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FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE WATER CONSERVATION PRACTICES IN SMALLHOLDER FARMING SYSTEM: *A CASE STUDY OF SMALLHOLDER FARMERS IN OMUSATI REGION, NAMIBIA.*

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ABSTRACT

Namibia is the driest country in Sub-Saharan Africa and water shortage remains a serious challenge in agricultural productivity. Smallholder farmers in rural areas are often advised to adopt sustainable water conservation practices aimed to counter these challenges. However, the adoption of such practices among smallholder farmers is far below the expectations. Hence, this study was conducted to examine the current sustainable water conservation practices used by smallholders and what influential factors affect adoption of the introduced water conservation practices. A random sample of 30 smallholder farmers from six constituencies in Omusati Region was used. Field observation and a two-part questionnaire were used to collect data used in examining the level of water conservation adoption and to profile smallholder farmers. Descriptive and analytical statistics were used to analyse the collected data. The study showed that some sustainable water conservation practices such as ripping, planting basins, compost and drip irrigation were being adopted. ANOVA test results indicated that education status and farming experience of household heads have a significant impact on adoption rate of the introduced sustainable water conservation practices. Conversely, family size per household, farm size or cultivated land and the age of household heads have no significant effects on the adoption of sustainable water conservation practices. The challenges affecting smallholder's adoption of sustainable water conservation practices include lack of farm implements, lack of water conservation awareness, climate characteristics, lack of funds, shortage of farm labour, lack of water conservation knowledge, limited farmland for cultivation and lack of extension services and institutional supports. Based on the study findings its thus recommended that the Ministry of Agriculture, Water and Forestry and other concerned bodies should consider the identified influential factors and challenges to improve the situation and enhance the adoption of introduced water conservation practices.

Key words: Water conservation, Adoption, Smallholder farmers, Sustainable practices

TABLE OF CONTENTS

ABSTRACT ……ii
TABLE OF CONTENTS iii
ACKNOWLEDGEMENTS vi
DEDICATION vii
DECLARATION viii
ACRONYMS 1
CHAPTER ONE: INTRODUCTION 2
1.1 Chapter overview 2
1.2. Background of the study 2
1.3. Problem statement 5
1.4 Research objectives 6
1.4.1. Main Objective 6
1.5 Hypotheses 6
1.6 Significance of the study 7
1.7 Limitations of the study 8
1.8 Delimitations of the study 8
CHAPTER TWO: LITERATURE REVIEW 9
2.1 Chapter overview 9
2.2 A Critical assessment of literature on Agricultural Water Conservation 9
2.2.1 Evolution of Conservation Agriculture and its adoption in Sub-Saharan Africa 9
2.2.2 Definition of Conservation Agriculture (CA) 11
2.2.3 Status of Agricultural Water Conservation in Namibia 13
2.2.4 Importance of Water Conservation in Agriculture 13
2.2.5 Factors affecting the adoption of sustainable water conservation practices 14
2.2.6 Agricultural extension services in Namibia 17
CHAPTER THREE: RESEARCH METHODOLOGY 18
3.1 Chapter overview 18
3.2 Background of the study area 18
3.3 Research Design 21

3.4 Population 22
3.5 Sample size and Sampling procedures 22
3.6 Research instruments 24
3.7 Field data collection 25
3.7 Data Analysis 26
3.8 Research Ethics 27
CHAPTER FOUR: RESULTS AND DISCUSSION 28
4.1 Chapter overview 28
4.2 Study analysis 28
4.3 Current water conservation practices used 29
4.3.1 Ripping Method 30
4.3.2 Planting Basin Method 31
4.3.3 Compost Method 32
4.3.4 Drip irrigation Method 33
4.3 Demographic profile of the study participants 34
4.3 Factors affecting adoption of sustainable water conservation practices 37
4.4 Challenges in the adoption of sustainable water conservation practices 42
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS 46
5.1 Chapter overview 46
5.2 Conclusion ..... **Error! Bookmark not defined.**
5.3 Recommendations 47
REFERENCES 49

LIST OF TABLES

Table 4. 1: Gender of the study participants 35
Table 4. 2: Age range of the respondents 35
Table 4. 3: Family size per household 36
Table 4. 4: Education level of the respondents 36
Table 4. 5: Cultivated land by respondents (Farm size) 36
Table 4. 6: Farming experience among the respondents 37

Table 4. 7: Analysis of Variance for factors affecting adoption of water conservation practices by groups of the independent variables (n = 30). 38
Table 4. 8: Water conservation adoption challenges faced by respondents: multiple responses . 43

LIST OF FIGURES

Figure 3. 1: Study Area Map: Constituencies in Omusati Region, Namibia..... 20
Figure 4. 1: Respondents per constituency 29
Figure 4. 2: Water conservation practices currently adopted by smallholder farmers 30
Figure 4. 3a: Usage of ripping method by farmers Figure 4. 3b: A ripped land of one interviewed farmer along the Olushandja-Canal……..……..31
Figure 4. 4a*: Usage of planting basin by farmers*; *Figure 4. 4b: Planting Basins*..... 32
Figure 4. 5a: Usage of compost method by farmers; Figure 4. 5b: Showing farmers making a good compost…….33

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DEDICATION

I humbly dedicate this thesis to my family for their love, encouragement, the patience they showed and the support they provided during my study at the University of Namibia up to the very end of writing this thesis was indeed delightful.

DECLARATION

I, Bernadette Ndemwiika-Hinananye Amukuhu, declare hereby that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for any degree or examination in any other institution of higher education.

…… [signature] Date: April / 2020
[B.N. Amukuhu]

ACRONYMS

MAWF	Ministry of Agriculture, Water and Forestry
CA	Conservation Agriculture
GDP	Gross Domestic Product
FAO	Food and Agriculture Organization
IPCC	Intergovernmental Panel on Climate Change
NPCC	National Policy on Climate Change
CCAP	Comprehensive Conservation Agriculture Programme
UN	United Nations
SWC	Soil and Water Conservation
WC	Water Conservation
WCP	Water Conservation Practices
SSA	Sub-Saharan Africa
ADCs	Agricultural Development Centres
UNESCO	United Nations Educational, Scientific and Cultural Organization
MET	Ministry of Environment and Tourism
NDP	National development Plan
FFS	Farmer Field Schools
USA	United States of America
GIZ	German International Development Cooperation
NUST	Namibia University of Science and Technology
NGOs	Non-Governmental Organisation
ADB	African Development Bank

CHAPTER ONE

INTRODUCTION

1.1 Chapter overview

This chapter presents a brief background of the study which explains in detail the importance of sustainable water conservation practices in agriculture, particularly, smallholder farming in rural development. Furthermore, the problem statement of the research is presented in this chapter together with the objectives in this thesis.

1.2. Background of the study

The stable economic, social and political environment are pre-requisites for sustainable and successful development in any given society. This can be achieved through the identification of sectors with potential and thus the agriculture sector is identified under this category Shikesho [1]. The Namibian Agricultural sector is one of the leading sectors of the economy. However, it is faced with numerous challenges amongst others, changing of climatic patterns, including low and erratic rainfall and lack of well-adapted water conservation technologies that have resulted in crop productivity being compromised according to the Ministry of Agriculture, Water and Forestry (MAWF) [2]. The fifth National development Plan (NDP 5) of Namibia has identified Conservation Agriculture (CA) as a highly prioritized Government initiative to mitigate climate change effects thereby ensuring sustainable environmental, natural resource management and resilience, and enhancing crops production, livelihood and quality of life of smallholder farmers in the country [2]. Furthermore, the NDP 5 of Namibia's desired outcome number three and four is expecting that by the year 2022 the proportion of food insecure households has dropped from 25% to 12%, while food production has increased from 5% to 30% and the equality of life in rural

areas as well as socio-economic well-being has improved, with rural poverty reduced to 25% and unemployment to 20%.

The background of the research is drawn from rural development literature, where water conservation in agriculture is seen as a viable activity for rural development according to the Food and Agriculture Organization of the United Nations (UN) [3]. In Namibia, it is estimated that over 70% of the country's population depend to a greater extent on the agricultural sector which employs 27.4% of the labour force and contributes 6.1% to the Gross Domestic Product (GDP) as described in the World Bank 2015 report [4]. Though its GDP contribution to the overall economic activity is relatively small, the government has acknowledged the importance of agriculture, particularly, the rural smallholder farming in terms of poverty alleviation, job creation and rural development [2]. The Namibia's agriculture sector is divided into two different sub-sectors: the capital intensive, relatively well developed and export oriented commercial sub-sector in the south of the country; and the subsistence-based, labour intensive, and low-technology communal sub-sector in north of the country [5, 6].

Water conservation in agriculture is the most important feature of sustainable development. Therefore, the development of governmental and non-governmental water conservation practices is essential [7]. Additionally, in order to move towards the goal of sustainability and efficient water use in agriculture, decisive changes in human attitudes as well as behaviours are necessary [8, 9]. [3] estimates that, over the next 30 years, 60% of the global food supply will require irrigation. Competition for water resources is a major challenge for humans and the optimization of water use in agriculture to produce food is crucial [10, 11]. Karani and Sori [12], further argues that

innovative approaches toward sustainable water conservation in agriculture are critical for attaining food supply to the increasing world population.

Climatic variability is already a common phenomenon in Namibia with persistent droughts and floods, and unpredictable and erratic rainfall [13, 14]. Climate change presents a challenging record in human history and the report from Intergovernmental Panel on Climate Change (IPCC) [15] indicates that African countries have already been affected by climate change and East Africa and Southern African regions would be particularly vulnerable to climate change. Climate change threatens food security, economies and lives of people worldwide. Namibia is highly vulnerable to the impacts of climate change due to the country's high dependency on the climate sensitive sectors such as agriculture [6].

Change in climatic conditions will worsen the existing challenges relating to water resources particularly for developing countries and those that are vulnerable to climate change such as Namibia [2]. Therefore, in order to safe guard the livelihoods of the local communities the Government of Namibia together with implementing agencies has developed and implemented some adaptation interventions as well as policy frameworks to deal with the impacts of climate change [2]. At the policy level, Namibia recently developed a National Policy on Climate Change (NPCC) that provides a legal basis for resource mobilisation to address climate change adaptation and mitigation, and strives to manage climate change response in a way that recognises the national developmental goals, among others. Whilst at a local level, Namibia developed and implemented several pilot projects and community-based adaptation initiatives to help smallholder farmers plan their local adaptation projects. Some excellent projects have now been implemented in north central Namibia. One such is the Comprehensive Conservation Agriculture Programme (CCAP)

by the MAWF in the northern regions aimed at reducing smallholder farmers vulnerability to climate variability and change [2].

