)*
	Tephrosia lupinifolia(A)	*Spermacoce sinesis (A)*		*Dactylotenium aegyptum (A)*
	Bulbostylis hispidula(A)	*Indigofera filipes(A)*		
	Zornia			
Percentage cover	10	10	30	40
Dominant species	*Sedera cordifolia(A)*	*Sedera cordifolia(A)*	*Sedera cordifolia(A)*	*Sedera cordifolia(A)*
	Cynodon dactylon(P)	*Orthatera jusminiflora(A)*	*Eragrotis lehmaniana(A)*	*Perotis vaginata (A)*
Onambaladhi 2	*Cynodon dactylon P*	*Cynodon dactylon(P)*	*Cynodon dactylon(P)*	*Cynodon dactylon (P)*

	Eragrotis trichophora (P)	*Eragrotis trichophora(A)*	*Eragrotis trichophora(A)*	*Chamaseque inaquilatera (A)*
	Tribulis zehyzeri A	*Chamaseque inaquilatera A*	*Chamaseque inaquilatera*	*Justicia exigua (A)*
	Justicia exigua A	*Bulbostylis hispidula (A)*	*Bulbostylis hispidula (A)*	*Eragrotis trichophora (P)*
	Dactylotenium aegyptum (A)	*Gisekia africana(A)*	*Indigofera species (A)*	*Bulbostylis hispidula (A)*
		Zornia species (A)		*Gomphrena celosiodes (A)*
				Helichrysum candolleain (A)
Percentage cover	30	15	7	*10*
Dominnt species	*Cynodon dactylon (P)*	*Cynodon dactylon (P)*	*Cynodon dactylon (P)*	*Cynodon dactylon (P)*
	Eragrotis trichophora (P)	*Bulbostylis hispidula (A)*	*Eragrotis trichophora (P)*	*Eragrotis trichophora (P)*
Onambaladhi 3	*Comelina species (A)*	*Perotis species (A)*	*Perotis vaginata(A)*	*Sedera cordifolia(A)*
	Perotis species (A)	*Hibiscus mastecianus (A)*	Ipomoea lanterenkie	*Indigofera flavicons(A)*
	Zornia species (A)	*Panicum maximum (A)G*	*Gisekia afrikaaner(A)*	
	Phylantus pentandrus A	*Comelina species (A)*		
		Ocimum americanum (A)		
		Vigna unguiculata (A)		
Percentage cover	15	10	1	2
Dominant species	*Comelia species (A)*	*Hibiscus mastecianus (A)*	*Perotis vaginata (A)*	*Sedera cordifolia (A)*
	Perotis species (A)	*Panicum maximum (A)*	Ipomoea lanterenkie *(A)*	*Indigofera flavicons (A)*

Oshikunde	*Aristida species (A)*	*Aristida species (A)*	*Aristida species (A)*	*Bulbostylis hispidula (A)*
	Megaloprotachne albescens (A)	*Megaloprotachne albescens (A)*	*Megaloprotachne albescens (A)*	*Aristida species (A)*
	Bulbostylis hispidula (A)	*Bulbostylis hispidula (A)*		*Megaloprotachne albescens (A)*
	Perotis species (A)			
Percentage cover	2	1	1	1
Dominant species	Aristida species (A)	Aristida species(A)	Aristida species (A)	Aristida species (A)
	Megaloprotachne albescens (A)	Megaloprotachne albescens (A)	Megaloprotachne albescens (A)	Megaloprotachne albescens(A)
Ongalangombe	*Eragrotis species (A)*	*Chamaseque inaquilatera (A)*	*Dactylotenium aegpytium (A)*	*Eragrotis species (A)*
	Eragrotis pergerana (A)	*Eragrotis species (A)*	*Urochloa brachyra (A)*	*Hermania modesta (A)*
	Hermania modesta (A)	*Dactylotenium aegpytium (A)*	*Hermania modesta (A)*	*Bidens schimperi (A)*
		Eragrotis pergerana (A)	*Cynodon dactylon (P)*	*Setaria vert (A) G*
			Eragrotis species (A)	*Eragrotis lehmaniana (P)*
				Geigeria ornativa (A)
Percentage cover	5	12	*10*	*15*
Dominant species	*Eragrotis pergerana (A)*	*Chamaseque inaquilatera*	*Eragrotis species (A)*	*Setaria vert (A)*

