INVESTIGATING THE EFFECTS OF SMALLHOLDER COWPEAS FARMERS' MANAGEMENT PRACTICES ON SOIL FERTILITY: A CASE STUDY OF THE KAVANGO REGION, NAMIBIA

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DECLARATIONS

I, Johannes K. Katjana, hereby declare that this study is my research. It has not been submitted for a degree in any other institution of higher education. I grant the Namibia University of Science and Technology the right to reproduce this dissertation in whole or in part, in any manner or format, which the University may consider to be fit.

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Johannes K Katjana Date

DEDICATION

This Thesis is dedicated to my dear late father Celestinus K. Katjana and my family.

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ABSTRACT

The declining trend of soil fertility of smallholder farms due to continuous land cultivation is a factor that limits crop production and threatens food security. Improving soil fertility is a major concern for the farmers, researchers and the government. Most smallholder farmers have scarce resources to invest in chemical fertilizers, composts, etc. to improve soil fertility. The planting of legume has been promoted by the researcher in that it can improve soil fertility by the nitrogen fixation process and this can be some form of affordable technology for the farmers. However, how long legume fixation becomes significant is still not clear. The objective of this study was to determine the effects of smallholder cowpea farmers' management practices on soil fertility. The cross-sectional data were collected through questionnaires from 90 households in the Kavango East and West regions of Namibia which were used for the present analysis. Descriptive statistics and frequencies were used to outline the responses. The principal component analysis was used to reduce the dimension of data to avoid multicollinearity. PCA was performed using the eigenvalue and vector of 10 principal components. The eigenvalue of the first 10 principal components (PC1-PC10) was greater than 0.9 and their cumulative variance proportion was 72.07 percent. Multinomial logit was also used to determine factors that affect farmers' soil management practices. The result from multinomial logit model showed that farming experience, planting date, climatology services transportation/extension services and access to farm tools and gender significantly influence planting millet only or intercrop millet with cowpea at 5 percent level of probability. The Wilcoxon rank test was used to ascertain the effects of cowpea on soil fertility for a season. The results showed that there was no significant influence of planting cowpea between the 2017 and 2019 growing season (p-value=0.103). The only significant difference occurred between the farmers' regions (p-value =0.009). The farmers in the Kavango East region had an average higher score. The difference in soil fertility in the two regions may be due to the different soils in the regions. It is recommended that improving the policy on access to climatology service, transportation/extension service, and farm tools can help the farmers to make a better decision on farming practices that can improve their soil fertility. There is also a need to find an innovative way to meet food security and improve soil fertility for the smallholder farmers. This should be based on the direct benefit to the farmers and soil improvement.

Table of Contents

LIST OF TABLES

LIST OG FIGURES

LIST OF ACRONYMS

CA	Conservation Agriculture
CI	Confident Interval
CT	Conservation Tillage
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GDP	Gross Domestic Product
MAWF	Ministry of Agriculture Water and Forestry
MDGs	Millennium Development Goals
MT	Minimum Tillage
NAB	Namibia Agronomic Board
NZH	Namibia Zero Hunger
NDP	National Development Plan
NGO	Non-Governmental Organisation
NSA	Namibian Statistics Agencies
NUST	Namibia University of Science and Technology
PH	Potential of Hydrogen
SSA	Sub-Sahara Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

1. INTRODUCTION

1.1 Introduction

The eradication of extreme poverty and environmental sustainability are important United Nation's Millennium Development Goals (Goals 1 and 7). Achieving these goals has dominated the development agenda in most developing countries for the past decade and reports show that some targets have been marginally achieved in some continents. For instance, hunger reduction is on track, poverty has been reduced from 28% in 1999 to 11% in 2013 (United Nation Millennium Development Goals (UN MDG), 2017) and living conditions have been enhanced (Lomazzi, Borisch & Laaser, 2014). Nevertheless, some goals are not yet met, particularly in the poorest regions due to the unstable micro and macroeconomic conditions. In many other countries, poverty reduction is low especially in Sub-Sahara Africa (SSA) where the poverty rate is still high. For instance, there is a report that shows that more than 27% of Namibians live below the poverty line (Namibia Zero Hunger (NZH), 2017). To improve from this frontier requires increased agricultural productivity, which is the main source of income for most rural communities. However, the provision of an environmentally sustainable and agriculturally productive services remains a challenge due to poor agricultural management practices (Lomazzi et al., 2014). Analysts have shown that poor soil management results in soil fertility loss and environmental degradation which culminates into low agricultural productivity (Álvaro-Fuentes, López, Cantero-Martínez & Arrúe, 2008; Farley, 1996; Sanchez & Buresh, 1997). Low crop productivity is a major problem in Namibia especially in the Kavango regions (Food and Agriculture Organization(FAO), 2009; Namibia Statistics Agency(NSA), 2015). According to the Namibia Statistics Agency (2015), these regions are highly vulnerable to food shortages. In these regions, communal farmers seldom use chemical fertilizers due to challenges with affordability. They do not use animal manure due to unavailability because of the long distance from the animal kraal to the crop field (Food and Agriculture Organization (FAO), 2009; Luther-mosebach, 2017; Mwoombola, 2017).

The use of legume plants such as cowpeas (Vigna unguiculata) could address this challenge of low soil fertility because it can fix nitrogen and organic matter in the soil, but this is not widely practised in these regions. In a symbiotic relationship with bacteria Rhizobium, cowpea can fix atmospheric nitrogen into nitrate up to 240kg/ha in a year which is adequate for what the plants need for growth and this leaves about 60 to 70kg/ha of nitrates in the soil after plant nutrient uptake (Dakora, Aboyinga, Mahama & Apaseku., 1987; Singh, Baoule, Ahmed, Dikko, Aliyu, Sokoto, Alhassan, Musa & Haliru, 2011). Besides the biological nitrogen fixation (BNF) benefit, the presence of cowpea in the soil increases organic matter and carbon fixation during crop rotation. As the organic matter increases, the soil fertility and physical characteristics also improve. It also facilitates the increase in soil water retention capacity, water infiltration and soil aeration.

Cowpea is one of the annual ancient crops to mankind which originated from Africa. Currently, cowpea is grown worldwide but Africa dominates in its production with 68%, followed by Brazil with 17%, the rest of the world 10%, the United States with 3% and Asia 2% (FAO, 2004). Cowpea is grown as a main legume crop in Africa (Nigeria, Egypt), South America (Brazil, Colombia), Asia (China, Pakistan, and Japan) and Europe (Spain, Italy). According to Xiong, Shi, Mou, Qin, Motes, Lu and Wu, (2016), roughly 5.8 million tonnes of dry cowpea is produced per annum with at least 11 hectares planted at the world scale with mean productivity of 527kg ha-1. The prospective of cowpea production worldwide is 6000kg ha-1, but this target is not met due to low productivity in some regions and lack of technical know-how. In addition, low productivity factors such as late planting time, inadequate spacing and planting population which can decrease production. Cowpea is a desirable and multifunctional crop that provides food to livestock and people and serves as a valuable profit-generating commodity for farmers (Food and Agriculture Organization (FAO), 2004; Xiong et al., 2016). It is truly a crop that has high protein which can be used to supplement the staple diet (Mhango, 2011; Ncube, Twomlow, Van Wijk, Dimes & Giller, 2007).

Many factors influence the farmer's choice for growing cowpeas, and these include social, economic and biophysical factors. A study by Snapp and Silim (2002) shows that farmers in Southern Africa are interested in growing legume plants including cowpeas but they are influenced by local conditions, the maturity period of the legume plant, availability of the market, ability to grow in low soil fertility, yield and grain quality. Farmers prefer cowpea varieties that give high yields, which are drought resistant, have a good taste and short cooking time (Freeman, Merwe, Van Der, Subrahmanyam, Chiyembekeza & Kaguongo, 2002). According to Ajayi, Akinnifesi, Sileshi and Chakeredza (2007), the adoption of the use of legume plant for fertility starts with the introduction of the farming techniques and its potential benefits to the farmers. When the technology is being promoted the farmers would like to see the result by testing it for a certain period. When the results from the experiment are satisfactory, only then can the farmers adopt the practice. In promoting new farming technology, there are mixed perceptions thus creating different responses from the farmers. The second group of farmers are pseudo-adopters who are involved in the testing of the technology because of the available benefits from the project that promote the technology such as seeds and training (Kiptot, Hebinck, Franzel, & Richards, 2007). Another group are the dis-adopters which discontinue after a short while. Farmers are sceptics and as such they are not in a hurry to take a decision venturing in new farming investments or the use of new technology unless they are totally persuaded.

Literature shows that there are many factors that are responsible for the decline of soil fertility which amongst others are soil erosion, monoculture, tillage system, etc. (Álvaro-Fuentes et al., 2008; Machado et al., 2006). The African soil including Namibia, is in a serious problem of degradation and if adequate care is not taken, food production will be seriously impaired (Farley, 1996). The situation is not different in the Kavango regions of Namibia given the nature of soil use and management. In the 2015 to 2016 growing seasons, about 10,134 farmers benefited from the government ploughing-assisting programme (Ministry of Agriculture Water and Forestry(MAWF), 2016). However, there is a concern that the practice pulverised the soil structure and created hardpans. Besides, the farmers' traditional monoculture practice might have depleted the soil nutrients. However, no known report has shown the extent of the soil nutrient loss and the role that farmers played in avoiding it in these regions. Therefore, there has been a need for a comprehensive understanding of farmers' management practices, their perceptions and the socio-economic factors that influence their ability to conserve the soil.

1.2 Statement of the problem

For the past 15 years, the government of the Republic of Namibia has promoted the de-stumping of trees in the fields to allow land preparation with tractors (MAWF, 2016). During the 2014 to 2015 cropping season, it was reported that 10 134 farmers practised heavy tillage with tractor ploughs, tilling 17 553 hectares (MAWF, 2016). Ploughing in the wrong time and direction has contributed to the erosion of the topsoil which is fertile, a reduction of organic matter and soil life as they are detached from the original place and deposited elsewhere (Álvaro-Fuentes et al., 2008). Smallholder farmers prefer to grow cereal crops in the same piece of land since cereal crops are the main staple food and yet this has been leading to the depletion of nutrients and vitamins in the soil than the rate at which there are replaced. This poor farming practice has contributed to the deterioration of soil fertility and microbial imbalance. For the past 30 years, about 200 million hectares of cultivated land in 37 African countries lost 660kg of N ha-1, 75kg P ha-1 and 450kg K ha-1, on average (Sanchez et al., 1997). According to the report, there is a gross imbalance in the nutrient uptake through plant growth, crop residue removal, erosion, surface runoff and nutrient inputs that are added to the soil in terms of manure, compost, biological nitrogen fixation bacteria and fertilizers. The causes of declined soil fertility are multiple and complex. Some smallholder farmers practice unsustainable farming methods such as monoculture and heavy tillage (ploughing) that depletes its nutrients, resulting in excess loss of soil fertility (Álvaro-Fuentes et al., 2008; Farley, 1996; Sanchez et al., 1997). The consequence of declined soil fertility is reduced crop productivity and food the security of rural livelihoods and environmental degradation (Sanchez et al., 1997). A report from the Food and Agriculture Organisation (14 July 2009) showed that a decline in soil fertility has contributed to low yields ranging from 0.5 to 0.55 t/ha of maize while millet and sorghum vary between 0 to 0.45 t/ha, thus resulting in increased food insecurity in many countries (FAO, 2009).

There are limited scientific researches that have been undertaken to investigate farmers' practices and soil management measures in the region and the assertion of poor soil fertility has been generalised. Although soil infertility certainly exists, there is no sufficient data and understanding for the smallholder farmers to manage soil fertility. Soil management practices by smallholder farmers have been overlooked and other factors that influence soil resource management in the regions.

1.3 Justification of the study

The use of legume plants such as cowpea (*Vigna unguiculata*), Bambara groundnut (*Vigna subterranea*), hyacinth bean (Lablab purpureus), peanut (*Arachis hypogaea*) and common bean (*Phaseolus vulgaris*) are simple ways of improving soil fertility through biological nitrogen fixation and could address the problem of low productivity (Mhango, 2011; Ncube et al., 2007; Saka, Agbeleye, Ayoola, Lawal, Adetumbi, Oloyede-Kamiyo, 2018). With the increasing concern about the effects of climate change, it is important to investigate high yielding varieties that can adapt to adverse climate conditions. This study was motivated by the possibility of using cowpea species for this purpose. On the other hand, there is a need to understand the socioeconomic factors that can influence farmers' management capabilities for efficient productivity and soil fertility management as these are useful for policy decision making.

1.4 Objectives of the study

The general objective of the study was to investigate the effects of smallholder cowpea farmers' management practices on soil fertility. To achieve the general objective of the study, the specific objectives were:

- To investigate the socio-economic factors that instigate poor soil management practices, and
- To evaluate the effect of nitrogen fixation ability of cowpea on soil fertility.

1.5 Research hypotheses

The objectives were attained by testing the following hypotheses:

Ha: Socio-economics characteristics of farmers contribute to soil nutrient depletion.

Ha: Planting cowpeas in a season can improve the level of soil fertility.

1.6. Methodology

The research was carried out in the villages in the Kavango regions in Namibia. The region is classified as a semi-arid area with an average rainfall pattern of 550mm. A total population of 108 smallholder farmers participated in the conservation agriculture projected and 92 farmers were sampled for participating in this study. Two farmers provided incomplete data and this resulted in the two farmers being excluded from the survey and this brought the sample size to 90 for observation.

The research collected data on household characteristics and field experiment. Household data were collected by administering the questionnaire to the smallholder farmers. Household data were imported from Microsoft Excel (MS Excel) to Stata v.13 where it was analysed using a multinomial logit model and a principal component. The multinomial logit model was used to identify the socio-economic characteristics of smallholder farmers that influence soil management practices. The principal component was used to reduce the variables in the data to few variables that explained much such as the variable that has an eigenvalue of 1.