1.3. Problem statement

Agriculture in Namibia is faced with numerous challenges including water insufficiency. The Ministry of Agriculture, Water and Forestry has made an effort to increase smallholder farmers resilience to climate change through the CCAP and recent studies confirmed that although several sustainable water conservation methods had been established and promoted for the past years, the percentage adoption of many recommended practices was still minimal as majority still farms under relatively harsh conditions resulting in poor yields of farm produce [2].

This reveal that the government strategies have not had a significance positive influence on smallholder farmers at the grassroots. Most studies on sustainable water conservation practices in Namibia have only highlighted the benefits of farmers engaging in water conservation practices. While those that have looked at factors influencing conservation practices have to a smaller extent addressed the issues without focusing into an extensive area of the country. Notwithstanding all this, there is little information on factors affecting smallholders regarding their water conservation adoption practices because limited research has been done in Namibia. Therefore, faced with such low levels, the foregoing situation makes it necessary to further understand factors affecting the adoption of sustainable water conservation practices among smallholder farmers. However, no studies could be found to assess factors hindering the adoption of sustainable water conservation practices in Omusati Region against the background that smallholder farmers have several practices to adopt and utilize.

1.4 Research objectives

1.4.1. Main Objective

The main objective of the study was to assess factors affecting the adoption of sustainable water conservation practices among smallholder farmer in Omusati Region.

To achieve this main objective the following specific-objectives were fulfilled:

- Study various sustainable water conservation practices currently implemented by smallholder farmers in Omusati region.
- Evaluate smallholder's knowledge towards variation in the adoption level of sustainable water conservation practices.
- Study challenges limiting the adoption of sustainable water conservation practices among smallholder farmers.

1.5 Hypotheses

Based on the assumptions and discussion made about water conservation adoption behavior of smallholder farmers, the following hypothesis was made:

- H_0: The existing factors (Age, Family size, Farming experience and Farm size) have no significant effect on the adoption of sustainable water conservation practices at 95% confidence level ($\alpha = 0.05$).
- H_1: The existing factors (Age, Family size, Farming experience and Farm size) have a significant effect on the adoption of sustainable water conservation practices
- H_0: Education level of household heads has no significant effect on the adoption of sustainable water conservation practices at 95% confidence level ($\alpha = 0.05$).
- H_1: Education level of household heads have a significant effect on the adoption of sustainable water conservation practices.

1.6 Significance of the study

This study is relevant to scholars, agriculturalists and other readers as it is in line with the Fifth National Development Plan of Namibia which has identified Conservation Agriculture (CA) as a highly prioritized government initiative to mitigate climate change effects and thus currently emphasizing water conservation practices among smallholder farmers to ensure resilience, promote development and improve their livelihood. An increase in the adoption of sustainable water conservation practices is critical for reducing the vulnerability of smallholder farmers, especially in Namibia where agriculture is one of the leading sectors and faced with challenges of rapidly changing climate conditions. The study will eventually conclude in an overview of the existing sustainable water conservation practices adopted by smallholder farmers in the Omusati region and the challenges encountered and therefore recommendations made from the study can be used to provide significant guidance on how to handle factors that will condition or possibly restrict the adoption of sustainable water conservation practices. The study would also provide an in-depth knowledge that would allow the formulation of well-tailored interventions to facilitate close monitoring of water conservation activities.

Furthermore, the research would also add to the existing body of current knowledge on factors that affect the adoption of sustainable water conservation practices in Namibia. Additionally, future related efforts in other areas with similar characteristics may be targeted with less difficulty and it would allow for prediction of the speed at which adoption of conservation practices to be introduced would likely take place. Lastly, this study could be used as a reference for other researchers intending to study more on water conservation practices.

1.7 Limitations of the study

Challenges were experienced in terms of data collection. Collecting data from participants proved to be very challenging especially in the rural areas where smallholders resides and carry out farming activities. This was due to limited time and remoteness of the villages resulting in fewer farmsteads being assessed. Moreover, the researcher carried out the study when water conservation practices were supposed to be in full implementation, but challenges were experienced due to low rainfall received in the study area and regarding the conservation practices some were farmer declared, and not observed hence it is not possible to establish if the farmers were truly implementing the practices. Additionally, agriculture extension officers were present during the interview and that had some negative impact as participants ended up reluctant to respond to questions with honesty. The study also had no control over the exact information that the participants would choose to give or withhold. Although there were challenges in terms of data collection, the study still makes a very significant contribution in understanding current sustainable water conservation practices adopted by smallholder farmers in the case study area.

1.8 Delimitations of the study

The study was carried out in Omusati region only and the generalization of the study was limited to six selected constituencies in the region. Furthermore, the research was only confined to the factors affecting sustainable water conservation adoption among the smallholder farmers and with such, any other information which was not part of the defined parameters of the study was deemed out of scope. In addition, the study was also limited to 5 participants per constituency in the region and results were then interpreted within the context of the case study area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter overview

This chapter presents the literature review on the background of sustainable water conservation practices in smallholder farming systems under Conservation Agriculture (CA). The chapter further discusses its definition, status quo regarding water conservation in Namibia, its importance to smallholder farmers, the factors affecting the adoption water conservation practices and also tries to give a brief overview of Agricultural extension services in Namibia. The information obtained from the review was crucial in determining the aims and objectives of the study.

2.2 A Critical assessment of literature on Agricultural Water Conservation

2.2.1 Evolution of Conservation Agriculture and its adoption in Sub-Saharan Africa

Conservation Agriculture (CA) has been practiced around the world for the past decades [16]. The adoption of CA practices began in the United States of America (USA) in the 1930s among commercial farmers following a severe soil erosion crisis in the Mid-West which became known as the "Great Dust Bowl" and Over time, the popularity of CA in the US grew due to increased viability of crop farming [16]. From the USA, CA spread to South America, particularly Brazil, among large-scale farmers, and later to small-scale farmers in the 1990s, Brown et al. [17]. Presently, Conservation Agriculture is gaining acceptance and is spreading to Sub-Saharan Africa region, particularly in eastern and southern Africa where at least 15 Sub-Saharan African countries are now using CA (Kenya, Uganda, Tanzania, Sudan, Swaziland, Lesotho, Malawi, Madagascar, Mozambique, South Africa, Namibia, Zambia, Zimbabwe, Ghana and Burkina Faso) [17]. In the

Sub-Saharan Africa, innovative participatory approaches are being used to develop supply-chains for producing CA equipment targeted at small holder farmers. Similarly, participatory learning approaches such as those based on the principles of Farmer Field Schools (FFS) are being encouraged to strengthen farmers' understanding of the principles underlying CA and how these can be adapted to local conditions [18].

According to [19] the concept of Conservation Agriculture is outlined in a series of principles and practices that are promoted. The Three basic principles of Conservation agriculture which must be fulfilled concurrently are briefly explained below.

- ***Maintenance of permanent organic soil covers***

Maintenance of permanent soil cover involves keeping the soil covered as much as possible as this ensure sufficient residual biomass to enhance soil and water conservation, and control soil erosion. In turn, this enhances water infiltration and soil moisture retention by reducing evaporation which provides increased insurance against drought. This principle also improves soil water use efficiency as it protects soil from erosion, extreme temperature and fluctuations. Permanent soil cover is maintained during crop growth phases as well as during fallow periods using crop residues left on the field, mulch and special cover crops maintaining residues on the surface which helps in suppressing of weed growth throughout the year [19].

- ***Continuous minimum soil disturbance***

This principle allows for continuous minimal or little mechanical soil disturbance as possible through zero tillage systems. Zero tillage is a 'cornerstone' of CA, this reduces soil erosion and

enhances water infiltration, improves soil structure, maintain soil biodiversity, slower mineralization of soil organic matter and improves nutrients retention as tillage or cultivation is reduced to ripping planting lines and/or making planting basins with a hoe. The reason is to plant directly into the soil, without ploughing or ensuring low- soil disturbance [19]

- ***Crop species diversification and crop rotations***

This is the third and last CA principle and it's also known as "Mix and rotate principle" as it involves planting the right mix of crops in the same field, and rotating crops from season to season. This helps to improve soil fertility through leguminous nitrogen fixation, ensure optimal utilization of available water and nutrients, promote a healthy, living soil through crop rotations, cover crops, and the use of integrated pest management technologies. In addition, these practices enhance biodiversity, reduce requirements for pesticides and herbicides and control off-site pollution. Crop rotations and associations can be in the form of crop sequences, relay cropping and mixed crops in order to balance natural soil biodiversity and to create a healthy soil micro-environment that is naturally aerated, better able to receive, hold and supply plant available water, provides enhanced nutrient cycling and better able to decompose and mitigate pollutants [19].

2.2.2 Definition of Conservation Agriculture (CA)

Conservation Agriculture has been interpreted differently. Thus, numerous authors have attempted to define it in order to bring out the key principles to sustainable water conservation. It is this different interpretation that brings about different perceptions towards the implementation of CA. According to [16], Conservation Agriculture is an approach to managing agro-ecosystems for improved and sustained productivity and food security while preserving and enhancing the

resource base and the environment. Moreover, [19] redefined Conservation Agriculture as farming system that maintains a permanent soil cover to assure its protection, avoids soil tillage, and cultivates a diverse range of plant species to improve soil conditions, reduce land degradation and increase water and nutrient use efficiency. CA enhances biodiversity and natural biological processes above and below the ground surface for improved and sustained crop productivity. On the other hand, Dumanski *at al*. [20] defined Conservation Agriculture as a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields.

Though there are various definitions of Conservation Agriculture, most definitions emphasized more on water conservation and producing high crop yields while reducing production costs. Thus, CA is the best way to achieve maximum water conservation in sustainable agriculture in order to improve livelihoods. [20] further argues that Conservation Agriculture relates directly to the United Nations Framework Convention on Climate Change, the International Convention on Biodiversity, the United Nations Convention to Combat Desertification as well as the various agreements on international waters. Therefore, it's essential as it provide direct benefits to environmental issues of global concern, such as climate change, water quality, biodiversity, land degradation, air quality and labour shortages. CA is best achieved through community driven development processes whereby local communities and farmer associations identify and implement the best options for CA in their location [20]. Moreover, local, regional and national farmer associations, working through community workshops, farmer-to-farmer training with

technical backstopping from conservation professionals, are the main players in the promotion of CA [20].