		(A)		
	Hermania modesta (A)	*Eragrotis species (A)*	*Hermania modesta (A)*	*Eragrotis lehmaniana (P)*
Oindimba	*Urochloa brachyra (A) G*	*Urochloa brachyra (A)*	*Urochloa brachyra (A)*	*Bulbostylis hispidula (A)*
	Spermacoce sinesis (A)	*Bulbostylis hispidula (A)*	*Chamaseque inaquilatera (A)*	*Urochloa brachyra (A)*
	Asparagus nelsii (A)	*Eragrotis species (A)*		
Percentage cover	2	2	1	5

Appendix 4: The soil moisture content of the selected villages in Ohangwena region.

Onambaladhi			
Sample no	Weight before(g)	Weight after(g)	Moisture content(g)
ona 11 g s (s)	457.6	440.5	17.1
ona o1 bd	171.3	167.7	3.6
ona 07 bd	163.9	159.2	4.7
ona 12 g s(40)	370.9	357.7	13.2
ona 09 gs (40)	558.8	536.8	22
ona 01 gs(s)	534.2	515	19.2
ona 06 g s (40)	401.7	390	11.7
ona 04 bd	171.3	168.3	3
ona 05 bd	445.9	433.9	12
ona 10bd	169.5	163.5	6
ona 08 g s(s)	187.5	182.7	4.8
ona 11 bd	128.6	124	4.6
Omboloka			

Sample no	Weight before(g)	Weight after (g)	Moisture content (g)
om01 bd	178.1	171.9	6.2
om 08 gs (40)	324.1	314.5	9.6
om02 gss	401	387.7	13.3
om 13 bd	177.9	157.4	20.5
om03gs (40)	427.3	410.6	16.7
om09bd	180.6	175.1	5.5
om07 gs (s)	458.8	443.9	14.9
om16 gs (s)	461.5	412	49.5
om11 gs (40)	356.1	341.6	14.5
om05 gs(s)	341.6	329.6	12
om10 gs (s)	208.8	203	5.8
om04 bd	149.6	145.3	4.3
om15 bd	145.9	132.2	13.7
om19gs(s)	120.1	106.5	13.6
om18 g s(s)	139.8	124.6	15.2
om06 gs(40)	219.5	210.9	8.6
om14 gs(s)	111.2	98.2	13
om17 bd	102.8	91.2	11.6
Ongalangombe			
Sample no	Weight before(g)	Weight after(g)	Moisture content (g)
ong 01 bd	186.5	164.1	22.4
ong 02 gss	544.9	477.2	67.7
ong 04 bd	191.1	160.7	30.4
ong 06gss	199.6	166.9	32.7
Oshikunde			

Sample no	Weight before(g)	Weight after(g)	Moisture content (g)
osh 01 bd	156.3	155.1	1.2
osh02 bd	161.6	156.9	4.7
osh 03 gss	176.8	172.5	4.3

Appendix 5: The pH and electrical conductivity in the selected villages in Ohangwena region.

	PH			
sample id	DIONISED WATER	TEMPERATURE(°c)	ELECTRICAL CONDUCTIVITY (ms/cm)	TEMPERATURE(°c)
ona 11 g s (s)	4.75	18.9	107.5	18.7
ona 01 g s s	5.18	18.5	1025	18.6
ona 09 g s 40	4.56	18.6	103.1	18.4
ona 12 g s (40)	4.94	18.3	64.6	18.7
om05 g s s	6.03	19.1	173.5	18.9
om 06 g s (40)	4.85	18.7	163.4	18.6
om 10 g s s	7.07	18.9	74.3	19
om 03 g s (40)	7.22	18.9	103.3	18.4
om 14 g s s	7.63	19.8	381	19.3
om 07 g s s	7.07	18.8	220	18.7
om o8 g s (40)	7.45	18.8	140.6	18.6
om 02 g s s	6.08	18.9	198.1	18.6
om 11 g s (40)	7.23	19.4	65.6	19.3
osh 02 g s s	6.736666667	Not obtained	168.8666667	Not obtained
osh 03 g s s	6.16	20.4	84.4	20.2