The field experiment involved the planting of cowpea to assess its ability to fix nitrogen with the native rhizobia in the soil. There were two categories of farming practices that were observed, one was to rotate millet with cowpea and the other group was to intercrop millet with cowpea. The soil sample was collected in the 2017 and 2019 growing season at the depth of 15cm using a soil auger. Soil data were analysed by Wilcoxon rank test to compare the mean difference of soil fertility between regions, soil type, growing season and farmers group.

1.7 Presentation of the thesis

This thesis consists of six chapters.

Chapter 1 is the background of the study, research problem, objectives, justification of the study, methodology and the presentation of the thesis. Chapter 2 outlines the literature review relevant to this study on the soil resource management, population growth, land uses, cropping system and multinomial regression model. Chapter 3 presents the overview of the cowpea production in Namibia, its challenges, market and contribution to food security. Chapter 4 shows the study site in detail, the methods and materials used to gather data that were useful for empirical analysis. Chapter 5 gives the empirical results and discussions from the study. Chapter 6 presents the conclusions from the empirical results and recommendations. The last section encompasses the list of references cited in the study and the appendices.

2. LITERATURE REVIEW

2.1 Introduction

This chapter presents a literature review on smallholder farmers' soil resource management and outlines the land acquiring process: how the land is used for different agricultural activities. The chapter also presents the econometrics modelling approach used.

2.2 Smallholder farmers

The smallholder farmers are considered as farmers with a small volume of production, mainly practiced on the family farm with little resources. The parameters used to characterise small-scale farm holding capacity in this study are the farm size operated, the value of production output sold from the farm, the unit of livestock kept, and days worked off-farm, level of input invested, and level of farm income.

2.3 Soil resource management

According to Farley (1996), improved agricultural production requires good knowledge of agricultural practices (GAP). Accordingly, it has been assumed that soil and land degradation can be improved with technical assistance such as improved extension service, conservation practices, use of fertilizer and labour input. Although good management practices have been promoted to conserve soil resources, the adoption of soil resource conservation and land improvement technologies in many developing countries have been limited (Farley, 1996). A study conducted to examine the effects of the tillage system on soil organic carbon shows that soil fertility and crop yield can be improved by altering farm management practices to enhance soil fertility (Álvaro-Fuentes et al., 2008). The contribution of soil organic nutrients to the yield was observed to be 1 Mg ha-1 of soil organic matter, which increased grain yield by 16Kg ha-1. The study concluded that the loss of soil fertility is correlated with low yields. Management practices such as deep ploughing accelerate the decomposition and loss of soil organic carbon (Álvaro-Fuentes et al., 2008).

Kavango regions are predominantly sandy (MAWF), 2016) and most of the trees are cleared away leaving the soil bare and exposed to erosion. Lack of soil cover or poor practices expose the soil to high temperatures during summer, which destroys the essential microorganisms that are necessary for maintaining soil fertility and making them unavailable for the plant (FAO, 2009). Despise the promotion of conservation agriculture in the Kavango regions, farmers still practice traditional farming methods because they are concerned about the risk of improperly adopting the new tillage system such as increased weeds, rodent attack, failure of crops, etc. (FAO, 2009; MAWF, 2016).

A study by Misika and Mwenya (1999), reported that the smallholder farmers in the Kavango region have observed an acceleration of soil fertility loss because of the use of animal-drawn ploughs and tractor ploughs. Based on observations, the crop fields where the hand hoe was used to cultivate take a longer time to show the sign of infertility compared to where the plough or disc was used. It has thus been argued that heavy tillage is associated with increased weeds infestation which are found to grow predominantly in poor soils (Misika & Mwenya, 1999). Farm management is the major concern for farmers and the government as well because the soil resources are depleted with less replacement taking place. The productivity of the crop fields also depends on the management and in some areas the farmers' land preparation is delayed by late rain or the unavailability of labour. The smallholder farmers have mixed knowledge of the conservation tillage system and not all the farmers know that the conservation tillage activities they were practising before conserve the soil water for crops and are connected to soil erosion prevention. However, the study carried out by Misika and Mwenya (1999), could not fully address the possible solutions to the problem of soil fertility.

In Ghana, a field experiment of cowpeas reported a positive contribution of cowpeas to soil fertility by fixing up to more than 200kg of nitrogen per hectare (Dakora et al., 1987). While a study in South Western Zimbabwe reported that the cowpeas contribution varied from 4 to 29kg of nitrogen per hectare in south-west Zimbabwe (Ncube et al., 2007). This difference indicates that nitrogen fixation differs depending on the environmental area and the population of the rhizobia. The rhizobia bacteria which are responsible for fixing nitrogen can perform poorly in a different environment to their original habitat. The effectiveness of the rhizobia depends on the host plant variety, rainfall, soil temperature and the PH (Ncube et al., 2007). The ability of the rhizobia in the cowpeas to fix nitrogen in the region cannot be assumed to be similar to the rate discovered in Ghana, Zimbabwe and other countries given the harsh conditions, different cowpea varieties and the heterogamous soil.

2.4 Population growth

The population growth and soil resource uses are synonymous. There are different views on the effects of the population on the environment and soil fertility. One view is that the increase in population growth degrades the soil resources, while another view suggests that population growth creates opportunities for innovation to conserve and improve the soil resources (Farley, 1996). The argument that states that population growth is linked to the degradation of soil resources is more supported and it sounds logical. The population growth in Sub-Saharan Africa has been linked to soil degradation due to intensive land use that leads to soil erosion and fertility loss (Farley, 1996; Sanchez et al., 1997).

The population of Namibia is increasingly putting pressure on the food demand in the household. A recent survey conducted by the Namibia Statistics Agency (2015), showed that the agricultural household population in the communal sector is 907,715. Out of this 907,715 smallholder farmers' population, 46% were male and 54% were female. The population of the female was found to be higher than the male, and this contributes to more numbers of females participating in agriculture than males. The agricultural households in the Kavango regions were 126,527, whereby 59,404 were from Kavango East and 67,123 were from Kavango west. The population of males and females showed that there are more females in both regions. There are 46% male agricultural households and 54% of female agricultural households in the Kavango East, while in Kavango West there are 46.5% male and 53.5% female agricultural householdss. This low percentage of male in both regions is also expected to contribute to low productivity as females presumably unable to cultivate large areas.

2.5 General land use and farming system

The communal land is acquired by various means in Namibia, whereby 44% of the communal land is acquired through clearing the land or debushing, 28% of the land is inherited and 18% is acquired through the local authority (NSA, 2015). The total crop field is estimated at 463,248 ha, with males having 52% of the land and females having 48%. In the Kavango regions, the land is mainly used for crop production, for livestock grazing and some area is for forestry. A report by the Namibia Statistics Agency (2015), showed that out of 59,404 agricultural households in the Kavango East region, 21.1% of the households are in crop production only, 1.6% are in livestock farming only and 0.5% of the households are involved in the combination of crop, livestock and forestry production. In the Kavango west, 7.8% of the agricultural household is in crop production only, 1.3% are in livestock production only, and crop, livestock and forestry sum up 9.5% of the agricultural households. There are two classifications of crop production in the Kavango regions: rain-fed and irrigated crop production for the farmers who are close to the river and have irrigation equipment. Rain-fed agriculture is carried out during the rainy season. Land preparation starts by removing the shrubs and other obstacles in land preparation. During ploughing, oxen or tractors are used to till the ground for easy sowing and to destroy the weeds then followed by planting, weeding, and harvesting. Threshing is mainly carried out manually and in a few cases is there the use machineries (MAWF, 2015a; 2016).

2.6 Cropping system

Crop production affects soil fertility as the crop uptakes the nutrients. Farmers adopt a cropping system based on factors such as labour availability (the more labourers the easier the work can be), rainfall duration, market demand, and household food demand (Mhango, 2011). Monoculture is commonly practised by the farmers while a few practise crop rotation and intercropping. Crop rotation helps to prevent the carryover of crop diseases and pests to the following season (Mhango, 2011; Ncube et al., 2007). Also, when a legume plant is used in crop rotation, legume fixes nitrogen through biological fixation. Some farmers do intercropping with millet, maize, pumpkin, cowpeas, groundnuts and other crops. Intercropping helps to use the land, labour and other resources needed for plant growth more efficiently (Mhango, 2011; Saka et al., 2018). Moreover, smallholder farmers have been considered as poor soil resource managers thus contributing to land deterioration.

3. REVIEW OF COWPEA PRODUCTION

3.1 Introduction

This chapter provides an overview of the cowpeas industry in Namibia which includes the production, marketing and contributions to food security and the challenges that the industry is facing.

3.2 Background of the crop production sector in Namibia

Before Namibia's independence, the South African administration did not pay attention to crop production and their vision was mainly on meat production. The government's focus on crop production began after independence in 1990, where there has been some discussions to improve crop production. Crop production is concentrated in the northern regions of Namibia which have better rainfall than the southern regions, although the soil fertility is low. Despise the higher rainfall that the northern regions have received in the past, the productivity of the communal farmers remains stagnant in comparison to commercial farmers. This points out that although rainfall is the key in rain-fed crop production, factors like fertility, water holding capacity, and management are also critical to output. The staple crops are pearl millet, sorghum, maize with limited planting of cowpea, groundnut and Bambara nut. Millet is the predominant crop that is cultivated on a large scale in the Northern communal areas than other crops, except for the Zambezi region where there is a favourable condition for maize (NSA, 2015). A publication by Fleissner and Bagnall-Oakeley (2001) showed that at least 95% of farmers grew cowpeas, thus indicating that cowpeas has been commonly cultivated in northern Namibia.

In the Kavango regions, cowpea is intercropped with pearl millet, but in some places, they plant it solely. The communal farmers in the Kavango regions consider cowpea after pearl millet and maize. Cowpea might be the third or fourth important crop competing with sorghum, groundnut and Bambara nut. The estimation of Fleissner et al. (2001), showed that farmers' cowpea production is 50kg per household on average. This low production of cowpea is based on planting cowpea in a small area. Farmers complain that the local variety of cowpea is late maturing, and that it is susceptible to drought and pests in the field (aphids, clavigralla) and during storage. It is also susceptible to Weevil attack thus reduces the cowpea post-harvest shelf life. In an attempt to address the challenge of the late-maturing of the local cowpea, the government brought exotic cowpea varieties which were tested under Namibia's climate conditions and they were found to be adaptive (Fleissner et al., 2001). The exotic cowpea could include suitable varieties of cowpea from which farmers could choose based on the characteristics such as maturity, yield-bearing, colour, taste, etc. but some farmers prefer the indigenous cowpea seeds. Cowpea is primarily cultivated for human consumption where pod are harvested when fresh or dry. The pods vary in colour (yellow, purple, brown), shape and size and it can contain 8 to 20 seeds per pod. The grain is covered by a coat that may be white, green, red, brown, speckled, black, blotched but in the region farmers prefer the white-coated cowpea. Figure 1 shows a handful of cowpea grains used in the study.

Figure 1: Cowpea grain used in the study for 2018 to 2019 planting season

3.3 Market for cowpeas in Namibia

Cowpea seeds are marketed at retail and wholesale outlets. Although there is an Agro Marketing Trading Agency (AMTA) which is a government parastatal that market agricultural products, cowpeas are bought on the open market (Namibia Agronomic Board, 2017). AMTA focuses mainly on the marketing of the staple agronomic crops (excluding cowpea) and horticultural crops. Under the agronomic board, cowpea does not appear on the list of the crops that the board regulates (Namibia Agronomic Board, 2012; 2017). Lack of a viable domestic market for the cowpea is a concern to the farmers as farmers are discouraged from cultivating more cowpea. However, the existing small cowpea market is dominated by smallholder farmers. The market operates occasionally on barter exchange whereby the trade occurs by exchanging cowpea for labour. A few farmers do market cowpea, especially in rural areas. The majority of farmers live in the rural areas where there is land for crop production. In most cases, the farmer acquires cowpea seeds from the neighbours or have to travel to town before acquiring the seeds. In recent years, the MAWF has provided seeds for millet, maize, groundnut and a few cowpeas at a lower cost to the smallholder farmers (MAWF, 2015a). Although the availability of seeds could motivate farmers to plant more, this is not the case with cowpea because farmers do not consume a lot of cowpeas and there is no domestic market for cowpea.

3.4 The challenges of cowpeas industry in Namibia

One of the Namibian Agricultural Policy goals is to ensure food security in the nation. However, years after adopting this developmental strategy, there are still limited levels of food production (MAWF, 2015b; National Agricultural Support and Services Programme (NASSP), 2005). The agriculture industry faces many challenges especially with regards to crop production. Part of the challenge with cowpea production is its availability and affordability in rural areas. According to Snapp et al. (2002), roughly 50% of smallholder farmers have no access to cowpea seed and production is limited by land size as many cultivate on a small portion in their homestead.

Marketing is also a challenge to the cowpea production for some smallholder farmers as they have no access to the seeds, especially if the farmers did not save seeds from their previous cropping season. The role of agro dealer including AMTA in ensuring seeds are available is unimpressive and unsustainable. The seeds must be available to the farmers and packaged in quantities that farmers can afford for ease accessibility. But this is not the case and besides, the farmer needs proper training on field management practices emphasising on seed harvest handling especially on cowpea and other legume crops.

Low soil fertility is another constraint to cowpeas, as low soil fertility affects cowpeas' ability to grow at an initial stage and during nodulation. Cowpeas needs fertile soil, especially at an early stage for rapid growth. A study by Mhango (2011) confirmed that cowpeas fixes less nitrogen and has less yields in low fertility soil than in fertile soils. In less fertile soils, there might be a need to consider a starter-up fertilizer to boost the initial growth of the cowpeas. In addition, some cowpeas varieties have less nodulation and such varieties require inoculation to improve the biological nitrogen fixation (BNF) and growth, whilst exotic varieties do not require inoculation.