2.2.3 Status of Agricultural Water Conservation in Namibia

In Namibia, nearly two-thirds of the population has been estimated to live in rural areas, where majority heavily depends on rain for crop production [2]. Poor rainfall negatively affects their livelihoods with crop failures or low production and leaving them food insecure [2]. For the past decades, Namibian farmers have been using traditional water conservation practices for pearl millet (*pennisetum glaucum*) production that have been passed on to them by their ancestors [6]. These practices are still an integral part of their farming systems and include planting basins (pot holding) method and the use of organic compost [6]. Regarding the Agricultural water conservation status, the Namibian Government has launched a Comprehensive Conservation Agriculture Programme (CCAP) in March 2015 that is to run until end of 2019 [2]. The CCAP aims to increase knowledge and awareness of CA among farmers and extension workers, and enhance crop production through various water conservation practices that have been promoted [2]. CCAP has been introduced to the farmers by public agencies. The German International Development Cooperation (GIZ) and the Namibia University of Science and Technology (NUST) are partners in the programme [21].

2.2.4 Importance of Water Conservation in Agriculture

According to Unger [22] water conservation in agriculture has been heavily researched globally during the past 100 years and researches has been conducted at several institutions and research

facilities. Water capture is the first step in water conservation. The need to promote water conservation in agriculture was encouraged by both economic and physical factors that became a common experience of the farmers. [22] further emphasized that the ideologies of water conservation for agriculture are the same whether crop production is under rainfed or irrigated conditions. Water must be captured, retained, and used efficiently for producing a desirable yield. These ideologies have been recognized for several years and thus, agricultural water conservation is promoted as a good method for reducing water diversion while minimizing the impact on production [22].

2.2.5 Factors affecting the adoption of sustainable water conservation practices

The need for further investigation in terms of smallholder farmer's perceptions towards the concept of sustainable water conservation adoption has becomes an agricultural issue of concern, more specifically during poor rainfall seasons. Thus far, several practical methods of water conservation procedures are made available for use by smallholder farmers in developing countries and therefore several studies have investigated factors affecting the adoption of water conservation practices as well as the appropriate management of this vital agricultural resource, Huckett [23]. Land and tenure is a constraining factor that influences smallholder farmers' decisions to adopt water conservation practices in Kenya [23]. Kassie et al. [24] found that farmers in rural Tanzania prefer to invest towards water conservation practices when they have secured land tenure because they themselves derive the benefits in the long run. Assefa-Mengstie [25] indicates that Ethiopian farmers used both traditional and advanced practices for water conservation where farmers education level and awareness has been closely associated with the adoption of sustainable water

conservation practices. Among small scale farmers in Kwara State in Nigeria, the educational level of the farmers was found to positively influence the adoption of conservation methods [10]. Additionally, [24] argues that the more educated the farmer, the higher the likelihood of adopting water conservation measures as educated farmers tend to be aware of the benefits of water conservation practices.

Sikwela [26] is also of the view that education level assist smallholder farmers with the ability to interpret and understand information. Siulemba and Moodley [27] acknowledge that water conservation practice is knowledge intensive, so high levels of education is necessary for the proper implementation and management of sustainable water conservation practices. Babalola and Olayemi [28] highlighted that adoption of sustainable conservation practices in maize and cassava production in Nigeria is greatly influenced by farmers' participation in programmes that teach conservation practices, as participation greatly increases the farmers' awareness of the various water conservation practices. Chomba [29] observed that contact between extension services and farmers can increase the adoption of water conservation practices. [10] supported the view that low levels of extension contact negatively affects farmers' adoption of sustainable practices due to the lack of information from extension agents.

Rezvanfar et al [30] expanded the idea of Chomba [29] that adequate extension services could increase awareness about the effects and consequences of sustainable water conservation practices among smallholder farmers as farmers tend to adopt water conservation practices that have been communicated to them by extension agents. Thomas [31] carried out a study on factors affecting subsistence farmers' adoption of sustainable land management practices in Oshikoto region, Namibia and found that factors such as Farm size, Labour shortages, Lack of finances, Climate

characteristics, Access to extension services and institutional support negatively affects farmers' adoption and use of land management practices. However, the study by [30, 7] found that farm size had no effect on the adoption of sustainable water conservation practices.

According to Arbuckle [32] analysis of past research indicated that the larger the farm, the more likely farmers are to adopt water conservation practices. Furthermore, Heyi and Mberengwa [33] states that large farm sizes can significantly increase farmers' prospect of implementing conservation practices. Insufficient land area may thus play a role in farmers' adoption of such practices. While individual farmer characteristics influence whether or not a farmer decides to adopt a given conservation practice, [10] reveals that key characteristics of the conservation practices themselves also affect farmer adoption. Therefore, identifying these key characteristics can help match a practice with a farmer and help determine how to best reach the farmer with information about a specific practice [10].

Siulemba and Moodley [27] states that socio-economic variables such as gender and age tend to influence farmers decisions to adopt sustainable agricultural practices. Sikwela [26] mention the importance of farmers' age and farming experience as important attributes in influencing the decision for the adoption and practice of sustainable farming practices. Additionally, Chisasa [34] states that farmers age affects their decisions and interest in practicing sustainable farming. Whilst [35, 36] studies indicated that farmers age does not affect farmers their decision on of water conservation adoption. A similar study on the analysis of factors affecting adoption of sustainable soil conservation practices among wheat growers in Iran and found that family size had no effect on adoption of water conservation [30].

2.2.6 Agricultural extension services in Namibia

Prior to Namibia's independence, extension services were mostly provided to commercial farmers while smallholder farmers were not receiving any farming assistance from the government according to, Paulus [6]. After independence, there was an essential policy shift for extension services to be mainly focused on the previously disadvantaged small-scale farmers in the rural areas. Extension services are being provided mainly by the state through the Ministry of Agriculture Water and Forestry, Thomas [31]. A few Non-Governmental Organisations (NGOs) and agricultural training institutions also provide extension services to farmers, but they are extremely limited [31]. Furthermore, [31] states that extension services are provided in the form of training, advice, information and credit schemes mainly in subsidized form. The Ministry of Agriculture, Water and Forestry have decentralized extension services to farmers and it has been a challenge as extension offices and farmers are in remote areas, away from Agriculture Development Centres (ADCs) where training on advanced farming technologies is being undertaken [31]. Moreover, farmers and extension officer's capacity to travel to distant centres is restricted by unavailability or unreliability of transport, hence the ratio of extension officers to farmers remains very low in Namibia [6].

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Chapter overview

This chapter provides an overview of the study area and discusses the methodology employed to undertake the study. Furthermore, it outlines the research design, describe the population, sampling process, data collection and data analysis procedures adopted in the study, and concludes with ethical procedures which were taken into consideration.

3.2 Background of the study area

The study area is the Omusati region, which is situated in the northern part of the Republic of Namibia and shares its frontiers with Angola on its North Western border, with Ohangwena Region on the North-East, Oshana Region on the East and Kunene Region on the South-West. According to [1] Omusati Region is semi-arid and covers approximately 26,551 km². The word 'omusati' is an Oshiwambo word meaning a mopani tree. The landscape of the Region is made up of mopane trees which is a dominant species and spreads across the Region on shallow sand. The Region is the third largest populated in Namibia with 249 885 inhabitants, constituting 10.8% of the total population, [1]. The majority of the population in this Region is mostly rural (94.3%) and depends heavily on agriculture for their livelihood with only 5.7% of the total found in the urban areas, [1] Subsistence farming is the main farming system practiced by smallholder farmers in the region and it contributes 7% to the total agricultural output in Namibia [2]. Here the farming is rain fed, and pearl millet (Mahangu) is the staple crop. The farming lands are normally distributed to individual households by traditional authority.

According to [1] the Region also includes various big and small-scale irrigation projects, with Etunda Irrigation Project (Government owned) being the largest. Maize is the primary crop on the commercial plot, while watermelons, tomatoes, potatoes and bananas, among other citrus fruits and vegetables are grown throughout the calendar year seasonally. Besides the aforementioned activities, local citizens also engage in livestock farming, conservancies and retailing. Shikesho [1] further state that the Region is a semi-arid and climate in the area is characterised by high temperatures ranging between 25-37 Degrees Celsius and the average annual rainfall ranges between 350-500 mm per annum with the highest rain falling from November to April. The relatively high and reliable average rainfall allows for crop farming. However, crop production remains low in many areas of the region due to poor water-holding capacity, low nutrient content, high salt content, and hard layers of clay below the surface as soil types are largely dominated by sands and clays. The Region falls under the very flat hydrogeological Cuvelai Basin (which drains into the Etosha Pan), an ephemeral river system bringing runoff rainwater from Angola during the rainy season.

Shikesho [1] states that the Omusati Region is divided into twelve (12) Constituencies, namely Anamulenge, Elim, Etayi, Ogongo, Okahao, Okalongo, Onesi, Oshikuku, Outapi, Ruacana, Tsandi and Otamanzi based on the latest 2018 Omusati Regional profile report. The study was only conducted in six constituencies. Below is a map that indicate the study area, Omusati Region (Figure 1).

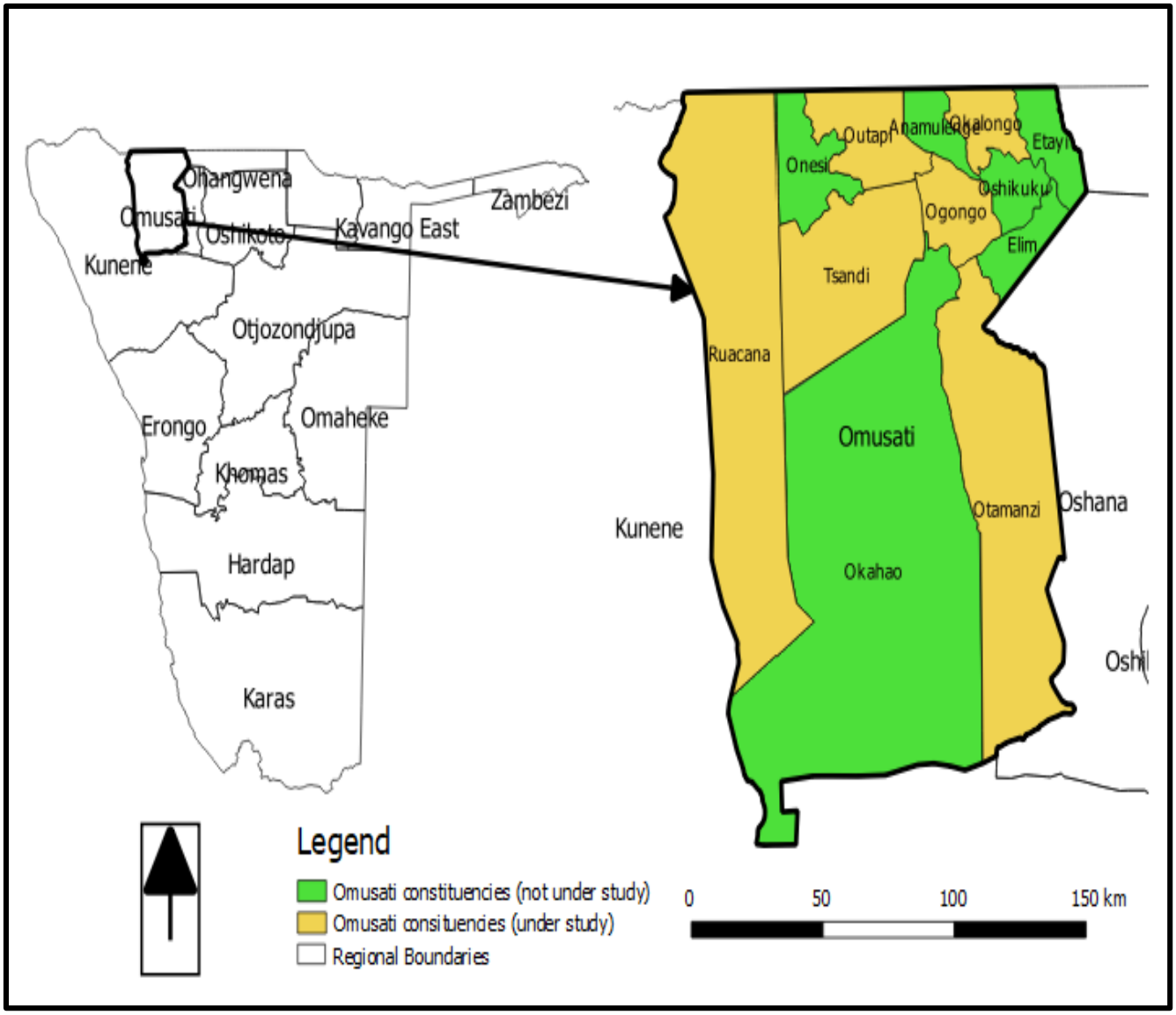

Figure 3. 1: Study Area Map: Constituencies in Omusati Region, Namibia

Source: Map produced from the Arch GIS

3.3 Research Design

The case study followed a mixed methods research design, using both quantitative and qualitative research (non-experimental) and employed a survey technique. Cresswell [37] indicates that mixed methods approach is a procedure for collecting and integrating both qualitative and quantitative data at some stage of the research process within a single study. The rationale for using a combination of both quantitative and qualitative approaches is that together they provide a more complex understanding of one's research problem as it counters the shortcomings of both the quantitative and the qualitative approaches. Glesne [38], further highlighted that quantitative research methods use numbers in closed-ended questions and its meant for testing theories by examining relationships amongst variables and on the other hand, qualitative research methods use words through open-ended questions, makes use of case studies and is mostly used for exploring and understanding the meaning of individuals or groups attributed to a social or human problem. Qualitative research is the category of research that focuses on qualities such as words or observations that are difficult to quantify and lend themselves to interpretation or deconstruction [38].

Chrownholm and Hjalmarsson [39] state that the mixed method approach is more than collecting data and analysing it from the qualitative and the quantitative approach, but provides a specific perspective of the world and to achieve findings that are more trustworthy. Therefore, in this study the researcher mixed the two methodological approaches in order to gain a better understanding of the problem under investigation.

3.4 Population

The population of the study comprised smallholder farmers resident in constituency of Ogongo, Ruacana, Outapi, Okalongo, Otamanzi and Tsandi who adopt various water conservation practices. The reason for the selection of this population was because the constituencies are distant and smallholder farmers may have different experiences and views of the different factors that affect the adoption of sustainable water conservation practices in their particular areas. In addition, smallholder farmers from the selected constituencies irrespective of their gender, age, education level, farmland size and farming experiences formed part of the population. This therefore, provided more insight into the factors affecting smallholder farmers adoption of sustainable water conservation practices in the Omusati Region.

3.5 Sample size and Sampling procedures

According to Creswell [37], Sampling involves the process of selecting the number of individuals for a study in such a way that the individuals represent the larger group from which they were selected. [37] further detailed that, there is a lack of guidance in the selection of sample size in qualitative research. Patton [40] acknowledged the role of resource limitation in determining a qualitative sample size. Marshall [41] argues that the selection of study sample is significant as it is not practical, efficient or ethical to study the whole population and that both quantitative and qualitative sampling procedures require different sample sizes. The purpose of quantitative sampling approach is to draw a representative sample from the total population so that the results of studying the sample can then be generalized back to the population while for qualitative research the researcher studies a phenomenon in a particular context and it cannot be generalized [41]. Onwuegbuzie [42] highlight that the sample size in the qualitative research should involve the use

of small samples, as dealing with too large samples may become difficult to extract thick, rich data at the same time and also that if samples are too large it may become difficult to achieve data saturation. Fox et al. [43] added that if the potential subjects of the study are a big number, reducing the number is necessary, through random sampling in quantitative research in order to ensure validity, as every individual in the population has an equal chance of being selected. The use of correct sampling procedures in research reduces costs, allows for the research to be conducted more efficiently and provides for greater accuracy [44].

Several statisticians such as Hogg *et al*. [45] and Longnecker and Ott [46] have demonstrated that at least 30 participants are considered a large sample size. For this reason, this study adopted the theory of these scholars by selecting a sample size of 5 participants from each of the six constituencies which amounted to a total sample size of 30 participants. Firstly, convenient sampling was used to select Omusati Region as the site for the study. The rationale behind selecting this region was because that was where the researcher came from and that farmers would be more open in sharing their viewpoints. In addition, it was expected that smallholder farmers might have similar water conservation challenges to any of the other regions. Purposeful sampling technique was used to select the six constituencies that forms part of the study sample. Furthermore, for the selection of smallholder farmers to answer the questionnaires, the simple random probability sampling was used to select 30 participants to form farmer's sample of the study. Consequently, the simple random probability sampling used allows each member of the population to have equal chance to be included in the study. Some farmers were contacted in advance to schedule a convenient time for the interviews.

3.6 Research instruments

In this study, the questionnaires were used as instruments to collect data with a single visit. The questionnaires were developed by the researcher, and contained both closed-ended and open-ended questions. Battacherjee [47] states that the questionnaire instrument in research consists of a set of questions intended to capture responses from the respondents in a standardized manner and that in the questionnaire, questions may be "Structured" (closed-ended questions) or "Unstructured" (open-ended questions). [47] further indicates that structured questions ask respondents to select an answer from various responses or options given, while unstructured questions ask respondents to provide responses in their own words. Therefore, this study used semi- structured questionnaires for data collection. The strengths of semi-structured questionnaires are that the researcher can get rich detailed data about individual experiences and perspectives to explore participants' views in more depth [47].

The questionnaire for each smallholder farmer (Appendix 1) consisted of three sections (A to C) which included both open-ended and closed questions. Section A constituted demographic questions to gather information regarding farmers' gender, age, education level, farm size, family size and farming experience. Section B, mainly closed questions focused on the adoption of water conservation practices by smallholder farmers. Farmers were asked whether they adopt a given water conservation practice such as Ripping method, Planting basin method, Compost method and Drip irrigation method to which a "Yes" or "No" answer was given. The questions inquiring farmer practices about water conservation practices were closed as there was no room for farmers to say anything more than the prescribed "Yes" or "No" answers. A Three-items scale was used for rating farmer's preferences on various field water conservation practices, with 1 representing poor, 2

Average and 3 Good. Lastly, Section C focused on the challenges limiting the adoption of water conservation practices. Herein, semi-structured, face-to-face interviews for smallholder farmers were employed. The interviews incorporated open-ended questions to allow for in-depth responses by the participants and attain clarification on the investigated factors. To reduce elements of bias, uniform questionnaire type (both open and closed-ended questions) were used to ensure that data on the same issues are collected from the different participants as stated by [47]. The questionnaires had content validity because they consisted of questions that were relevant to the subject under study and that questions were formulated according to various categories which provided answers to the research questions. [47] indicates that questions in the questionnaire should attempt to answer the research questions. The questionnaires were prepared in advance and revised to ensure proper layout and usability before the actual interviews took place. The surveys were conducted over a timespan of two weeks.

3.7 Field data collection

Both quantitative and qualitative data were considered of equal importance in the study. Data collection started with the collection of quantitative data through the questionnaires, and then moved to the collection of qualitative data through the interview and field observations. Firstly, visits were made to the Agriculture extension offices in all the constituencies under study. The intentions for the visits were to get the list of the names of the smallholder farmers in each constituency. Each selected farmer was contacted telephonically and separate appointments were made for appropriate consultation. The questions in the questionnaire were translated to the participants to have a clear understanding of the questions. The qualitative data was gathered using a combination of in-depth interviews with the farmers and some field observations. Observations

were also done during the study period, especially on the existing water conservation practices in the region, in order to fulfil the first objective of the study, which was to determine various sustainable water conservation practices current implemented by smallholder farmers. The combined use of methods ensured a complete understanding of current practices and behaviour towards water conservation when collecting information on farms and where possible to uncover possible differences between actual practices and those stated by the participants. In addition, each semi-structured, face-to-face interview per participant was conducted separately. The data gathered in the field was collected in the form of detailed field notes.

3.7 Data Analysis

The qualitative data collected was categorised into key issues and analysed using Statistical Package for the Social Sciences (SPSS) software to produce graphs and descriptive statistics of frequency, mean, standard deviation to describe smallholder farmers characteristics. Frequency tables were also used to present the frequencies to which the factors re-occur in the participant's responses. ANOVA test was used to detect significant differences among the means of the water conservation scale by the groups of the independent variables (factors). Descriptive statistics by drops was computed to compare the independent variables (age, farm size, farming experience, education level and family size) with respect to the dependent variables of the study (adoption of water conservation methods). This was done in order to compare differences in descriptive statistics which rate smallholder farmers' tendency to adopt various water conservation practices. The analysis was guided by the research questions and thus, results are discussed based on the objectives of the study. Confidence interval of $p < 0.05$ was used.