The other challenges that are faced in crop productivity are climate change and human wildlife-conflict. These factors limit production amongst smallholder farmers.

3.5 Contribution of cowpeas to food security in Namibia

Cowpeas is a safe food that is rich in protein which has the potential to improve food security for the poor farmers in Namibia. Food security is a concern for all the countries in the world since food security is an international human right (NZH, 2017; Ncube et al., 2007). According to the Food and Agriculture Organization (FAO), 2009), all the people at all times must have physical and economic access to safe, sufficient and nutritious food that meets their dietary needs and larger food preferences for an active and healthy life. Legume plants are widely cultivated among the smallholder farmers and they have a balanced source of nutrients. The use of cowpeas could provide protein at a lower cost to the majority of Namibians that cannot afford an expensive source of protein such as meat. Mixing cowpeas which has high protein and cereal that is high in carbohydrate content may improve the balanced diet. Cowpeas can be consumed as leaves, green beans and dry beans.

4. MATERIALS AND METHODS

4.1 Introduction

This chapter provides an overview of the study area where the research was conducted, the sampling procedures and sample size determination. The chapter further gives the details on data collection and the statistical methods used.

4.2 Overview of the study area

The study was conducted as part of the topsoil project in both Kavango East and West regions, which are two of the fourteen regions of Namibia (figure 2). The two Kavango regions share borders to the Cuando Cubango Province of Angola in the north. Kavango East shares a border to the North-West District of Botswana and with the Southeast Zambezi region to the east. Kavango West has a border with Kavango East to the east and Otjozondjupa region to the southwest (Luther-mosebach, 2017; Mendelsohn, 2006). The regions are classified as semi-arid with a mean annual rainfall of 550 millimetres with warm temperatures. The average maximum temperature is above 30 degrees Celsius in the summer (Luther-mosebach, 2017; Mendelsohn, 2006; Misika et al, 1999). The rainy season usually starts from late October or early November and is followed by a cool to warm period from April to September (FAO, 2009; Misika et al., 1999). The soil texture in the region is predominantly sandy with low water-retention capacity (Sweet & Burke, 2006). The two regions were selected because of their high dependence on crop production and also because of the fact that they are more vulnerable to climate change.

In 2015, a conservation agriculture project was initiated by the Ministry of Agriculture in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to address the problem of poor crop yield and soil fertility (MAWF, 2015a). The project focused on educating the farmers on minimum tillage, soil cover and crop rotation. The crops used were millet, groundnut and cowpeas, and the two legume crops (groundnuts and cowpeas) were used for crop rotation to enhance biological nitrogen fixation.

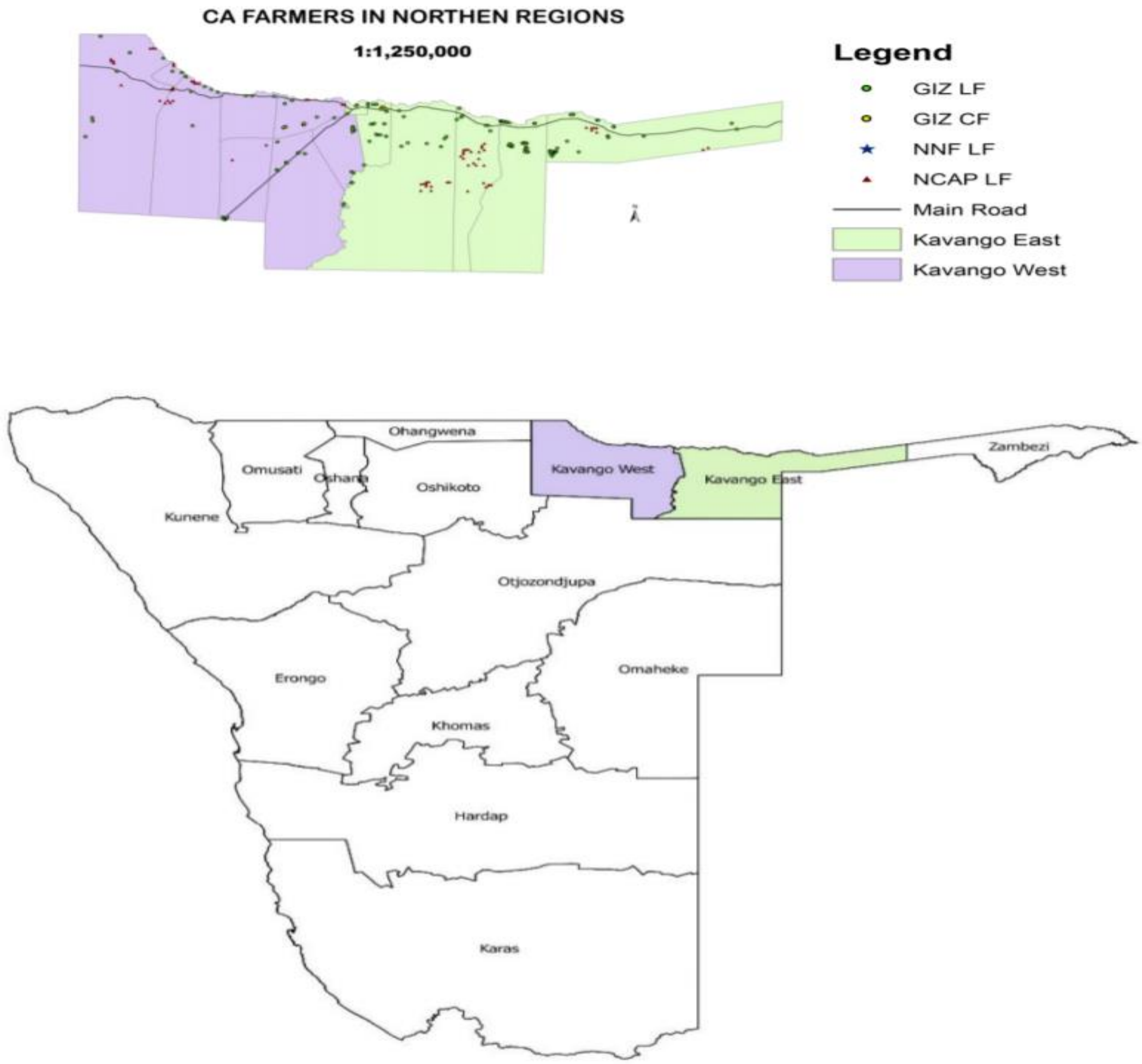

Figure 2: Map of Namibian showing the study regions

4.3. Qualitative reliability and validity

There are various things that can affect the reliability and validity of the data. These are personal information such as salaries, marital status, age, etc. To ensure the collection of reliable and valid data, the questionnaire was reviewed and pre-tested to clear out errors and sensitive information that could lead to poor responses (Ritchie & Lewis, 2013). Specific questions which are short and clear without ambiguous words were used. Leading questions and long instruments were avoided. The data captured from the questionnaire were analysed using Stata statistical software. The information collected was complete, accurate and devoid of any ambiguities.

4.4. Ethical issues

During data collection, farmers were asked to voluntarily participate in the study at their discretion. Farmers' information was handled with confidentiality. Generality was employed in presenting the results such that no one was mentioned in the report.

4.5. Limitation of the study

The survey was conducted in the villages that reflect the real situation of the Kavango regions. These villages were selected to participate in conservation agriculture trials in the region. These regions are predominantly sandy which could limit accessibility during data collection. Accessibility was enhanced by the use of a 4x4 vehicle during data collection. The unfavourable condition such as drought was a limitation, hence soil fixation by cowpeas was supposedly impaired.

4.6. Research tool

4.6.1. Sampling procedure and selection of farmers

Sampling is a process of selecting a predetermined number of observation from the population (Ritchie and Lewis., 2013). The results obtained from the sample were used to make inferences about the population. The target population of the study was the smallholder farmers in the Kavango regions who participated in a field trial on the conservation agriculture project. A total of 108 farmers participated in the project, therefore, using the formula: $n = N / (1 + N(e)^2)$, a sample of 92 was determined, where (N) is the population, (e) is the assumed margin of error of 4%. The respondents were randomly selected by a simple probability method of sampling.

4.6.2. Soil sampling and soil measurement

The soil sample was taken first in 2017 and in 2019 during the months of July to September. The soil sample was collected from 70 smallholder farmers' fields in the Kavango East and 20 farmers in the Kavango West. There were two farmers that were not included due to incomplete data collection. The fields which were sampled were those where cowpeas was planted either sole or intercropped. A soil auger was used to collect soil samples from a 15 cm depth to represent different soil layers, following a zigzag pattern to ensure random collection (figure 3). The sampling intervals were determined by dividing the farm size over the number of samples needed (Twenty samples per hectare). In a ploughed field, the auger was placed halfway down the ridge and not on top or below the ridge. The areas that were close to the kraal, pathway, edge of the crop field, houses and anthills were not sampled as they can have a high influence on soil nutrients. The samples from each farm were mixed in a sampling bucket for a better representative field sample. The samples from each farmer were kept in plastic bags which were filled halfway for laboratory analysis.

The soil sample was analysed by soil care laboratory before and after the experiment to provide soil physical, biological and chemical properties for comparison (figure 4). A one-kilogram composite of soil sample was prepared from the subsample of each field, the soil was air-dried and sieved to pass a 2mm sieve before laboratory analysis. The soil test results were printed and distributed to the farmers. Based on the information collected at the time of sampling, some smallholder farmers were assigned into two categories; one group was to intercrop millet with cowpeas, the second was to rotate millet with cowpeas. Farmers who were to rotate millet with cowpeas were supposed to use NPK fertilizer in their millet field. Unexpectedly, some farmers used the NPK fertilizer and some did not due to some reasons known to them.

Figure 3: Taking the soil sample from the farmer’s field

Figure 4: Mobile soil care lab for soil analysis

4.6.3. Household survey

Both closed and open-ended questionnaires (Appendix 3) were formulated based on the specific objectives of the study to collect cross-sectional data from the farmers. An open-ended question was needed to allow the farmers to provide more information to clarify and qualify their responses for accuracy. The questionnaires contained six sections: The first section contained the socio-economic profile, the second was on household information, farm-related information, participation and access to the institution, food consumption and preference and finally on the perception of climate change and the general situation. The farmers were interviewed using a printed questionnaire (Figure 5) which was tested before the commencement of the study to identify and remove errors. To quantify some figures into a percentage, 10 stones were used whereas a stone represented 10 percent. The households' responses were entered into a Microsoft Excel and imported into Stata.

Table 4. 1: Selected villages for the survey

Constitutions Area	**Villages**	**Implementer**	**C.A. implemented**	**Data collection**
Mukwe	Kangongo Mbapuka Tjova	NNF	2017	2019

	Katenture			
Ndiyona	Mbambi Mukuvi Shikoro Kangweru Dumushi Dosa Kandjara Shambahe	NNF and GIZ	2017	2019
Rundu Rural East	Kambowo Manwangombe Mayana Kaisosi	NNF and GIZ	2017	2019
Ncuncuni	Singuruve Ncaute Gcatjinga	GIZ	2017	2019
Rundu Rural West	Mile 20 Masivi	NNF and GIZ	2017	2019
Mashare	Ncaha	GIZ	2017	2019
Kapako	Kapako Kasivi	NNF	2017	2019

Table 4.1 shows the villages and the constituencies, the year the project commenced and when the data were collected. It further shows the two project facilitators in all the villages selected (NNFU and GIZ).

Figure 5: Interviewing farmer at his home in Ndiyona constituency, Kavango east region

4.6.4: Statistical analysis

Multinomial logit was used to determine the factors that influence the smallholder farmers' management practices measured using Stata 14 software. Multinomial logit was chosen because it is extensively used in analysing multiple choices and it is ease to compute. The data were tested for normality distribution using a Shapiro-Wilk test. Shapiro-Wilk test was chosen for its powerful properties than all types of distribution and sample size tests (Razali & Wah, 2011). Shapiro-Wilk test lies between the value of zero and one, whereby, the value of one indicates the normality of the data and the small value leads to the rejection of the normality ($p<0.05$). The Residual Maximum Likelihood (REML) model was used to partition the variance between the soil fertility into differences between households. Descriptive statistics were computed on continuous variables which are: age, household size, and area of crop fields. Frequencies and percentages were calculated on categorical variables: the source of income, preferred cowpeas, marital status and educational level. Data on soil chemical characteristics before and after planting cowpeas were analysed as the Wilcoxon rank test in Stata using the univariate procedure. The Principal Component Analysis (PCA) was used to reduce the dimensions of the survey data by determining Eigenvalues and component scores and thus removing any multicollinearity in the data. An eigenvalue of one or greater than one was considered as they contribute one unit or more to the total variance of the data set. The components that have eigenvalue of less than one account for less variance in the data set and they are not necessary to be retained (StataCorp LP., 2013; Xie & Wu, 2015). The principal components rule for selecting the eigenvalue is that each principal component is bigger than 1 and the cumulative variance proportion of all principal components is more than 85%. The smallholder farmers' land use probability model can be represented as,

$$P_{ij} = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots + \beta_k X_k + e$$

P_{ij} represents the probability of land use methods by the farmers, where i takes values (1, 2, 3), each representing the land use (millet only =1, Millet intercrop with cowpeas =2, millet rotated with cowpeas =3). The β are parameters to be estimated in the model whereas e is a randomized error and X represents factors affecting land uses. With a number of alternative methods, the log odds is
formulated as,

$$\ln \left(\frac{Pij}{Pik}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots\ldots + \beta_k X_k + e_i$$

P_{ij} and P_{ik} are probabilities that a farmer will choose a given outlet and alternative outlet respectively. In this regard, $\left(\frac{Pij}{Pik}\right)$ is a natural log of the probability of choice j relative to probability choice k, α is a constant, β is a matrix of parameters that reflect the impact of changes in X on the probability of choosing a given outlet, e is the error term that is independent and normally distributed with a mean zero. The parameter estimates of the multinomial logit model provide only the direction of the effects of the independent variable on the dependent (response) variable but do not represent either the actual magnitude of change or probabilities. The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in the probability of a particular choice being made to a unit change in an independent variable from the mean (Gujarati & Porter, 2010; Rahji & Fakayode, 2009).