3.8 Research Ethics

Brikci and Green [49] state that in doing research, the starting point is to consider ethical issues and four principles should always apply, which are; "Autonomy – respect the rights of the individual; Beneficence – doing good; Non-maleficence – not doing harm; Justice – particularly equity". According to [50] adhering to ethical issues is part and parcel of any research project. Assuring respondents of critical issues, such as confidentiality and anonymity and how this is adhered to, is imperative for the success of any study. Researcher must obtain consent from the respondents who wish to participate in the study without forcing them [49].

For this study an ethical clearance letter to conduct the study was first obtained from the University of Namibia. Then, permission to carry out the study in smallholder farmers from the six constituencies under study was acquired from the regional office (The Chief Regional Councilors and Traditional authorities) (see Appendix 2). After obtaining the permissions, the researcher went to the smallholder farmers within the selected constituencies so that they can voluntarily participate in the study. The researcher clearly informed the participants of the purpose of the study and that the information gathered in the questionnaire would be kept confidential and would only be used for study purpose; therefore, no part of the information would be used for any other purpose. The researcher also assured them of their right to withdraw from the study if they so wish to at any time during the course of the data collection without any consequences or explanation. All effort was taken to ensure that no harm is done to any participant. The identities of the participants were kept anonymous by the exclusion of participants' names and use of numbers. The data collected was kept confidential by storing the questionnaires in a locked suitcase.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chapter overview

This chapter presents the data collected as well as the data analysis and discussion of the results from thirty (30) study participants according to the research questions. Additionally, appropriate links are made with the literature on smallholder farmers perceptions towards factors affecting water conservation adoption, both in general and specific to Namibia. Data collected through questionnaires is presented and analyzed into themes such as the socio-demographic profile of respondents (age, family size, gender, farm size, farming experience and level of education). The chapter will further be divided into different units to make a distinction between current water conservation practices adopted and factors affecting farmers decisions in regards to sustainable water conservation practices.

4.2 Study analysis

This section presents data from 30 participants in the six sampled constituencies of the Omusati region, namely; Ogongo, Okalongo, Otamanzi, Outapi, Ruacana and Tsandi. *Figure 4.1* below shows percentages of the respondents whereby five participants were interviewed from each constituency and represents 16.7%. This is supported by [45] and [46] who demonstrated that in any research at least 30 participants are considered a large sample size to represent a population.

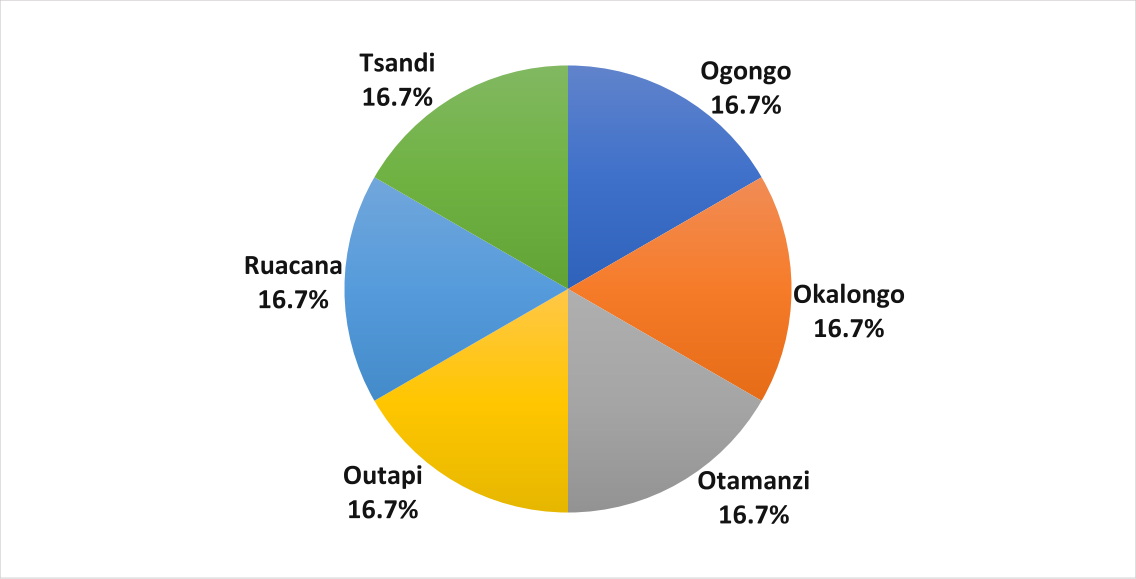

Figure 4. 1: Respondents per constituency

4.3 Current water conservation practices used

One of the research objectives was to study the current sustainable water conservation practices implemented by smallholder farmers in Omusati region. To achieve this, both field research and observations were carried out which provided a clear insight on various water conservation practices currently used by smallholder farmers in the region and the motivation behind these. The usage of practices has been similar throughout the visited constituencies with minor deviations in some areas. The majority of the respondents highlighted that water decline is a major problem experienced due to rainfall variations and stated that water conservation measures are therefore necessary. Figure. 2 below shows the various water conservation practices found to be used within the study area.

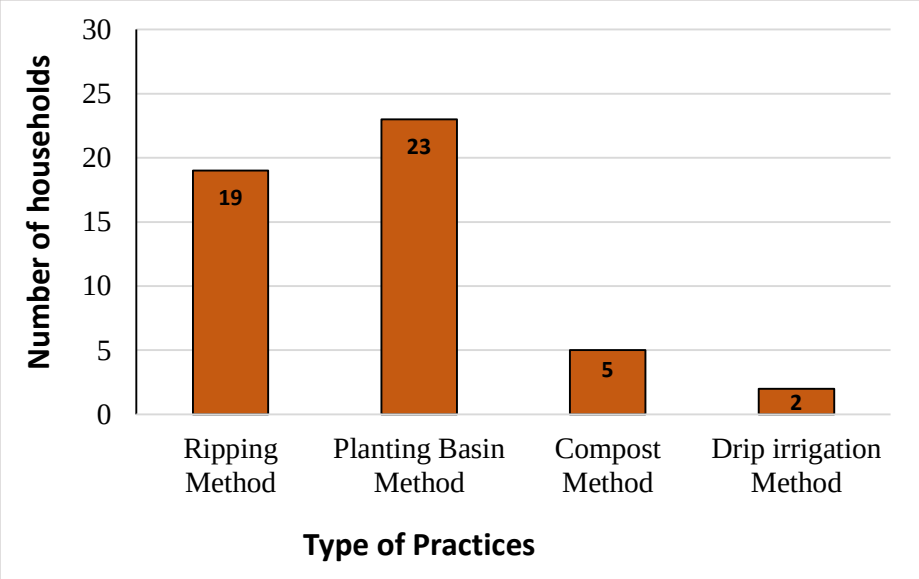

Figure 4. 2: Water conservation practices currently adopted by smallholder farmers

As shown in *Figure 4.2*, of all 30 respondents interviewed, planting basin was the most adopted water conservation practice with a vast majority of 23 households, followed by the ripping method with 19 households, compost method with 5 households and drip irrigation method with 2 households. Moreover, it was depicted from the results that some smallholder farmers interviewed tend to adopt more than one water conservation practices. This could be explained by the fact that some conservation practices are traditional practices and form part of basic farming.

4.3.1 Ripping Method

The deep ripping method also known as "*deep tillage*" is a water conservation practice that involves the use of strong deep working tines (spikes) that penetrate the compacted soil and mechanically break up and shatter the soil hard pan [51]. The effectiveness of deep ripping is achieved when the ripping tines are able to penetrate below the compacted soil layer. This creates deep furrows that traps water and increase soil moisture content as presented on *Figure 4.3*(*b*).

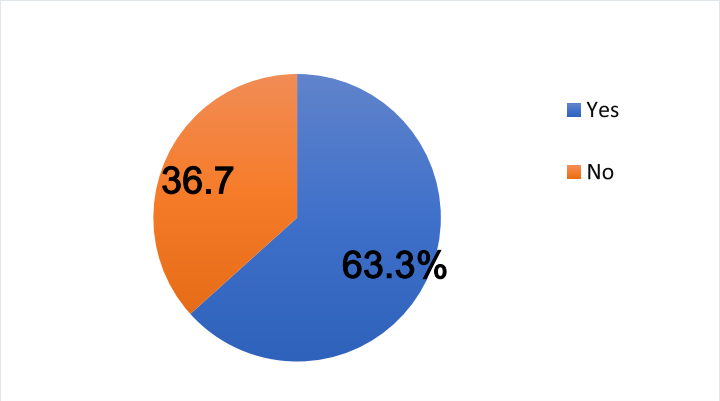

Figure 4. 3a: Usage of ripping method by farmers

Figure 4. 3b: A ripped land of one interviewed farmer along the Olushandja-Canal

(Photo taken by BN Amukuhu)

As depicted in *Figure 4.3*(***a***), only 63.3% of farmers currently use the ripping method as a water conservation practice whilst 36.7% do not use the practice. Some farmers, though make up the 63.3% explained that they had used some ripping practices but later stopped them. Respondents further stated that they have abandoned the use of ripping method because of the cost and absence of ripping implements. Several farmers insisted that they only have one ripper per constituency to be shared of which the ploughing season is too short to depend on one implement and that buying one is too expensive. However, others who managed to use the ripper said they do not have the labour to plough the whole field at once.

4.3.2 Planting Basin Method

According to FAO [51] this method is also known as "*Pot holing*" or "*Planting pits*" and describes it as a precipitation harvesting method used to preventing water runoff and thereby increasing infiltration and reducing soil erosion. Mostly, holes are dug 50-100 cm apart from each other with a depth of 5-15 cm in order to prevent water runoff, as demonstrated in *Figure 4.4 (b)* below. This practice disturbs only a small percentage of the topsoil area of fields which supports the second Conservation Agriculture principle of ensuring continuous minimum soil disturbance as explained under literature review.