Marginal effects of the attributes on choice are determined by getting the differential of the probability of a choice and it is given by,

$$\partial = \frac{\partial Pi}{\partial Xi} pi \left(\beta_j - \sum_{k=0}^{j} P_k \beta_k\right) = P_i(\beta_k - \beta)$$

The list of variables used in the multinomial Logit model is given in Table 4.2 as

$P_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_n X_n + \varepsilon_i$

The influence of socioeconomic factors on land use decision = $\beta 0 + \beta_1$farmexp + $\beta_2$plntdate + $\beta_3$climat + β_4Hrvdate + β_5Climatos + β_6Tra&Ext + β_7AvgFrmPtdy + β_8Educt + β_9AvgFrmIncm + β_{10}Frmtol&Age + εi

Table 4. 2: Summary of the variables used in the multinomial logit

Variable code	**Variable**	**Measurement of Variables**	**Expected sign**
Dependent variable:			
Land use	Farmers farming practices	(1=Millet only, 2=Intercrop, 3=Rotated)	
Regressors:			
Farmexp	Farm experience	In years (continuous)	+
Plntdate	Planting date	In Dates (Continuous)	+
Climat	Climate change awareness	Dummy (1 = Yes, 0 = No)	±
Hrvdate	Harvest date/planning	In Dates (Continuous)	+
ClimatoS	Climatology services	Dummy (1 = Yes, 0 = No)	±
Tra&Ext	Transportation/extension	Dummy (1 = Yes, 0 = No)	±
AvgFrmPtdy	Average farm productivity	In kilograms (Continuous)	+
Educt	Education	(1 = illiterate, 2 = Primary, 3= Secondary, 4= High School, 5= Undergraduate, 6= Above all)	+
AvgFrmIncm	Average monthly income	In N$ (Continuous)	+
Farmtool	Access to farm tools	Dummy (1 = Yes, 0 = No)	±
Age	Age in years	In years (Continuous)	+

The Goodness of Fit Test for the model is related to the likelihood ratio statistic. It is similar to the least squares multiple regression coefficients (R2) and it is bounded between zero and one. The index increases from zero as the fit of the model improves (Gujarati et al., 2010).

5. RESULT AND DISCUSSIONS

5.1 Introduction

This chapter presents the results obtained from the descriptive statistics which is presented in section 5.2, followed by soil fertility classification in section 5.3. Section 5.4 presents the results on the effects of cowpeas on chemical properties and section 5.5 presents the Wilcoxon rank test. The empirical results of Principal Component are discussed in section 5.6.1 and followed by a multinomial Logit model in section 5.6.2.

5.2: Descriptive statistics results

Table 5. 1: Descriptive statistics of household characteristics

Characteristic of household	Frequency N=90	Mean N=90	Standard deviation
Family type		1.31	0.47
Joint family	62	68.9	
Nuclear family	28	31.1	
Household size:			
Under 15		4.2	2.64
15-65		4.12	2.50
Above 65		0.2	0.48
Farm size		4.18	2.77
Gender:			
Male	41	45.6	
Female	49	54.4	
Age		46.9	11.74
Income:			
Crop farming (%)		32	65.25
Wages/ Salary (%)		33.7	109
Livestock (%)		1.67	8.4

Business (%)		18.8	43.3
Other (%)		65.5	160.08
Access to extension services		0.8	0.4
Education level		2.48	0.8
Illiterate	8	8.9	
Primary	41	45.6	
Secondary	31	34.4	
Higher secondary	10	11.1	

5.2.1: Gender representation and the age of the household

Household characteristics show that respondents' age range between 28 years to 77 years with a mean and standards deviation of 46.9 years and 11.74 respectively. This result indicates that respondents are in the productive age and this could lead to an increment in their farm productivity. Specifically, the majority of the respondents are middle-aged adults (aged from 36 to 55). These are the 50 respondents that were involved in the survey. The least participants were the young adults aged under 35 who were 15 in number while the older adults (aged 56 and above) were 25 respondents. This may suggest that there were few young adults that participated in farming activities because they regard farming to be elderly people's work. A total of 54.4 percent of respondents were female and 45.6 percent were male. This result suggests that women are mostly involved in cowpeas farming compared to their male counterparts.

5.2.2: Household members

On average, the household members consisted of nine persons, some were school children, school dropouts and elders. Household size is crucial to smallholder farmers as of them lack machinery and highly depend on the available manpower. The larger the household, the easier the farming activities can be. On average, out of nine household members, two were full-time farmers, and another two members were part-time farmers who farm occasionally.

5.2.3: Educational level

Education is an important factor in agriculture because it can affect the understanding, writing and reading skills which are needed for agricultural technologies. Education level might not only influence farmers' perception of soil fertility but it can also influence their responsiveness as an educated farmer is able to apply the information and the agricultural technologies effectively. In this study, with 90 observations, about 8 respondents (9 percentage) were illiterate and 46 percent had primary education. The respondents who had secondary education had the second-largest frequency of 34 percent and lastly, only 11 percent of the respondents had higher secondary education. The results showed that 54 percent of the respondents had not obtained any secondary education, thereby suggesting that the majority of the farmers may not be able to fully understand instructions if these are passed to them in English. The training given to the farmers must be based on the level of their education, see the frequency in Table 5.1.

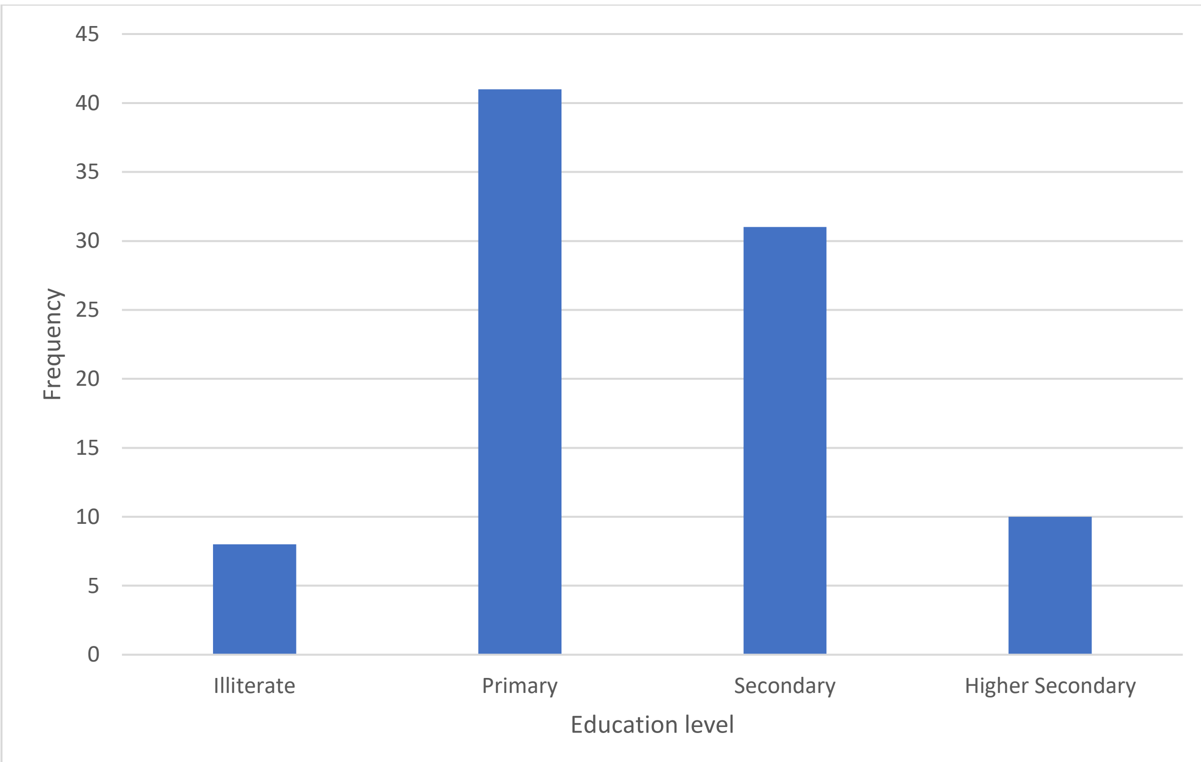

Figure 6: Educational level of the respondents

Figure 6 shows the farmers' educational levels, where 8 respondents were illiterate, 41 had attained primary education, 31 had secondary education and 10 had higher secondary. About 54% of the farmers did not have secondary education.

5.2.4: Farm size

The farm size of the 90 respondents varied between from 1 to 20 hectares, with an average farm size of 4 hectares. A large proportion of the farm size was under millet cultivation as millet is the staple crop food for the regions. This can also be supported by comparing the yield of millet harvested and that of other crops as millet yields are much higher. Similar findings were reported by Fleissner et al. (2001) and NSA (2015), that farmers in the region cultivate more of millet than other crops. This is a challenge to the soil fertility of the farmers' field as millet is continually cultivated on a large size than legume plants that is responsible for biological nitrogen fixation.

Table 5. 2: General farmers' characteristics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
EducLevel	90	3.00	1.00	4.00	2.4778	0.8104	0.657
Age	90	49.00	28.00	77.00	46.9333	11.74141	137.861
FarmExp	90	44.00	3.00	47.00	19.7778	11.2687	126.984
LandSize	90	19.00	1.00	20.00	4.1778	2.7746	7.698

5.2.5 Source of income for smallholder farmers

Agriculture is considered as the main source of income for farmers. In this study, the findings show that more households depend on agriculture for income. Approximately 78 percent of the households generate income from agriculture and 22 percent from non-agricultural sources. Agricultural income is generated from crop sales, livestock sales and wages from agricultural work. Non-farm sources of income are government grants and white collar jobs. A large percentage of the households generate income from farms and this shows that agriculture is a significant source of income and livelihood for farmers in these regions.

5.2.6 Access to extension services

Access to extension services is important as it provides useful information for the farmers such as climate change, fertility management, land uses, marketing information and new or improved technology. There is a difference in access to extension services between farmers who rotated their cropping and the farmers who did intercropping (Figure 7). There was 85.7 percent of GIZ farmers who had access to extension services and 88.2 percent of farmers were for the NNF funded project. This result indicates that the majority of the farmers under GIZ and NNF received similar information from the extension services.

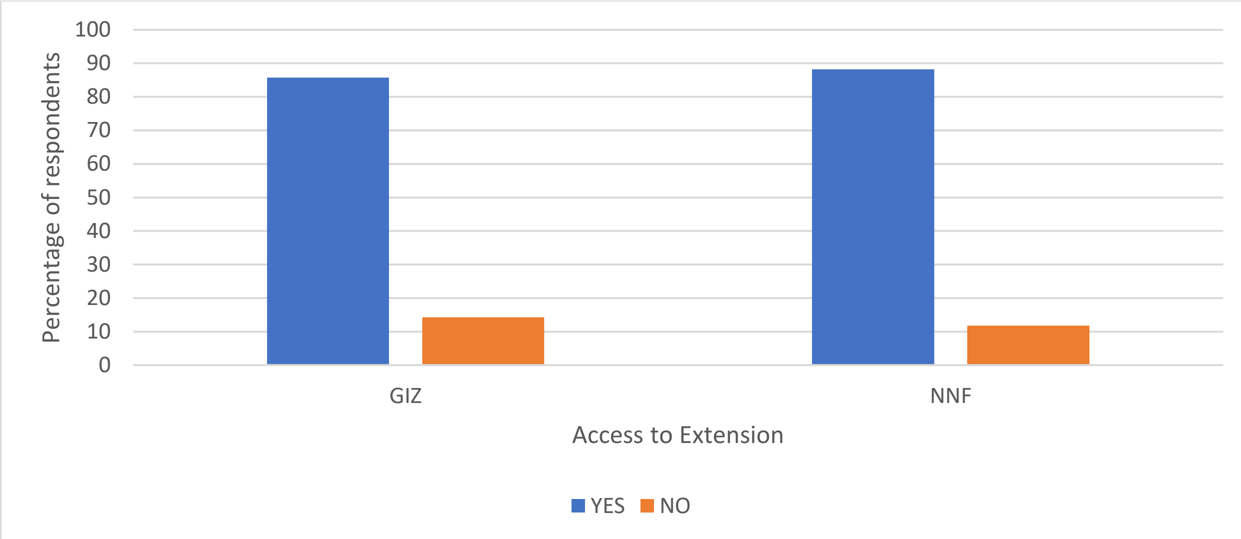

Figure 7: Access to extension services

There is a slight difference in the access to extension services between GIZ farmers' with 85.7 percent access and NNF farmers with 88.2 percent. Overall, there is 86.67 percent access to extension services by the smallholder farmers. Thus, the result shows that farmers in this trial had access to extension services.

5.2.7 Access to agricultural credit by the smallholder farmer

Access to credit is vital to smallholder farmers as this is a means to improve agricultural capacity as farmers who have access to credit may afford the cost of crop rotation with a legume, the application of manure and or other fertilizers. In this study, farmers were asked if they had access to credit for the agricultural purpose from private, public institutions, families and friends. Smallholder farmers had very little access to agricultural credit as about 6.6 percent had access. Lack of agricultural credit could be that the smallholder farmers are not commercial farmers and the creditors might doubt their willingness and their ability to pay back the credit. The lack of agricultural credit makes it difficult for smallholder farmers to properly fund farming activities to improve productivity and soil fertility.

5.3 Soil fertility classification based on farmers' opinions and lab analysis

Figure 8 shows the perceptions of farmers about soil fertility and the soil lab test. About 41 percentage of the farmers understood that their soil fertility is high, another 41 percentage thought that the soil fertility is average and 17 percentage thought that the soil fertility is low. The lab results showed that 15.6 percentage of the farms had low soil fertility and 84.4 percentage was very low (figure5.3). This means that farmers were continuously exhausting the land and yet they thought that their soil's fertility was still fine.

Despise the access of extension services in the regions, it is not clear how knowledgeable are the smallholder farmers about soil fertility. An interview with the farmers showed that the majority of the farmers perceived that their soil fertility level was high and average. The results from the lab proved that the farmers did not know their soil fertility levels as the results appeared to be low and very low (figure 8). This finding is necessary for the capacity building of the future projects to try to improve and educate farmers on soil fertility issues.

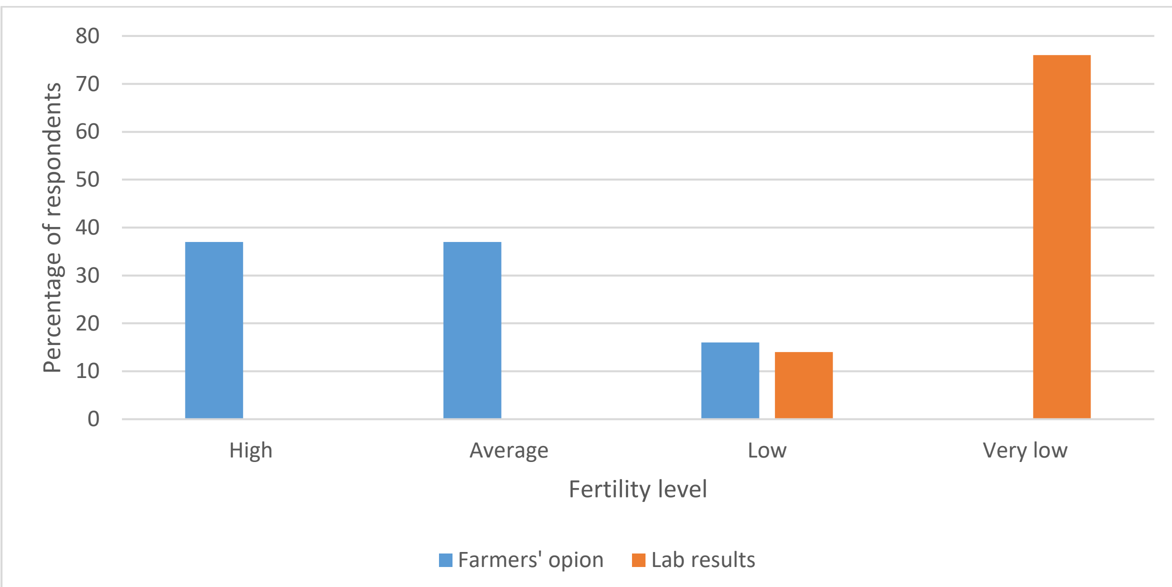

Figure 8: Farmers' opinions versus lab results on soil fertility level

The results in figure 8 show the highest number of farms that had very low soil fertility with 76 farms. No farm had high and average soil fertility from the lab results and about 17.8 percentage were farmers' opinions that their field had low fertility and the lab result showed that 15.6 percentage of the fields had low soil fertility.

5.4 The effects of cowpeas on soil chemical properties

Table 5.3 shows descriptive statistics and confidence intervals for soil nutrient levels for 90 observed fields at 0-15 cm soil depth. There was a high variability of soil properties between farms. The soil nutrients between farms varied from zero adequate nutrients to four adequate nutrients in some crop fields. Table

5.4 showed that 84.44% of farms have loamy sand (LS) soil, 11.11% farms have sand soil (SS) and 4.44% have sandy loam soils (SL) at between 0 to 15cm soil layer depth. The soil PH ranges from 4.1 to 8.2 with the average PH of 5.9 at the 15 cm depth of the soil layer, indicating that the majority of the farmers involved in the survey are under acidic soil (Table 5.3). Approximately 77 farms had a PH level below 7, about 12 farms had a PH of above 7 and one farm had a PH of exactly 7. The level of adequate PH varies between a PH of 5 to 6.4, whereas below 5 was considered as low and above 6.4 was high. Only 19 farms were found to have an adequate PH (Appendix 1). The soil organic carbon is a component of organic compound which is a measurable component of soil organic matter. Soil organic matter has an important role in the availing of soil nutrients, and improving the soil's physical, chemical and biological properties. The soil organic carbon ranges from 2 g/kg to 9 g/kg with an average of 3.7 g/kg from a 15 cm depth (Table 5.3).

By examining the major nutrients needed for crop growth, the result showed that all major nutrients were very low. The amount of Nitrogen that was available ranged from 0.2 g/kg to 0.8 g/kg with an average of 0.3 g/kg (Table 5.3). An adequate nitrogen level was expected to be between 1 g/kg to 2 g/kg, but the results showed that none of the farms had an adequate Nitrogen level. Nitrogen is an important and major nutrient that is absorbed in the form of nitrates by the crops. Nitrogen is necessary for the photosynthetic process and plant growth while lack of nitrogen can result in yellowish leaves and poor crop growth. This could contribute to low yields if soil nitrogen is not improved by fertilizer applications.

Phosphorus (P) is one of the major elements needed for crop production, however, this element was very low in all the farms with the maximum Phosphorus level of 0.1 g/kg while in some farms it was not detectable (Table 5.3). Phosphorus is absorbed by the crop in the form of phosphates and is vital for photosynthesis and plant growth. Furthermore, phosphorus is important for root development which can affect the process of nodulation for legume plants, the flowering which influences the yield, respiration and fruit maturing. Generally, Namibian soil is low in phosphorus and in this study, so 70% of the farms had zero detectable levels of phosphorus while 30% of farms had 0.1 g/kg. None of the farms had adequate phosphorus levels which was between 0.2 g/kg to 0.6 g/kg. Although phosphorus is not required in large quantities, it is necessary to increase cowpeas yields by augmenting nitrogen fixation through nodulation. The deficiency of phosphorus could have reduced the ability of cowpeas to improve nitrogen fixation. Potassium exchange (K) is a macronutrient which is essential for the plant metabolic process and as well the opening and closing of the stomata. Potassium exchange ranged from 0.2 mmol /kg to 4.8

mmol /kg and had an average of 1.1 mmol/kg (Table 5.3). An adequate level varied between 1.5 mmol/kg to 3 mmol/kg. Potassium exchange was found to be adequate in 25 farms.

Magnesium exchange (Mg) is a secondary nutrient that is crucial for chlorophyll formation and for photosynthesis to take place. A deficiency of magnesium can be observed on discolouration and premature defoliation of plants. The low magnesium level was found in the acidic soil and as the soil PH increased, the magnesium level also increased and vice versa. Magnesium exchange ranged from 0.5 mmol/kg to 20.1 mmol/kg and on average had 5.3 mmol/kg (Table 5.3). Magnesium levels of less than 4.6 mmol/kg is low, between 4.6 mmol/kg to less than 10 mmol/kg is adequate and above 10 mmol/kg is high.

Calcium exchange (Ca) is a secondary nutrient that is necessary for the growth of the cell tissue and the formation of the cell wall structure. Calcium can also increase the resistance of roots to toxic conditions in acidic soils. Calcium exchange had 25.8 mmol/kg on average, indicating a low level with a range of 4.5 mmol/kg to 120.4 mmol/kg (Table 5.3). An adequate calcium exchange is above 75 mmol/kg and below 200 mmol/kg, below 75 mmol/kg was low and above 200 mmol/kg was high. Sulphur is one of the secondary nutrients that are needed for the formation of amino acids, which builds up proteins, and promotes the formation of chlorophyll as well as root nodules on legumes. The farms in the study had a low Sulphur level with a range of 0.1 mmol/kg to 0.2 mmol/kg and a mean of 0.039 mmol/kg (Table 5.3).

Table 5. 3: Soil properties across the 90 observed crop fields at 15cm depth.

Variable and Units	**Depth (cm)**	**Mean N=90**	**Std deviation**	**Min**	**Max**	**Confidence Level (95.0%)**
PH (KCL)	0-15	5.89	0.947	4.1	8.2	0.198
Organic Carbon (g/kg)	0-15	3.727	1.192	2	9.1	0.250
Total Nitrogen (g/kg)	0-15	0.3	0.116	0.2	0.8	0.024
Total Phosphorus (g/kg)	0-15	0.03	0.046	0	0.1	0.010
Potassium exchange (mmol+/kg)	0-15	1.116	0.678	0.2	4.8	0.142

Magnesium exchange (Mg) (mmol+/kg)	0-15	5.269	4.068	0.5	20.1	0.852
Calcium exchange (Ca) (mmol+/kg)	0-15	25.806	19.370	4.5	120.4	4.057
Total Sulphur (g/kg)	0-15	0.001	0.011	0	0.1	0.002
Zinc (mg/kg)	0-15	0.181	0.377	0	1.7	0.079
Copper (mg/kg)	0-15	0.082	0.153	0	0.6	0.032
Caution Exchange Capacity (mmol+/kg)	0-15	50.354	19.517	23.3	144.2	4.088
Total Aluminium (g/kg)	0-15	7.083	2.212	3.7	13	0.463
Total Potassium (g/kg)	0-15	1.493	1.376	0.3	7.3	0.288
Total Silicium (g/kg)	0-15	441.682	7.377	421.3	459.9	1.545
Total Iron (g/kg)	0-15	3.413	1.447	1.3	12	0.303

Table 5. 4: General soil type and the PH of the crop field

Soil type	Percent of the soil type sampled	Number of sampled farmed	Average PH level	Minimum PH	Maximum PH
Sand (%)	11.11	10	5.69	4.1	6.8
Sandy loam (%)	4.44	4	7.15	6.1	8.1
Loam (%)	84.44	76	5.85	4.4	8.2

5.5 Wilcoxon signed-rank test

Wilcoxon signed-rank test was used to analyse soil fertility data since the test does not assume normality in the data. The soil fertility score was not significantly different between the 2017 and 2019 data with the p-value of 0.103. The reason could be that the cowpeas did not have more seasons to bring about significant differences to soil fertility and if planted for a shorter period, the differences might not be significant. By comparing the different farmer groups (GIZ and NNF) for the 2019 soil fertility scores, thus one can see that there was no significant difference, the p-value is 0.315. This could because all the farmers' groups used cowpeas for a season.

The soil fertility score in 2019 was found not to be significantly different between farmers with sandy soils and farmers' with loamy sand soils (sandy loam was omitted due to scarcity of data). The Wilcoxon rank test indicated the p-value of 0.691. The only significant difference for soil fertility score in 2019 was observed between the farmers in the Kavango East and West regions with a p-value of 0.009. The farmers in the Kavango East region had higher scores on average. The differences in soil fertility in the two regions may be due to different soils types in the regions.

Table 5. 5: Wilcoxon signed rank test

Compared Variable	Obs	P-value > z
2017 and 2019 growing season	90	0.103
Kavango East and West	90	0.009
GIZ and NFFU farmers	90	0.315
Sand soil and Loamy sand soil	90	0.691

The Shapiro-Wilk test was fit to test for normality of the data. The lab results on soil fertility, soil type and the regions are not normal distributed ($p<0.05$). The data on farmers' education (edulevel) and farmers' group had a normal distribution ($p>0.05$).

Table 5. 6: Shapiro-Wilk test for five parameter data

Variable	Obs	W (Wilk)	V (Covariance Matrix)	z-stat	P-value > z
Edulevel	90	0.9973	0.207	-3.089	0.9990
Farmergrou	90	0.9897	0.777	-0.031	0.5123
Lab result	90	0.908	6.960	5.05	0.0000
Soil type	90	0.822	13.461	6.597	0.0000
Regions	90	0.9483	3.898	3.712	0.0001

*p<0.05 reject the normal distribution in the population

Table 5. 7: The average major nutrients level after a growing season

Nutrients level	2017 Season	2019 Season	GIZ afarmers	NNF Farmers	Kavango East	Kavango west
Nitrogen (g/kg)	0.3622	0.3	0.3125	0.2794	0.3043	0.285
Phosphorus	0.0389	0.03	0.02321	0.0412	0.0271	0.04
Potassium (Exch) (mmol/kg)	1.3711	1.1156	1.16786	1.0294	1.1386	1.035
Organic carbon	4.6644	3.7267	3.9286	3.3941	3.8043	3.455
Calcium (Exch)	34.6744	25.8056	26.607	24.4853	27.14	21.135
Magnesium (Exch)	8.2111	5.2689	5.7625	4.4559	5.6086	4.08
Sulphur	0.0033	0.0011	0.0000	0.0029	0.0014	0.00

There were insignificant differences between the 2017 and 2019 growing seasons and between farmers' groups ($p>0.05$). There was also a significant difference between the soil fertilities in the two regions ($p<0.05$).

Two seasons of contrasting the ability of cowpeas to improve the nitrogen fixation on soil fertility were not enough to contribute significant changes. Similar studies have shown no significant differences in nitrogen fixation given a short season (Marandu, Semu, Mrema & Nyaki., 2010). This might be because of the short length of the time span within which cowpeas can fix atmospheric nitrogen.