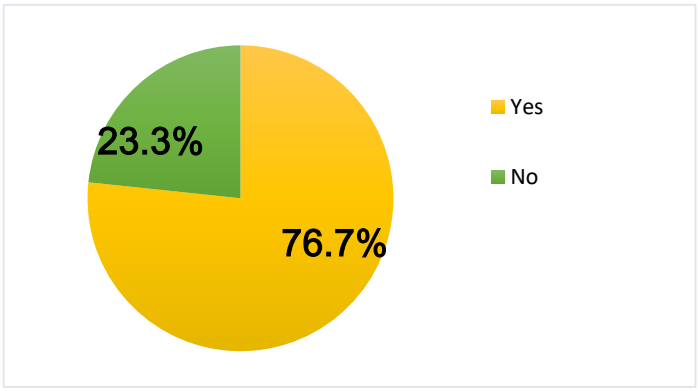

Figure 4. 4a*: Usage of planting basin by farmers*

Figure 4. 4b: Planting Basins

Source: Internet (2019)

The use of planting basin method is a common practice as shown in *Figure 4.4*(***a***) and attained the highest level of adoption by 23 farmers with 76.7% amongst all other available water conservation practices. The majority of respondents during the study highlighted that they have knowledge on planting basins and that they use hand hoes to make planting basins for water conservation. This method ensures minimum tillage to avoid soil disturbances. Farmers further detailed that planting basins are simple to implement and maintain as crops are planted directly into planting holes or basins, largely for the purpose of harvesting water. Planting basins are most suitable on arid and semi-arid area and soils with low permeability, such as silt and clay [51].

4.3.3 Compost Method

Composting is the process of speeding up the biological decomposition of organic materials by microorganisms under controlled, aerobic conditions which would otherwise occur more slowly if materials were directly added to the soil Shock [52]. Plant and grass materials are broken down to a relatively stable humus-like material called compost. Adding compost as a thin layer of mulch over bare soils by a practice called top- or side-dressing is an effective barrier against water evaporation [52]. Compost improves the soil's water holding capacity and increases moisture retention as soils tend to hold water for a longer period, more on *Figure 4.5 (b)* below;

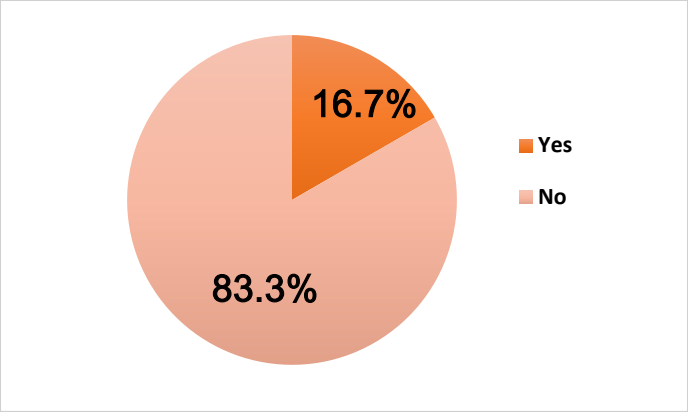

Figure 4. 5a: Usage of compost method by farmers

Figure 4. 5b: Showing farmers making a good compost

(Photo courtesy of Score Project)

The results in *Figure 4.5(a)* shows that among the smallholders interviewed, adoption of compost method as a water conservation practice is very low with 16.7%. While majority 83% of the responded indicated to make no use of the compost method, although all the ingredients to make a basic organic compost where found to be readily at hand. Furthermore, one respondent reasoned that he does have knowledge of compost method, but cannot adopt it as extra labour is needed to handle large amount of compost for a bigger field.

4.3.4 Drip irrigation Method

Drip irrigation method is a type of micro-irrigation system used in sustainable water conservation and help in water use efficiency, Shock [52]. The author further detailed that this practice conserve water by allowing water to drip slowly in order to reduce evaporation, runoff and deep percolation, and also to improve irrigation uniformity. Drip irrigation use plastic tubing which are placed in or near the plants' root zone and provides slow, uniform application of low-pressure water to soil and plants [52]. The drip irrigation method is illustrated in *Figure 4.6 (b)* below.

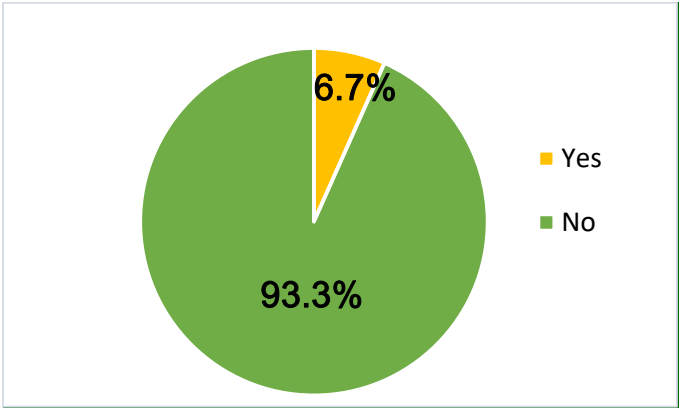

Figure 4. 6a: Usage of drip irrigation by farmers

Figure 4. 6b: Vegetables grown under drip irrigation by interviewed farmers along Olushandja-Etaka Canal

(Photo taken by BN Amukuhu)

The use of drip irrigation as a water conservation practice among the respondents shows more variation throughout the results as depicted in *Figure 4.6(a)*. Where there was sufficient water to irrigate crops in the dry season, drip-irrigation was used by 6.7% of the farmers. Low rate of adoption is to a large number of the respondents who indicated that there was no enough water to practice drip irrigation during the dry season. And since the wet season doesn't require any irrigation due to sufficiency of rainwater alone, farmers who only cultivated their fields in the wet season drip irrigation system was never a priority.

4.3 Demographic profile of the study participants

The demographic profile of respondents was taken into consideration during this study. This is supported by Makhura [53] who states that demographic profile of respondents are essential attributes in any research as they determine some decisions or action taken by smallholder farmers to practice sustainable agriculture. The author indicated attributes such as gender, age, family size,

education level, farm size, and farming experience as contributory factors in adopting sustainable water conservation practices. The profile data was collected and is presented below.

Table 4. 1: Gender of the study participants

Gender	Frequency (n = 30)	Percentage (%)
Males	13	43.3
Females	17	56.7

Table 4.1 above reveals that out of thirty (30) respondents interviewed in the study area 43.3% were males and 56.7% were females. Its commonly acknowledged globally that women are more involved in agricultural activities than the male counterparts. Thamaga-Chitja and Morojele [54] emphasises that 80% of active smallholder farmers in the Sub-Saharan Africa (SSA) are females and over 2 million of these come from Southern Africa. The author further detailed that in Southern Africa poor people enter into smallholder farming to obtain extra food for poverty eradication, and that women do most of the productive work in smallholder agriculture due to their traditional and cultural roles. Moreover, women do more in rural areas, and that traditional and cultural constraints usually extend further to women beyond household chores as some male heads of households leave women to take decisions related to participation in water conservation practices.

Table 4. 2: Age range of the respondents

Age range of respondents (years)	Frequency (n = 30)	Percentage (%)
< 40	1	3.3
40 to 60	6	20.0
< 60	23	76.7

Table 4.2 shows the age range of the respondents. The respondents below the ages of forty years (< 40) constituted 3.3%, the ages of 40 to 60 years constituted 20.0% and respondents above the ages of sixty years (> 60) constituted 76.7%.

Table 4. 3: Family size per household

Number of people per household	Frequency (n =30)	Percentage (%)
< 2	0	0
2 to 5	17	56.7
> 5	13	43.3

The data from Table 4.3 shows that majority 56.7% ranges between 2 to 5 people per household, whilst only 43.3% are more than 5 people per household.

Table 4. 4: Education level of the respondents

Education level of the respondents		Frequency (n = 30)	Percentage (%)
	None	9	30.0
	Basic	10	33.3
	Secondary	3	10.0
	University	8	26.7

Table 4.4 displays the education level of the respondents. According to the results presented only 30 % of the respondents have no formal education, 33.3% of the respondents have basic education, 10 % of the respondents in the study area have secondary education and 26.7% of the respondents have university certificates and diplomas. The primary occupation of most respondents was agriculture and the rest had off farm employment.

Table 4. 5: Cultivated land by respondents (Farm size)

	Cultivated land (ha)	Frequency (n = 30)	Percentage (%)
	< 2	1	3.3
	2 to 3	13	43.3
	> 3	16	53.3

The results in Table 4.5 shows the amount of land cultivated by respondents where majority 53.3% indicated that their cultivated area is more than three (3) hectares, 43.3% indicated to cultivate

about 2 to 3 hectors while the remaining 3.3% reported that their cultivated area is less than 2 hectares of land. In addition, respondents indicated that they acquire their land through inheritance or through traditional authority.

Table 4. 6: Farming experience among the respondents

Number of years in farming	Frequency (n = 30)	Percentage (%)
< 10	2	6.7
10 to 20	9	30.0
21 to 30	10	33.3
> 30	9	30.0

Table 4.6 above shows the number of years the respondents have been involved in farming (farming experience). According to the results 6.7% of respondents have been involved in farming for less than 10 years, 30% of the respondents have been involved in farming between 10 and 20 years, 33.3% of the respondents have been involved in farming between 21 and 30 years and 30% of respondents have been involved in farming for more than 30 years.

4.3 Factors affecting adoption of sustainable water conservation practices

The main aim of this study was to find out what exactly prevents smallholder farmers adoption of introduced sustainable water conservation practices. As noted previously in the literature review that nearly two-thirds of the Namibia's population has been estimated to live in rural areas where majority are smallholder farmers and they heavily depend on rain for crop production [2]. Poor rainfall impends food security and thus sustainable water conservation practices are intended to increase famers resilience to climate change [2]. Based on assessment and field observations major influential factors in adopting water conservation practices in the study area were identified by analysing the dependant variable (adoption of water conservation methods) against five independent variables as shown in Table 4.7 below.

Table 4. 7: Analysis of Variance for factors affecting adoption of water conservation practices by groups of the independent variables (n = 30).

		Descriptive		*statistics*	*ANOVA Test*							
					Ripping	method	*Basin*	*method*	*Compost*	*method*	*Drip*	*method*
Variables	**Groups**	**Frequency**	**%**	**Group mean of WC Scale scores**	***F***	***P-Value***	***F***	***P-Value***	***F***	***P-Value***	***F***	***P-Value***
Age (years)	< 40	1	3.3	10.01								
X = 2.73,	40 to 60	6	20	16.67	0.002	**0.962**	0.273	**0.680**	0.924	**0.345**	0.422	**0.521**
SD = 0.52	> 60	23	76.7	13.04								
Farm size (ha)	< 2	1	3.3	20.00								
X = 2.5,	2 to 3	13	43.3	14.62	2.92	**0.099**	0.628	**0.435**	3.871	**0.059**	0.000	**1.000**
SD = 0.57	> 3	16	53.3	12.50								
Education	None	9	30.0	10.06								
Level	Basic	10	33.3	12.23	4.595	**0.001**	2.861	**0.093**	5.654	**0.001**	9.737	**0.001**
X = 2.74	Secondary	3	10.3	16.34								
SD = 0.85	University	8	26.7	20.15								
Farming	< 10	2	6.7	15.00								
experience	10 to 20	11	36.7	12.72	0.147	**0.001**	0.487	**0.000**	6.44	**0.001**	1.421	**0.001**
X = 2.73,	21 to 30	10	33.3	14.00								
SD = 0.91	> 30	7	23.3	14.29								
Family Size	< 3	0	0	0								
X = 2.43,	3 to 5	17	56.7	14.12	0.324	**0.574**	1.643	**0.210**	0.078	**0.782**	2.885	**0.101**
SD = 0.50	> 5	13	43.3	13.08								

Table 4.7 presents the ANOVA test results used to identify significant differences among the water conservation methods by the groups of the independent variables (factors) shown, and the descriptive statistics by drops was computed to compare the independent variables (age, farm size, farming experience, education level and family size) with respect to the dependent variables of the study (adoption of water conservation methods).

The results of the analysis indicated that age had no significant effect on the adoption of water conservation methods ($p > 0.05$). The mean score of the water scale for the age range of 40 to 60 group was higher than other groups, which suggests that middle aged farmers are more likely to adopt water conservation techniques. As farmers age increased above 60 years, the probability of adopting water conservation decreased as they become exhausted and unable to adopt water conservation methods. This finding is supported by Prokopy [55] who found that older farmers are less likely to change their behaviours and adopt new practices. This author further reasoned that for farmers near retirement, purchasing new equipment for conservation practice adoption or learning a new technology or management skill is a low priority. Whilst young farmers below 40 years are mostly no longer part of farming as they are discouraged by the lack of economic returns of growing crops or rather not interested in farming as they have a view that farming is for the elderly people, Jara-Rojas et al. [35].This finding is similar to that of Bekele [36] who argues that farmers age had no significant effect on adoption of water conservation measures.

Some study respondents explained why they tend to practice water conservation at a late stage of their lives; one male respondent indicated that he only got into serious farming and started water conservation practices after he retired from work in Outapi. Additionally, respondents above 60

years of age indicated that they practice water conservation to ensure food security, because a monthly grant that they are receiving is not enough for them to buy food to sustain their families.

Similarly, farm size is often, but not always related to innovation adoption. According to the results of Table 4.7, the farmlands size cultivated by respondents had no significant impact on farmers' adoption of water conservation practices ($p > 0.005$), this means that as farm size increases the possibility to adopt water conservation practices decreases. The study finding is in line with the findings of [30, 7] that farm size had no significant effect on the adoption of sustainable water conservation practices.

On the other hand, a study by Asfaw and Mulugeta [56] showed a negative relationship between the size of farmland cultivated and the probability of adopting water conservation practices. [56] reasoned that it is due to labor intensive nature of constructing water conservation structures. The same result is also supported by Habtamu [57] who acknowledged that there exists no significant relationship between farmland size and farmer decision to adopt water conservation practices because most farmers who cultivate large farmlands are old aged farmers and have short term plan and/or lack the labor force for maintaining conservation practices.

Number of years involved in farming is one of the contributing factors to involvement in water conservation adoption, [53]. The years of farming (farming experience) results as presented in Table 4.7 indicates that experience in farming had a significant effect on adoption of sustainable water conservation practices at the 95% confidence level ($p< 0.005$). This is consistent with the findings of Illukpitiya and Gopalakrishnan [58] as they explained that farmers with experience knows the benefits of adopting water conservation methods hence are more likely to continue adopting and maintaining them.

Family size as shown in Table 4.7 the results reveals that it had no significant effect on adoption of water conservation practices since $p > 0.005$. additionally, from the study results, the highest mean scale scores were found to be for families with less than five family members per household. Corresponding to this, is the study findings of [30, 59, 60] indicated that family size had no significant effect on adoption of water conservation since increase in family size put pressure on financial resources available to hire employees for water conservation practices. [60] further stated that the increase in family size put pressure on financial resources available to hire employees for water conservation practices. Similarly, Fikru [61] detailed that farmers with larger family sizes are less likely to continue using introduced water conservation practices, because, in a larger household, competition arises for labor between on-farm food production and off farm activities, and hence, less time will be allocated for undertaking water conservation measures.

In line with the second objective, it is hypothesized that smallholder's education level is likely to have an impact upon the adoption of best sustainable water conservation practices. From the attained results in Table 4.7 shows that the mean of the water conservation scale score increased from 10.06 to 20.15 as education level increased., the p-value for ripping, compost and drip irrigation method was significant at $p<0.005$ level and were mostly adopted by respondents with basic and university education level only. Whilst for planting basin method the p value = 0.093 > 0.05 which show that there is no statistically significant difference between education level and adoption of planting basin method as it appears that even respondents with no formal education used the method.

Therefore, considering the p-value results for ripping, compost and drip irrigation method it shows that better educated farmers are more engaged in the adoption of the newly introduced water conservation practices than non-educated household farmers. This finding is similar to that of other

scholars, like [62, 25, 7] who argues that the level of education had a significant effect on adoption of water conservation practice because smallholder farmers with higher education levels were more aware of the benefits of adopting water conservation methods. Siulemba and Moodley [27] also detailed earlier that adoption of water conservation practices require high levels of formal education since it is knowledge intensive. This is in agreement with the results of Rezvanfar et al. [30] who found that the education level and adoption of sustainable water conservation techniques are positively and significantly correlated.

Similarly, [61] described that better education level of household heads had a strong and positive relationship with farmers' adoption of water conservation practices, because better exposure to education increases farmers' better understanding of the benefits and constraints of water conservation.Contrary to this, [35, 60] found that education level had no significant effect on water conservation practices and this supports the finding of the study that shows education level had no significant effect on use of planting basin method. Furthermore, [6] indicated earlier that Namibian farmers have been using traditional water conservation practices that have been passed on to them by their ancestors without formal education. This explains that illiterate farmers are better to be involved in the use of water conservation practices than educated farmers who are usually engaged in the off-farm activity [6].

4.4 Challenges in the adoption of sustainable water conservation practices

As noted previously, smallholders are faced with numerous challenges. The third objective to study the challenges limiting adoption of sustainable water conservation practices faced by smallholder farmers in the study area, was achieved by asking the respondents what the main challenges in the

adoption of sustainable water conservation practices were and possibly, how they could be addressed. During the interviews, majority of respondents indicated that there were challenges in the study area with regards to sustainable water conservation adoption and this is indicated in Table 4.8 below.

Table 4. 8: Water conservation adoption challenges faced by respondents: multiple responses

Water conservation challenges	Frequency (n=30)	Percentage (%)
Climate characteristics or seasonal differences	25	83.3
Lack of Funds	24	80.0
Limited farmland size	13	43.3
Shortage of farm labour	16	53.3
Lack of extension services and institutional support	26	86.7
Lack of water conservation knowledge	15	50.0
Lack of farm implements to use (e.g. Rippers)	28	93.3
Lack of water conservation awareness	27	90.0

Table 4.8 above shows various challenges in implementing sustainable water conservation practices by respondent in the case study area. Most of the respondents (93.3%) indicated lack of farm implements (Rippers) as a challenge. One respondent pointed out that "*there are no enough implements in our constituency and that sometimes the extension services have to borrow rippers from other constituencies to help us rip our fields, this gives us limited time to prepare our fields as rainfall season is too short"*. Another 90.0% indicated lack of water conservation awareness. Respondents' stresses that there is no enough awareness available to provide them with advanced water conservation practices. Therefore, they rely only on indigenous knowledge, their own experience, neighbours and other farmers for all their agricultural information.

Furthermore, 86.7% of respondents indicated lack of extension services and institutional support as they stressed that they do not receive extension services and there is no extension agent from supporting institutions to interact with them and advise them on how to improve their water conservation practices. 83.3% indicated climate characteristics or seasonal variation to be another challenge due to changed rainfall patterns and thus not able to adopt water conservation on time.

Respondents highlighted that it is hard to think of water conservation practices to use when one half of the ploughing season almost doesn't get any rain, and the other half way too much. Conservation measures that are effective for a whole season almost never work for half a season. 80.0% indicated financial limitations (lack of funds) as another challenge. Some respondents stated that they rely on monthly pension and they cannot afford to buy personal farm implements for water conservation because it is expensive. 53.3% shared their view that shortage of farm labour is also a challenge they experience in implementing water conservation practices. These farmers indicated that some water conservation methods are labour intensive and they required a helping hand to cover large portion of the field. This had forced some farmers to hire labour, which they claim to be expensive.

On the other hand, 43.3% of the respondents indicated that due to limited farmland size they become too reluctant and do not implement the necessary water conservation practices. As one responded revealed "*I would like to start adopting water conservation, but the size of the crop producing land is not enough, so the Department of Agriculture should help with stumping equipment's for land clearing and avail more land for farming and to adopt water conservation practices".* and lastly 50.0% indicated lack of water conservation knowledge. Respondents reasons that they lack knowledge about the most effective methods of water conservation practices

and thus did not consider to try them. This means that knowledge about sustainable water conservation methods should be widespread. The results are in consistent with the findings of Thomas [31] on challenges limiting farmers' adoption of sustainable land management practices.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter overview

This chapter concludes the study findings. The findings are discussed in relation to the aim and objectives of the study. It further summarizes recommendations to provide room for improvement in the future.

5.2 Conclusion

The poor level of sustainable water conservation practices adoption is common in developing countries. Given the continuing poor productivity of smallholder agriculture in sub-Saharan Africa, Namibian farmers are advised to adopt sustainable water conservation practices that help to minimize the impact of climate change and become climate-resilience. This study was conducted with 30 smallholder farmers from six constituencies in Omusati Region to assess factors affecting the adoption of sustainable water conservation practices and thus providing useful information about the status of agricultural water conservation practices in the region. The study further looked at the current water conservation practices adopted and the results obtained during field visits and observation has been similar throughout the visited individuals with minor deviations in some areas. The findings further indicate that smallholders interviewed are aware and adopt sustainable water conservation practices such as ripping method, planting basins method, compost method and drip irrigation method. Planting basin method is the most adopted water conservation technique, and drip irrigation being the least. It can, therefore, be said that

respondents understand water conservation methods theoretically and not practically. Furthermore, the adoption of water conservation practices in the study area are influenced by factors such as education level and farming experience which were found to have a significant impact on the rate of sustainable water conservation adoption. Whilst factors of age, farm size and family size were found to have no significant effects on the adoption of sustainable water conservation practices. Nevertheless, smallholders were also found to face numerous water conservation adoption challenges which includes; lack of farm implements to use (e.g. Rippers), lack of water conservation awareness, climate characteristics or seasonal differences, lack of funds, shortage of farm labour, lack of water conservation knowledge, limited farmland for cultivation and lack of extension services and institutional supports. these were all observed on the ground and are critical.