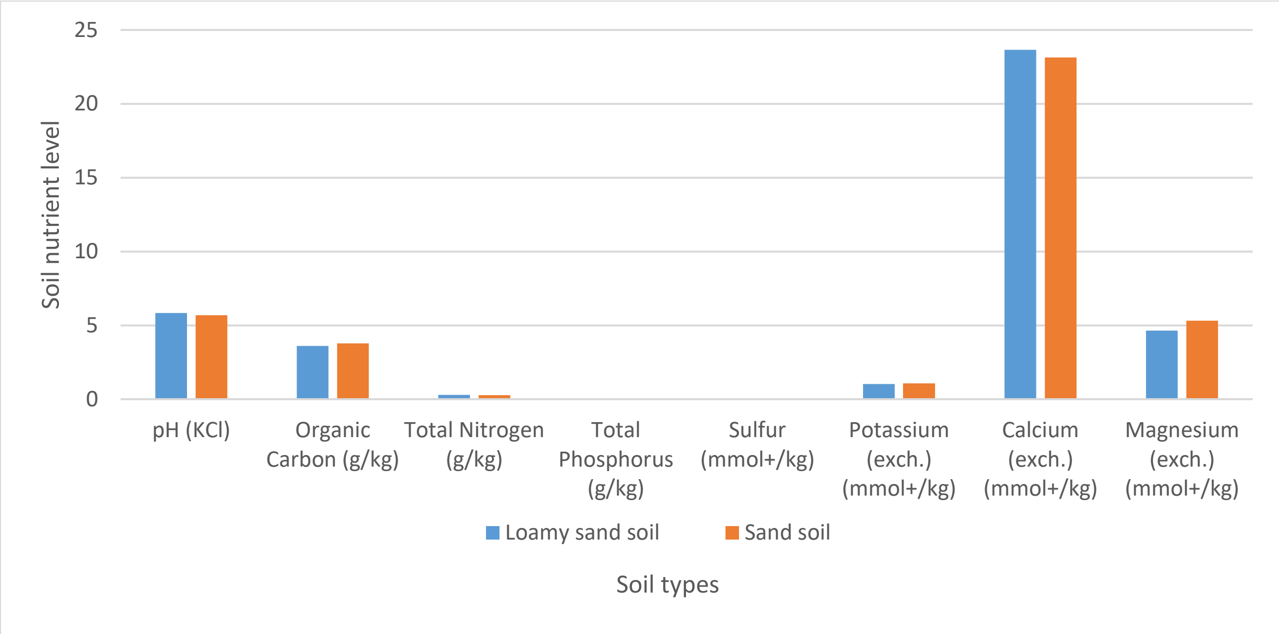

Figure 9: Soil nutrient for loamy sand and sand soil field, p>0.05.

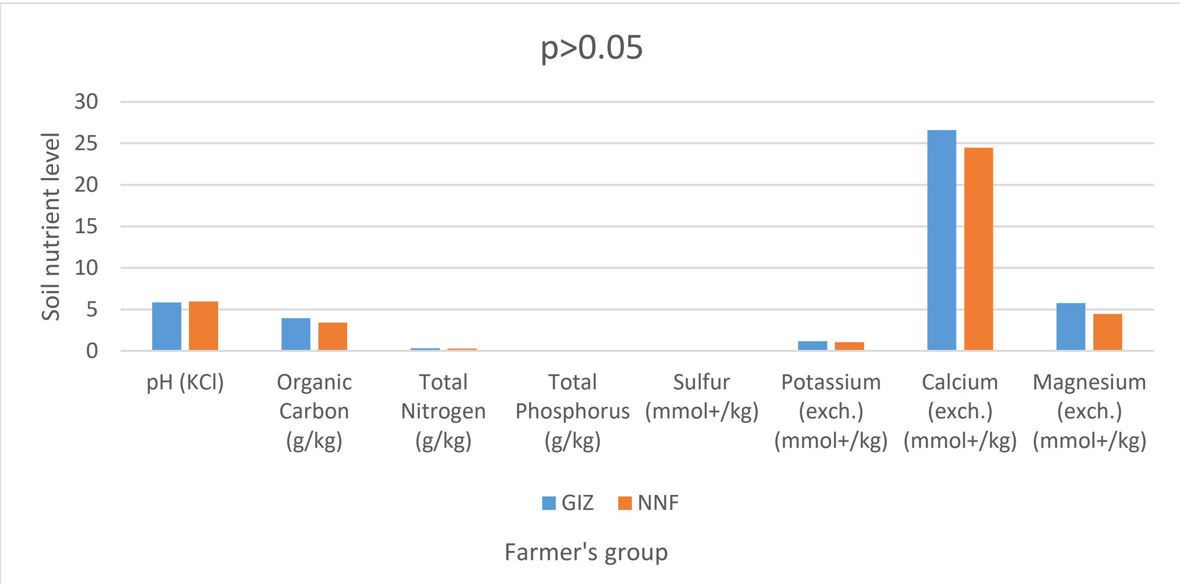

Figure 10: Soil nutrient for farmer’s group, p>0.05.

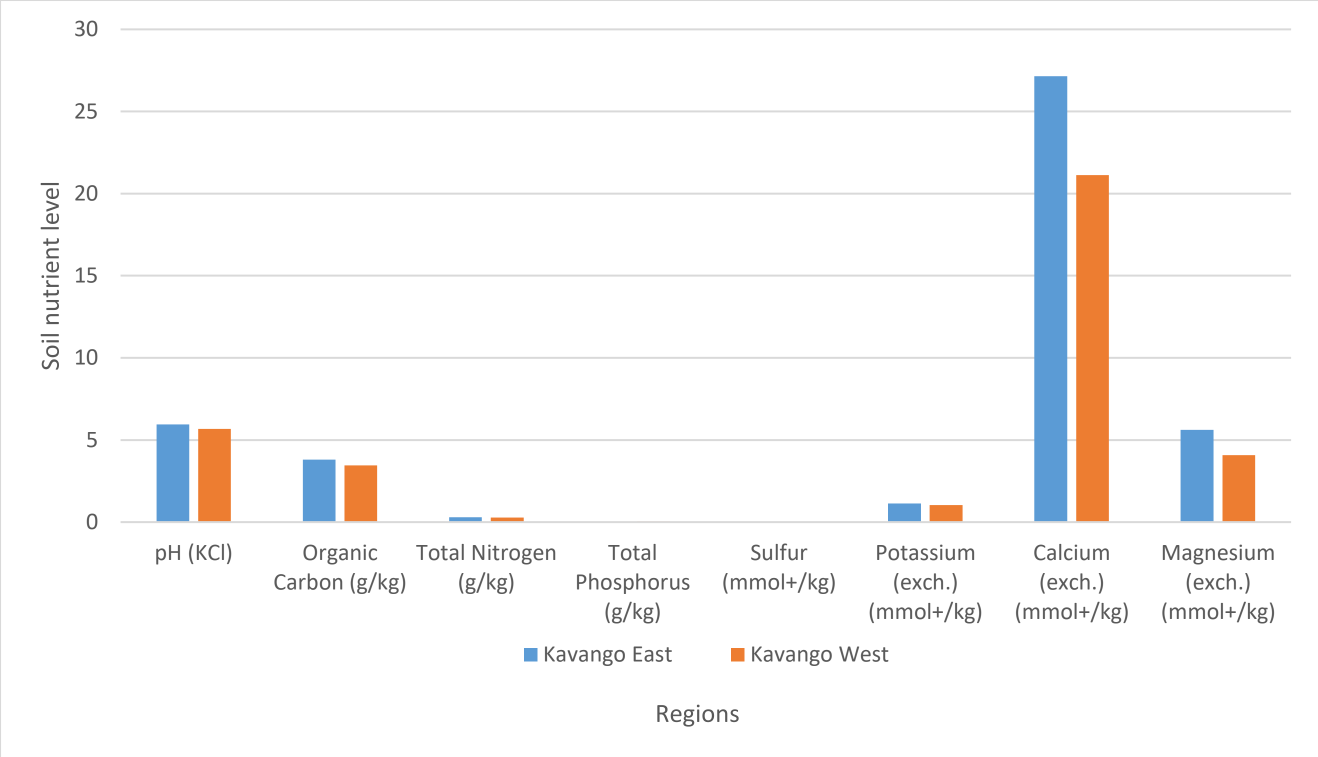

Figure 11: Soil nutrient for the two regions, $p<0.05$.

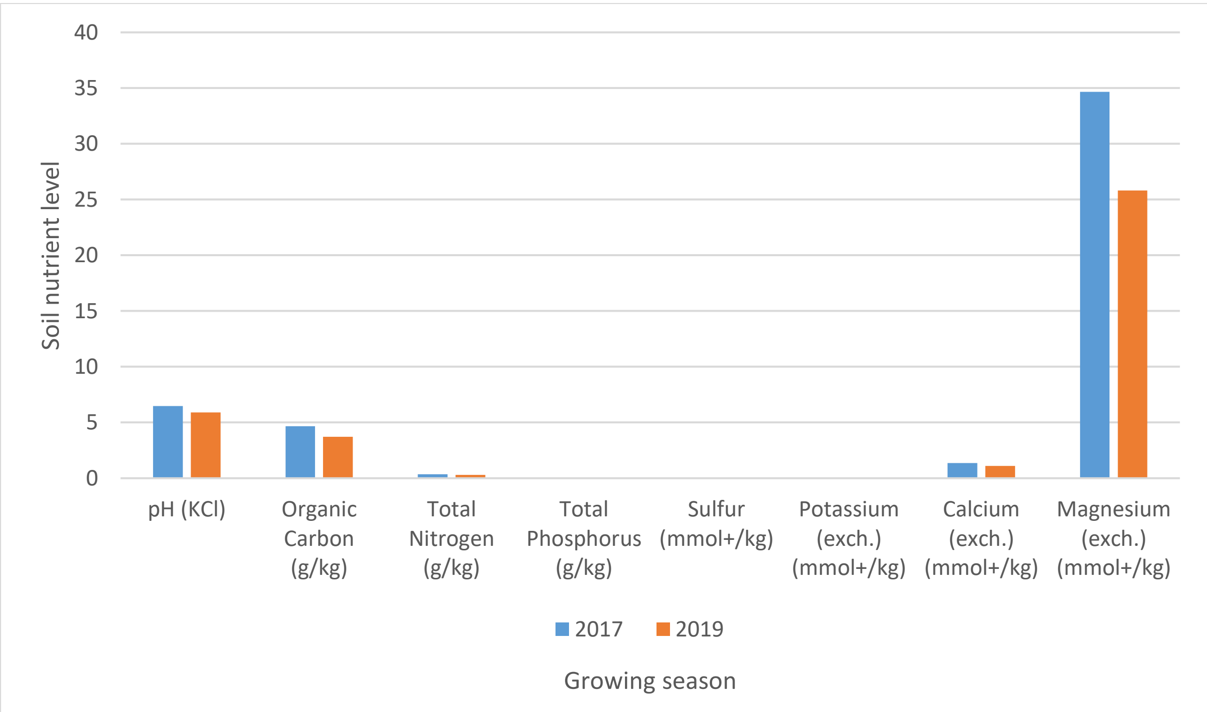

Figure 12: Soil nutrient for the 2017 and 2019 growing season, $p>0.05$.

From the results in figure 12, all the nutrients had decreased from the 2017 to 2019 growing season. The GIZ farmers who rotated cowpeas with millet had slightly higher nitrogen levels, potassium, organic carbon, calcium exchange and magnesium exchange than NNF farmers who intercropped. The NNF farmers who intercropped had a slightly high phosphorus and sulphur than farmers who rotated (Figure 10). The farms in the Kavango East region had a slightly higher nutrient level in all the nutrients and there was a significant difference ($p<0.05$) (Figure 11). All the soils in the study lacked adequate soil nutrients and the nutrients can be improved by applying fertilizers (Figure 9).

5.6 Empirical results and discussions

5.6.1. Principal component analysis

The results of the total variance explained by returned components showed that only the first ten components had eigenvalues greater than 1 (Table 5.9). The first component extracted 15.15% of the total variance in the observed variables. The second component explained 12.06% of the variance in the data set that was not explained by the first component. The ten component accounted for 3.68% of the variance in the data set. The column that contained component 10 showed that the cumulative percentage of variance accounted for by the current and all preceding principal components to be 72%. This means that the first ten components together account for 72% of the total variance. Only those principal components whose eigenvalues are greater than 1 are kept. Components with an eigenvalue of less than 1 account for less variance than did the original variable (which had a variance of 1), and so they are of little use.

Table 5. 8: Correlation between variables and extracted components

Variable	Variables' full name	Cp1	Cp2	Cp3	Cp4	Cp5	Cp6	Cp7	Cp8	Cp9	C10
lnfarmexp	Farm experience	0.537									
gender	Gender										0.509
lnedu	Education								0.564		
lnaveincome	Average income									0.718	
lnavemcon	Average monthly income							0.632			
lnavecyield	Average yield							0.588			
pdmillet	Planting date for millet		0.545								

pdmaize	Planting date for maize	0.559								
pdcowp	Planting date for cowpea	0.566								
hdmillet	Harvesting date for millet			0.529						
hdmaize	Harvesting date for Maize			0.591						
hdcowp	Harvesting date for cowpea			0.534						
Believecc	Climate change awareness		0.520							
Dailyfcast	Daily forecast				0.636					
Seafcast	Seasonal forecast				0.598					
Accessft	Access to farm tools									0.663
Farmsysc	farming system and decision change							0.609		
Lnfamlabft	Family labour		0.549							
Donkey	Donkey					-0.427				
Extdawf	Extension services					0.474				

*Eigen value of greater than 1 was considered. PC Comp=Principal components

5.6.2: Factors affecting smallholder farmers' land management practices

The multinomial Logit model was used to determine the factors influencing smallholder farmers' management practices. Two categories of farming practices were defined earlier in the methodology. These include growing Millet (P_1) only and Millet intercropped with Cowpeas (P_2). A positive and significant coefficient shows that the independent variables significantly influence the farm management practice (growing Millet (P_1) only and Millet intercropped with Cowpeas (P_2). A negative coefficient gives the opposite. The variables included in the estimation were: farming experience, planting date, climate change awareness, harvesting date, access to climatology service, access to transportation and extension services, average farm productivity, education level, average monthly income, access to farm tools and gender.