5.3 Recommendations

Majority of the respondents showed to have a positive attitude towards the adoption of sustainable water conservation practices and therefore the study recommends that to accomplish maximum water conservation adoption by smallholders the most important issue is education. Education level proved to increased respondent's awareness of the benefits of sustainable water conservation practices. Increasing extension delivery and continuous awareness campaigns in the study area to disseminate and support practices that are useful and easy to adopt should be considered. For sustainable water conservation programmes to be effective, base-line information on their potential users is crucial. It is important to talk with people in the area to identify local concerns before promoting a certain water conservation practice because if the messages don't address local concerns, then the outreach campaign will have limited success.

Prokopy [55] detailed that according to Everett Rogers' famous theory on the "Diffusion of Innovations," for innovations like conservation practices to diffuse through a community, the potential adopters first have to be knowledgeable about the key characteristics of conservation practices. Then, they have to be convinced that the practice is beneficial to them. Consequently, such information can contribute to sound decision-making about what water conservation practices should be promoted or discouraged, and how it should be done [55]. Therefore, the Ministry of Agriculture, Water and Forestry and other concerned bodies should consider the identified influential factors and challenges, participatory learning approaches such as Farmer Field Schools should be encouraged to strengthen farmers' understanding of the principles underlying CA and how these can be adapted to local conditions (capacity building), as well as the Everett Rogers' famous theory on the "Diffusion of Innovations to enhance the adoption of introduced water conservation practices.

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APPENDIX 1

Agricultural Water Conservation Questionnaire

JUNE, 2019

This questionnaire is based on Water Conservation Practices (WCP) available to smallholder farmers in Omusati region. The WCP were approved by the Namibia's Ministry of Agriculture water and Forestry and were implemented for a successful water management program intended to enhance smallholder farmers resilience to climate change and climate variability to improve their livelihood. This questionnaire will assess various Water Conservation methods adopted as well as challenges for improving water use efficiencies by subsistence farmers.

FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE WATER CONSERVATION PRACTICES QUESTINNAIR FOR SMALLHOLDER FARMERS

FARMER'S BACKGROUND INFORMATION

Questionnaire number : **……** **Date: …….**

Put a cross (X) in the correct box where appropriate

Gender: Male [ ] Female [ ]

Constituency Name: …….. **Number of family members…….**

Years of Farming : …… **Land under cultivation (ha)…….**

Age of household head : < 40 years [ ], 40 - 60 years [ ] > 60 years [ ]

Education Level of household head: …… No education [ ], Basic [ ], Sec [ ], Univers [ ]

Best Management Practices (BMPs)

a). <u>For Current Condition</u>: Please indicate whether or not the following best water conservation practices were implemented and how many hectors were affected by the practice.

b). <u>For Water (Moisture) Retention</u>: Please rate from a ratio of 1 to 3; (3 being Good and 1 being Poor).

1. <u>Best Water Conservation Management Practices</u>

1.1. **RIPPING METHOD**

Yes ☐ No ☐

Rating: Good ☐ Average ☐ Poor ☐

Reason for your rating

……
……
……
……
……

1.2. **PLANTING BASIN METHOD**

Yes ☐ No ☐

Rating: Good ☐ Average ☐ Poor ☐

Reason for your rating

……
……
……
……
……

1.3. **COMPOST METHOD**

Yes ☐ No ☐

Rating: Good ☐ Average ☐ Poor ☐

Reason for your rating

……
……
……
……
……

1.4. **DRIP IRRIGATION METHOD**

Yes ☐ No ☐

Rating: Good ☐ Average ☐ Poor ☐

Reason for your rating

……
……
……
……
……

2. Briefly state the Challenges limiting the adoption of these sustainable water management practices (i.e. Farm size, Level of education, awareness, availability of extension services etc.):

……
……
…….

3. What do you think can be done to overcome these challenge

……
……
……

APPENDIX 2

REPUBLIC OF NAMIBIA

OMUSATI REGIONAL COUNCIL

OFFICE OF THE CHIEF REGIONAL OFFICER

Tel: +264 65 251019
Fax: +264 65 251078 / 088639090
E-mail: info@omusatirc.gov.na
Website: www.omusatirc.gov.na
Our Ref: 9/2/2
Enquiries: Mr Abisai Shaningwa

Erf 1080 Namaungu Street
Private Bag 523
OUTAPI

15 April 2019

Dr Ing. Joachim Lengricht
HOD Civil and Environmental Engineering
University of Namibia
PO Box 3624
ONGWEDIVA

Dear Dr Lengricht

FINAL THESIS PROJECT ON "ASSESSMENT OF FACTORS AFFFECTING THE ADOPTION OF SUSTAINABLE WATER MANAGEMENT PRACTICES IN SUBSISTENCE FARMING, OMUSATI REGION, NAMIBIA

1. The Council hereby acknowledges receipt of your Letter dated 11 April 2019 regarding the above-mentioned subject

2. We therefore would like to inform your office that approval is hereby granted for Ms Bernadette Ndemwiika Amukuhu (Student No 201778236) to proceed with her research. However, she is advised to report herself at Otamanzi, Okalongo, Ruacana, Ogongo, Outapi and Tsandi Constituencies Offices before she embarks on her work in the Constituencies.

3. In addition, she is requested to provide a copy of the findings to the Regional Council upon completion of her research.

Sincerely,

Gervasius Kashindi
ACTING CHIEF REGIONAL OFFICER

OMUSATI REGIONAL COUNCIL
Private Bag 523 Outapi
15/04/2019
2019 -04- 15
No 4
Tel. 065-251019
Fax. 065-251078

All official correspondences should be addressed to the Chief Regional Officer

APPENDIX 3

Dr.-Ing. Joachim Lengricht
Head of Department
Civil and Environmental Engineering
University of Namibia, Eng. José Eduardo dos Santos Campus
P.O. Box 3624, Ongwediva, Namibia
✉ jlengricht@unam.na

UNAM
UNIVERSITY OF NAMIBIA

April 11th, 2019

TO:
Mr. Gervasius Kashindi
Acting Chief Regional Officer
Omusati Regional Council
P/Bag 523, Outapi

**RE: OUR FINAL YEAR STUDENT IN THE PROGRAMME "MSC WATER RESOURCES MANAGEMENT"
BERNADETTE NDEMWIIKA AMUKUHU (STUDENT. NO 201778236),
FINAL THESIS PROJECT ON "ASSESSMENT OF FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE WATER MANAGEMENT PRACTICES IN SUBSISTENCE FARMING, OMUSATI REGION, NAMIBIA"**

Dear Mr Kashindi,

UNAM's MSc Water Resources Management final year student, Ms Bernadette Ndemwiika Amukuhu (Student. No 201778236), is going for her final thesis project on "Assessment of Factors Affecting the Adoption of Sustainable Water Management Practices in Subsistence Farming, Omusati Region, Namibia".

With reference to that research project, I would kindly like to ask for your cooperation, assistance and support to Ms Amukuhu.

Ms Amukuhu would like to carry out her study within the six selected constituencies (Otamanzi, Okalongo, Ruacana, Ogongo, Outapi and Tsandi) and therefore requires a permission to get information from the smallholder farmers.

In order to help the student to complete her studies, we would kindly like to ask you to assist the student with that permission and smooth facilitation.

Ms Amukuhu (and we) would be grateful if you could provide any additional information. If necessary, Ms Amukuhu will explain her research approach by addressing you personally.

It will be a pleasure for us to make the final report of Ms Amukuhu available to you after the student will have finalised and submitted it. We sincerely thank you in advance.

Yours sincerely

Dr.-Ing. Joachim Lengricht
HOD Civil and Environmental Engineering

UNIVERSITY OF NAMIBIA
Department of Civil & Environmental Engineering
2019 -04- 11
HEAD OF DEPARTMENT

APPENDIX 4

Bernadette. N. Amukuhu (**2017 782 36**)
Dep. of Civil and Environmental Engineering
University of Namibia
Ogwendiva
13 May 2019

Dr Petrina Johannes
Dean of Faculty of Engineering and IT
University of Namibia
P.O.BOX 3624
Ogwendiva

Dear Madam:

REQUEST TO OBTAIN TRANSPORT AUTHORISATION TO CONDUCT RESEARCH IN OMUSATI REGION

I am studying towards a MSc. in Water Resources Management at the University of Namibia. The Master degree programme is sponsored by Ministry of Water, Agriculture and Forestry under the UNESCO Water Sector Support Project. With reference to the above-mentioned matter, this letter seeks to obtain authorisation from the University of Namibia to provide transport for data collections. My area of investigation is **"ASSESSMENT OF FACTORS AFFECTING THE ADOPTION OF SUSTAINABE WATER MANAGEMENT PRACTICES IN SUBSISTENCE FARMING".** The motivation of my study is to explore the issue of water conservation among smallholder farmers in Namibia, focusing on the Omusati Region.

As part of the research, I need to collect data from six constituencies in the Omusati region (Ontamanzi, Okalongo, Ruacana, Tsandi, Outapi and Ogongo) and the results of the research will be used to implement a successful water management program intended to enhance smallholder farmers resilience to climate change and climate variability to improve their livelihood. The data collection in the selected constituencies will involve semi-structured interviews of smallholder farmers, observing fields and documentation analysis. Apart from the semi-structured interviews with the farmers, (The Chief Regional Councillor, Constituency Councillors and Traditional Headmen) will be conducted. During the period of the research, I commit myself to be ethical and professional.

I therefore seek permission to use UNAM vehicle with a driver for a period of Seven (7) days for data collection as part of my Master studies.

Thank you for your consideration.

Yours Sincerely,

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B.N. Amukuhu
(Research Student: Water Resources Management)

.....30/05/2019
Prof Damas. A. Mashauri
(Research Supervisor)

APPROVED: 20/05/2019
Acting Dean