Table 5. 8: Marginal effects at the mean of predictors

Variables	Millet only	Rotation of millet with cowpeas	Intercropped millet with cowpeas
	0.1140***	-0.0019	-0.1122***
Farming Experience	(0.000)	(0.941)	(0.000)
	-0.0360	-0.0126	0.0486**
Planting date	(0.112)	(0.651)	(0.027)
	-0.0136	0.0222	-0.0086
Climate change awareness and family labour	(0.691)	(0.410)	(0.782)
	-0.0350	-0.0173	0.0523**
Harvesting date	(0.251)	(0.570)	(0.075)
	-0.0955***	0.0498	0.0457*
Daily forecast and seasonal forecast	(0.001)	(0.11)	(0.069)
Animal transportation (donkey) and extension	-0.1873***	0.0081	0.1792***
services	(0.000)	(0.805)	(0.000)
	-0.0535	0.0243	0.0292
Average monthly income and average crop yield	(0.257)	(0.585)	(0.411)
	4.16E-05	0.0436	-0.0437
Education and changes to farming system	(0.999)	(0.144)	(0.161)
	-0.0061	0.0107	-0.0046
Average income	(0.859)	(0.787)	(0.884)
	-0.0111	-0.0986***	0.1097***
Gender and access to farm tools	(0.725)	(0.007)	(0.005)

* Marginal effects are above while p-values are in brackets. *, **, *** refer to significant at 10%, 5% and 1% respectively .Figures in parentheses are probabilities.

Table 5.10 shows the value of the estimated marginal effects. The marginal effects from the MNL model, which measure the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. The significant value shows whether a change in the independent variable significantly influences the Logitic odds at a given level (Gujarati et al., 2010).

For growing millet, results show that farming experience, climatology services and transportation/extension were the variables that significantly influence growing millet only. Specifically, the coefficient of farming experience is negative and significant at 5 percent. This result suggests that farming experience reduces the probability of growing millet only. This could be due to the fact that experienced farmers are multi-crop farmers and they are likely determined to be involved in multi-crop farming. In contrast, the coefficient of climatology services and transportation/extension are positive and significant at 5 percent level of probability. This result suggests that climatology services and transportation/extension increase the probability to grow millet only. This could be due to the training and knowledge acquired by farmers on the mono-cropping system which they believe can increase their productivity.

For millet intercropped with cowpeas, results show that farm experience, planting date, harvest date/planning, climatology services, transportation/extension and access to farm tools and gender were the variables that significantly influence growing millet intercropped with cowpeas. Specifically, the coefficient of farm experience is negative and significant at 1 percent level of probability. This result suggests that farm experience does not play a significant role in the decision to intercrop millet with cowpeas. In contrast, the coefficient of planting date is positive and significant at 5 percent level of probability. This result suggests that the planting date increases the probability of millet intercropped with cowpeas. This could be due to the fact that agricultural practices are time-bound. Similarly, the coefficient of harvest date/planning is positive and significant at 10 percent level of probability. This result suggests that harvest date/planning increases millet intercropping with cowpeas. Also, the coefficient of climatology services is positive and significant at 10 percent level of probability. This result suggests that climatology services increase the probability of millet intercropping with cowpeas. Finally, the coefficients of transportation/extension and access to farm tools and gender are positive and significant at 5 percent level of probability. This result suggests that transportation/extension and access to farm tools and gender increase the probability of millet intercropping with cowpeas.

Table 5. 9: Results of Multinomial Logit Regression

Independent Variables	Dependent Variables	
	P_1	P_2
	-0.5498	-1.2026
Farming experience	(0.025)**	(0.000) ***
	0.1222	0.4570
Planting date	(-0.555)	(0.026)
	0.1509	0.0137
Climate change awareness	(0.526)	(0.966)
	0.0988	0.4738
Harvest date/planning	(0.662)	(0.091)*
	0.6484	0.7229
Climatology services	(0.023)**	(0.011)**
	0.9222	1.9446
Transportation/extension	(0.011)**	(0.000)***
	0.3490	0.4262
Average farm productivity	(0.349)	(0.245)
	0.1700	-0.2571
Education	(0.467)	(0.386)
	0.0711	0.0021
Average monthly income	(0.807)	(0.994)
	-0.3316	0.6978
Access to farm tools and gender	(0.218)	(0.035)**
	-0.2057	-0.2057
Constant	(0.931)	(0.645)
Wald chi2(20)	44.02	
Prob > chi2	0.0015	
Log pseudo likelihood	-63.496258	
Pseudo R^2	0.3467	

*, **, *** refer to significant at 10%, 5% and 1% respectively

Figures in parentheses are probabilities for growing millet (P_1) only and millet intercropped with cowpeas (P_2),

Table 5.11 presents the results of the Multinomial Logit model. The Chi-square value of 67.38 showed that the Wald statistics are highly significant (P< 0.00), suggesting that the model had strong explanatory power. In the literature, Rahji et al. (2009) reported Pseud R^2 value of 0.3145 as representing a good-fit for a multinomial logit model. This study obtained a Pseudo R^2 value of 0.3467 which is an indicative of good fit for the estimated model.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This study investigated farmers' management practices and the effects of cowpeas on soil fertility in the Kavango regions. The aim was to determine the variation of soil fertility between farmers over time. This chapter presents the conclusion of the study where policy recommendations are given to improve smallholder farmers' farming practices based on the research findings.

6.2 Summary of the results and conclusions

The first objective was to investigate the socio-economic factors that lead to poor soil fertility by the smallholder farmers with the hypothesis that socio-economic characteristics of the farmers contribute to soil nutrients depletion. Most of the farmers perceived that their soil fertility varies from average to high which was not correct. Only 46 percent of the smallholder farmers had an education from secondary level upwards and this group could not understand the instruction given to them in English. Access to agricultural credit had a low percent with 93.4 percent of farmers indicating that they are without access. The least participants in farming activities were the young adults aged under 35 who were 15 in number. This may suggest that there are few young adults that participate in farming activities because they regard farming to be elderly people's work.

The results from multinomial regression show that the factors that lead to the growing of millet only are farming experience, climatology services and transportation/extension. The coefficient of farming experience is negative and significant at 5 percent. This result suggests that farming experience does not play a significant role here. This could be due to the fact that experienced farmers know the importance of multi-cropping and as such they are likely to be involved in multi-crop farming. On the other hand, the coefficient of climatology services and transportation/extension were positive and significant at 5 percent level of probability. This result suggests that climatology services and transportation/extension increase the probability to grow millet only. This could be due to the training and knowledge acquired by farmers on the mono-cropping system which they believe is less risky and could increase their productivity levels.

The second group of farmers were those who intercropped millet with cowpeas. For millet intercropped with cowpeas, results show that farm experience, planting date, harvest date/planning, climatology services, transportation/extension and access to farm tools and gender were the variables that significantly influence the growing of millet intercropped with cowpeas. The coefficient of farm experience is negative and significant at 1 percent level of probability. This result suggests that planting date increases the probability of millet intercropped with cowpeas. This could be due to the fact that agricultural practices are time-bound. Similarly, the coefficient of harvest date/planning is positive and significant at 10 percent level of probability. This result suggests that harvest date/planning increases millet intercropped with cowpeas. Also, the coefficient of climatology services is positive and significant at 5 percent level of probability. This result suggests that climatology services increase the probability of millet intercropped with cowpeas. Finally, the coefficients of transportation/extension and access to farm tools and gender are positive and significant at 5 percent level of probability. This result suggests that transportation/extension and access to farm tools and gender increase the probability of millet intercropped with cowpeas of the farmers as the experienced farmers might have knowledge and skills to improve soil fertility.

Objective two was to determine the nitrogen fixation ability of cowpeas to improve soil fertility. Cowpeas has been promoted as having the capability to improve soil fertility and increasing crop yields. The soil fertility result for the 90 observed farmers in the study was between low and very low. All the soil nutrients had decreased from the 2017 to 2019 growing season. One group of farmers who rotated cowpeas with millet had a slightly higher nitrogen level, potassium, organic carbon, calcium exchange and magnesium exchange than farmers who intercropped on average. The farmers who intercropped had slightly high phosphorus and sulphur than farmers who rotated on average.

The result from a Wilcoxon signed-rank test showed that there was not significant difference between 2017 and 2019 soil fertility score (p-value of 0.103) at 1 and 5 percent probability. The reason could be that the cowpeas was not grown for more seasons to bring significant differences to soil fertility and if planted for a shorter period the differences might not be significant. This study concludes that cowpea should not be grown for one or two seasons and expect a significant change in nitrogen fixation in the region. The only significantly difference for soil fertility score occurs between farmers in the region with a p-value of 0.009. The farmers in the Kavango East region have an average higher score. The differences in soil fertility in the two regions may be due to different soils in the regions. This result suggests that soil fertility is not homogeneous within the crop farms in the regions. The study concludes that there is no significant difference on soil fertility for planting cowpea or not, for a season.

6.3 Recommendations

This study supports the use of cowpeas or any legume crop to address the challenges of soil fertility as it is the cheaper method of improving soil fertility. Moreover, there is a need to find an innovative way to meet food security and improve soil fertility for the smallholder farmers. This should be based on the direct benefit to the farmers and soil improvement. Furthermore, young adults must be motivated to fully participate in farming by creating agribusiness opportunities. Improving policy on access to climatology services, transportation/extension services and farm tools will help the farmers to make a better decision on farming practices that will improve their soil fertility. Farmers should also have access to all agricultural services as an incentive to plant more cowpeas to improve soil fertility and productivity. Understanding that the smallholder farmers' soils have poor soil fertility, it is essential to apply fertilizers before planting especially phosphate fertilizer. Moreover, since phosphorus and potassium cannot be fixed by legumes, farmers have no option but to apply any available forms of fertilizers to add some nutrients to the soil. Besides, farmers' training must be extended to all the smallholder farmers in the regions with a designed programme to improve farmers' understanding of soil fertility, if changes are to be observed.

In addition, the government must aim at improving the market for cowpeas as this will increase the chances of farmers adopting the growing of cowpeas because it will have the additional benefit of generating money for the farmer. Policymakers must also consider that the farmers will derive primary benefits from the technology introduced such as cash returns, market contexts, yields, etc., which are some preferences that the farmers consider first before the secondary benefits such as soil fertility. Planting cowpeas has been proposed to improve soil fertility and increase crop productivity after a long period of time. The ability of cowpeas to improve soil fertility might not be seen immediately since it's a process but when farmers develop a positive attitude to adopt, it will offer long term positive results. This study recommends that cowpeas must be planted for a long period of time for soil fertility purposes so that its impact on soil fertility can be realised.

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APPENDICES

Appendix 1: The adequate nutrient from the observed farms

Adequate nutrient

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Calcium (Exch)	2	2.2	2.2	2.2
	Cation Exchange Capacity	1	1.1	1.1	3.3
	Magnesium (Exch)	3	3.3	3.3	6.7
	None	7	7.8	7.8	14.4
	Potassium (Exch)	1	1.1	1.1	15.6
	Potassium (Exch) and Cation Exchange Capacity	4	4.4	4.4	20.0
	Potassium (Exch) and Magnesium (Exch)	2	2.2	2.2	22.2
	PH	19	21.1	21.1	43.3
	PH and Calcium (Ech)	1	1.1	1.1	44.4
	PH and Calcium (exch)	19	21.1	21.1	65.6
	PH and Calcium (Exch)	2	2.2	2.2	67.8
	PH and Magnesium (exch)	7	7.8	7.8	75.6
	PH, Calcium (Exch) and Magnesium (Exch)	1	1.1	1.1	76.7
	PH, Cassium (Exch) and Magnesium (Exch)	3	3.3	3.3	80.0
	PH, Potassium (exch) and Calcium (exch)	1	1.1	1.1	81.1
	PH, Potassium (Exch) and Cation Exchange Capacity	1	1.1	1.1	82.2
	PH, Potassium (Exch) and Magnesium (Exch)	3	3.3	3.3	85.6
	PH, Potassium (exch), Calcium (exch) and Magnesium (Exch)	1	1.1	1.1	86.7
	PH, Potassium(Exch) and Magnesium (Exch)	1	1.1	1.1	87.8

	PH, Potassium (Exch) and Calcium (Exch)	2	2.2	2.2	90.0
	PH, Potassium (Exch), Calcium (Exch) and Magnesium (Exch)	1	1.1	1.1	91.1
	Potassium (Exch)	1	1.1	1.1	92.2
	Potassium (exch) and Cation Exchange Capacity	3	3.3	3.3	95.6
	Potassium (exch) and Magnesium (Exch)	4	4.4	4.4	100.0
	Total	90	100.0	100.0	

Appendix 2

QUESTIONNAIRE

Project: Potentials of adopting inoculate-treated cowpea and chickpea seeds for a higher nutrient accumulation in agrarian soils

Lat: **Long:** **Elevation:** **Start:** **Finish:**

Personal interview of farmers in Namibia

Place of interview:___________________________________ Date of interview:_________________

Name of interviewer:____

Instructions for interviewer

Before the interview:

i. Read all the instructions
ii. Read all the questions at least twice for yourself
iii. In case something is unclear, please contact the project head for further explanations

During the interview:

iv. Inform the interviewee about our institutes and the aim of the project

The aim of the project is ..

v. Tell the farmer that the survey may take a little longer. Stay focused and don't divert.
vi. Don't comment or explain a question. Repeat the question if necessary.
vii. Encourage the farmer to speak their mind.

After the interview:

viii. Take a photograph of the interview session for the record.
ix. Answer the following two questions based on your impressions:

1. Was the interviewee

① interested ②uninterested ③ cooperative ④ off-handed?

2. Do you think you got realistic/thoughtful responses? ① yes ② no

x. Maintain strict confidentiality about the answers

Types of questions

Open ended
Write key words, ideas, phrases, not whole sentences

Multiple choice
• Don't reveal the options to the interviewee, seek their views

	• Tick the appropriate option by darkening the circle: ① ->❶

1. Socio-economic profile

No.	Question	Response
1.1	Name of interviewee	
1.2	Village	
1.3	District	
1.4	State	
1.5	Age (in years)	_______ years
1.6	Gender	①Male ②Female ③Other
1.7	Family type	①Joint family ②Nuclear family
1.8	Education status	①Illiterate ②Primary ③Secondary ④Higher secondary ⑤Undergraduate ⑥Above all
1.9	Average monthly income	____________ (N$/month)
1.10	Sources of income	①Farming……………….% ②Wages/Salary……………..% ③Livestock……………..% ④Non-farm business……….% ⑤Other…………………..%
1.11	House type of interviewee (*observe and tick correct answer*)	①Cement+brick house with concrete roof ②Cement+brick house with metal sheet roof ③Wood house with metal sheet roof ④Traditionally built house ⑤ ⑥
1.12	Electricity access	①Regular ②Irregular ③no access
1.13	Available vehicles	①Bike ②Motorcycle ③Quad bike ④Car ⑤Tractor ⑥Lorry ⑦Drawn cart ⑧Other
1.14	Household utilities	①Gas connection ②Traditional stove ③LED bulbs

		④Refrigerator ⑤Radio/stereo
1.15	Sources of information/ ICT tools	①Cell-phone ②Smartphone ③Tablet ④Internet access ⑤Computer/laptop ⑥Television ⑦Landline phone ⑧Cable TV ⑨Other
1.16	Financial tools	①Bank account ②ATM/Debit card ③Credit card ④Internet banking ⑤Phone banking ⑥__________
1.17	Major living expenses of last month	①Food………………………………% ②Clothing…………………………% ③Education………………………% ④Housing…………………………% ⑤Health care……………………% ⑥Celebrations…………………% ⑦Investment……………………% ⑧Mobile phone………………% ⑨Travel……………………………% ⑩……………………………………% ⑪……………………………………% ⑫……………………………………%
1.18	Major agricultural costs of last season	①Seeds……………………………N$ ②Tilling……………………………N$ ③Insecticides…………………N$ ④Electricity……………………N$ ⑤Labor……………………………N$ ⑥Transport……………………N$ ⑦Feed/fodder…………………N$ ⑧Fuel………………………………N$ ⑨Irrigation………………………N$ ⑩Land rent……………………N$ ⑪Fertilizer………………………N$ ⑫Storage…………………………N$ ⑬Wages……………………………N$ ⑭ ……………………………………N$ ⑮……………………………………N$ ⑯……………………………………N$

2. Household information

No.	Question
2.1	How long have you been residing in this village? ___________years
2.2	Household size, on farm/off farm employment status?

Age	Number of members	In school	Full time on farm	Part time on farm	Full time off farm	Part time off farm	Status off farm
<15							

15-65							
>65							

2.3 How long have you been practicing agriculture? ___________years

2.4 What is the minimum cash you need for a month to run your household normally? _____________N$

2.5 Assuming that if every basic need of your family is met you are at 100%, to what extent do you think the basic needs of your family are met today? ____________%

2.6 Are you receiving any social security benefits or other governmental assistance (money/infrastructure/education)?

① no ② yes (then choose the appropriate categories):

①Food items	②Health care	③Free education	④Sanitation
⑤Transport	⑥Drinking water	⑦Agricultural support	⑧Housing
⑨Pension	⑩Electrification	⑪Employment	⑫Youth development
⑬Crop insurance	⑭ ____________________	⑮ ____________________	⑯ ____________________

2.7 Are you receiving any agriculture related assistance?

① no ② yes (then choose the appropriate categories):

① Fertilizers	② Seeds	③ Irrigation assistance	④ Support prices
⑤	⑥	⑦	⑧
⑨	⑩	⑪	⑫
⑬	⑭	⑮	⑯

2.8 What is the source of your drinking water?

① River	② Canal	③ Pond	④ Well
⑤ Hand-pump	⑥ Tap water	⑦ Spring	⑧ Other

2.9 Do you process/purify your drinking water?

① Always ② Sometimes ③ Never

3. Farm/agriculture related information

No.	Question
3.1	What is your land holding? ___________acres or __________hectare
3.2	What is your agricultural focus? ① Agriculture ② Horticulture ③ Animal husbandry ④ Fishery ⑤ Agro-forestry ⑥ _________________ ⑦ _________________ ⑧ _________________
3.3	Animals on farm? ① Poultry ② Cattle ③ Pigs ④ Sheep ⑤ Goats ⑥ Honeybees ⑦ _________________ ⑧ _________________
3.4	From where do you acquire your seeds? ① Last year's crop ② Traders ③ Seed company ④ Neighbors ⑤ Government ⑥ _________________ ⑦ _________________ ⑧ _________________
3.5	What are the assets of your farm? ① Drip irrigation ② Well ③ Farm pond ④ Cattle shed ⑤ Poultry house ⑥ Solar panel ⑦ Nursery ⑧ Bee hives ⑨ Plough ⑩ Sprinkler ⑪Pigsty ⑫Multi-purpose shed ⑬ ____________________ ⑭ ____________________ ⑮ ____________________ ⑯ ____________________
3.6	In your opinion, how high is the soil fertility of your farmland? ① very high ② high ③ average ④ low ⑤ very low

3.7	In the present situation, what are the main factors influencing your farming decisions? (*Go through the categories in table and tick appropriate column)*.

1	Weather	2	Soil fertility	3	Past experiences	4	Market demand	5	Own preference
6	Availability of inputs	7	Price of inputs	8	Transportation	9	Water availability	10	Crop condition
11	Expert advice	12	Investment potential	13	Season	14	Indigenous knowledge	15	Farm labor
16	Type of insect	17	Type of disease	18	Traditions	19	Associated risk	20	Expected profits
21	Trend in village	22	Market availability	23		24		25	

Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Crop choice																							
Sowing date																							
Fertilizer type																							
Fertilizer quantity																							
Soil tillage																							
Pest control method																							
Disease control method																							

	Irrigation investment																							

3.8	What is your main objective in farming? ① Maximize yield ② Sustain family livelihood ③ Maintain present yield levels ④ Sustain the environment

4. Participation and access to institutions

No.	Question
4.1	What is the distance of your farm to the nearest market? ____________km
4.2	What is the distance of your farm to the nearest paved road? ____________km
4.3	What is the distance of your home to the nearest school? ____________km
4.4	What is the distance of your home to the nearest health care facility? __________km
4.5	What is the distance of your home to the nearest bank? ____________km
4.6	What is the distance of your home to the nearest agriculture officer? __________km
4.7	What is the distance of your home to the nearest agricultural extension service center? ____________km
4.8	What is the distance of your home to the nearest police station? ____________km
4.9	What is your social participation/membership status? ① NGOs ② Village council ③ Religious institution ④ Farmers' club

	⑤ Farmers' coop	⑥ ________________ _	⑦ ________________ _	⑧ ________________ _
4.10	Do you regularly receive news about new farming knowledge/technologies/seeds? ① yes ② no ③ infrequently			
4.11	Have you changed anything in the last decade in your agricultural activities because you received new information? ① no ② yes, what:			
4.12	From which entities do you receive knowledge/information/awareness about new developments in agriculture?			

Agency/source	Quality of service			Frequency of contact (every …)				
	high	average	poor	week	14 days	month	2nd month	season
State department of agriculture								
Agricultural university								
Private companies								
Neighboring farmers								
Agricultural extension services								

4.13	Access to institutional services							
	Service	Access ?		Used?		Quality of support?			Source of service
		yes	no	yes	no	high	medium	low	(own, relative, agency, NGO,...)
	Agricultural credit								
	Machines								
	Farm tools								
	Marketing of produce								
	Post-harvest processing								
	Extension services								
	Weather forecast								
	Seasonal forecast								
	Market information								
	Crop insurance								
	Soil testing								
	Water testing								
	New seed varieties								

5. Food consumption and preferences

No.	Question
5.1	What are your family's main non-vegetarian food choices? ① Poultry ② Beef ③ Pork ④ Mutton

	⑤ Milk products ⑥ Eggs ⑦ __________________ ⑧ __________________
5.2	What are your family's main cereal/vegetable food choices? ① Millet __________% ② Maize __________% ③ Sorghum ________% ④ Wheat __________% ⑤ Pulses __________% ⑥ Cowpeas ________% ⑦ __________________% ⑧ __________________%
5.3	If your family regularly consumes cowpeas, do you prefer white or black ones? ①prefer white ②prefer black ③ depends on the dish ④ don't care
5.4	Which crops do you produce for your family and which for sale?

Crop	Own consumption [%]	Sale [%]
Millet		
Maize		
Sorghum		
Wheat		
Pulses		
Cowpeas		

5.5 Please provide some crop-specific information about yields/management on your fields:

Crop	Average **yields** [unit]	Av. **fertilizer** application [unit]	**Fertilizer** type(s)	**Tillage**? (yes/no)	Usual **planting** date(s)	Usual **harvesting** date(s)
Millet						
Maize						
Sorghum						
Wheat						
Pulses						

Cowpeas						

5.6 Storage of crop products

Crop	Easy to store, long storability	Easy to store, short storability	Hard to store, long storability	Hard to store, short storability
Millet				
Maize				
Sorghum				
Wheat				
Pulses				
Cowpeas				

5.7 Do you grow cowpeas on your farm? ① yes ② no

5.8 Do you grow chickpeas on your farm? ① yes ② no

5.9 Have you ever heard of inoculant treated seeds? ① yes ② no

5.10 Would you be willing to plant inoculant treated seeds if they increased yields on your fields?
① yes ② no

5.11 Would you be willing to pay more for inoculant treated seeds if they increased yields?
① yes ② no

6. Perception of climate change and general situation

No.	Question
6.1	I am aware about climate change ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree
6.2	I have observed unusual climate events in the last 10-15 years ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree
6.3	Climate change is man made ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree
6.4	Climate change is real and currently happening ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree
6.5	I am concerned about climate change and will contribute towards slowing it down ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree
6.6	Do you perceive the need to change your agricultural decisions based on the changes in climate? ① strongly agree ② agree ③ neutral ④ disagree ⑤ strongly disagree

6.7	Are you able to meet your family's nutritional needs? ① yes ② no ③ don't know
6.8	Are you able to meet your family's educational needs? ① yes ② no ③ don't know
6.9	Are you able to meet your family's health care needs? ① yes ② no ③ don't know
6.10	Are you able to meet your family's security needs? ① yes ② no ③ don't know
6.11	Are you able to meet your family's social needs? ① yes ② no ③ don't know
6.12	Are you able to make some savings each year? ① yes ② no ③ don't know

Any other comments?

Appendix 3: A sample of Soil test result

Fertilization and Management Advice

Rundu Rural West Namibia

88 Windhoek East/Namibia
354654321354
giz@email.com

General Information

Sample Number : ATTEF00230A17
Crop Name : Cowpea

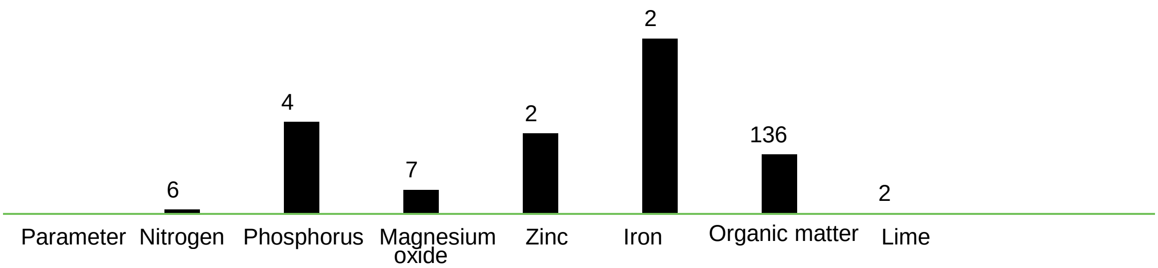
Date : 2017-01-30
Target Yield : 600 kg

Field Name : MILE 30 ADC

Field Size : 1 ha

Soil Texture : Sand

Actual Nutrient Need (in kg)



Soil Correction Plan

	Activiti	Instruction	Best	First	Second
1	Before	If Available	5 kg Agricultural Lime		
2	Before	If Available	136 kg Compost or Manure Animal		
3	At	Place the fertiliser at the bottom of the planting holes, put 10 cm of soil on top, add the seed and cover the seed with soil.	70 Kg 2:1:2 (19) and 85 kg TSP	3 kg DAP and 65 kg TSP	2 kg ENTEC 25:15 and 85 kg TSP

Suitable Crop Types

Potatoe	Bean	Grain	Vegetable

Your soil is suitable for growing potatoes, grains, vegetables and beans.

Soil Status

Parameter	Unit	Analysis Result	Range Low	Range High	Low	Adequate	High
pH (KCl)	pH Value	6,1	4,90	6,40		■	
Organic Carbon	g/kg	5,4	17,00	50,00	■		
Total Nitrogen	g/kg	0,4	1,00	2,00	■		
Potassium (exch.)	mmol+/kg	1,7	1,50	3,00		■	
Calcium (exch.)	mmol+/kg	31,0	15,00	25,00			■
Magnesium (exch.)	mmol+/kg	15,1	4,50	10,00			■
Zinc (M3)	mg/kg	0,1	2,50	4,00	■		
Cation Exchange Capacity	mmol+/kg	46,7	75,00	200,00	■		
Total Aluminium	g/kg	8,7	70,00	112,00	■		
Total Potassium	g/kg	1,0	11,00	23,00	■		
Total Silicium	g/kg	449,2	240,00	340,00			■
Total Iron	g/kg	4,8	31,00	81,00	■		
Total Phosphorus	g/kg	N/A					
Total Sulfur	g/kg	N/A					
Copper (M3)	mg/kg	N/A					

Head of Soil Cares Research - Peter van Erp