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GREENHOUSE VEGETABLE CULTIVATION AND ITS IMPACT ON POVERTY ALLEVIATION AMONG SMALLHOLDER FARMERS IN THE QILOANE COMMUNITY COUNCIL

DISSERTATION SUBMITTED

BY

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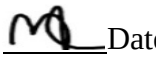
DECLARATION

I declare that this dissertation titled '*Greenhouse Vegetable Cultivation and its Impact on Poverty Alleviation among Smallholder Farmers in Qiloane Community Council'* is my original work, except where otherwise indicated, and its materials have not been presented for examination in any other institution of higher learning or published in journals, textbooks or any other media. The contributions from other authors that have been cited are acknowledged. No, part of this project may be reproduced without authorization from the author and the National University of Lesotho.

Student name **Morato Elizabeth Malerato** Signature  Date **25 /07/2023**

Supervisor's name. **Dr M.T. Macheka** .Signature  Date **25 July 2023**

DEDICATION

I would like to dedicate my thesis to my mother ‘Mabafokeng, my sisters Matšele, ‘Mantlhoisi, and Refuoe, my brothers Bafokeng and Seipati, my aunt Dr. Morato Maleke and to all my nieces and nephews for their unwavering support and love throughout my studies.

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I would like to express my further gratitude to my family for support they have given me throughout the research process. “Father, this is for you, and I know you are proud. May your soul rest in peace.”

ABSTRACT

In the light of the changing climate and poverty, the Government of Lesotho with donor support made investment to promote climate-smart agriculture among smallholder farmers. Despite these efforts, Lesotho is experiencing high acute food insecurity, and low productivity remains a major challenge among smallholder farmers. Against this background, this study assesses the impact of greenhouse vegetable cultivation on poverty alleviation among smallholder farmers in Lesotho. Specifically, the study assesses the contribution of greenhouse vegetable cultivation on the livelihood making of smallholder farmers, investigates the contribution of greenhouse cultivation to living standards and suggests intervention measures in order to assist greenhouse vegetable cultivation smallholder farmers. The study used mixed method methodology for data collection using case study of Qiloane community council where face-to-face interviews and closed ended questionnaires were utilized. The results showed that greenhouse cultivation had contributed to smallholder farmer's livelihood making by protecting crops from adverse weather conditions, increasing crop yields, crop variety and efficient use of water resources. Greenhouse vegetable cultivation had contributed to smallholder farmers' living standards by increasing income, food security, employment opportunities and skills development. Training, availability of agricultural inputs and subsidies, installation of temperature controllers and access to markets were intervention measures suggested to address the challenges faced by greenhouse vegetable cultivation smallholder farmers. The study concluded that greenhouse vegetable cultivation is a cost effective way of cultivation that can contribute to the economic wellbeing of smallholder farmers and contribute to country's economy. Therefore, the study recommends implementation of integrated pest management and strategies, regular inspection, market-oriented approaches

and close monitoring of greenhouse tunnels so that they can contribute effectively to livelihoods of smallholder farmers.

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ACRONYMS

AERC	African Economic Research Consortium
AMMAR	Agriculture Modernisation, Market Access and Resilient
CSA	Climate-Smart Agriculture
CSAPs	Climate-Smart Agricultural Practices
EIF	Enhanced Intergraded Framework
FAO	Food Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse Emission
HPDP	Horticulture Production Development Project
IFAD	International Fund for Agriculture Development
IPC	Intergraded Food Security Phase Classification
ITC	International Trade Centre
SADP	Smallholder Agriculture Development Project
SLF	Sustainable Livelihood Framework
WAAPP	West Africa Agricultural Production Programme
WAMPP	Wool and Mohair Promotion Project

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Poverty alleviation has become one of the very important issues around the globe. Mhlongo et al. (2020) state that governments and international organisations are taking different measures to end poverty in all its dimensions and forms. Thus, relying on technology-driven interventions in agriculture is one of the measures considered as rural poor depend on it. Greenhouse technology, as one of climate-smart innovation serves as some stimuli for increasing productivity, helping the rural poor (mostly smallholder farmers) to better manage the environmental risks. It also improves food production, promotes employment and increases their food nutrition, food security and standard of living, as a way out of poverty. It is therefore, essential to assess the impact of greenhouse vegetable farming on poverty alleviation among smallholder farmers in Qiloane community council.

1.2 Background of the study

Poverty alleviation and ensuring food security are the priority strategies in the pursuit of Sustainable Development Goals around the globe. Despite ongoing attempts to improve farmer's living conditions, poverty and food insecurity are still widespread worldwide as 80 percent of the world's extreme poor live in the rural areas and 65 percent of them depend on smallholder agriculture for a living (Vos & Cattaneo, 2021). The World Bank estimated that there were 735 million people in extreme poverty and most of them are living in rural areas of sub Saharan Africa (Hansen et al., 2019;Vos & Cattaneo, 2021).

Due to population growth, industrialisation, climate change, environmental pollution, the arable land around the world is declining each year and this indicate that less land will be available for

agriculture. The world population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050 and over 11 billion in 2100 and feeding these fast growing population with concurrently improving the living standards of the poor have reflected an ongoing global challenge (Shukla et al., 2019; Ampim et al., 2022). As such, Czyzyk et al. (2014) highlighted that the Food and Agriculture Organisation (FAO) projected that production of food would need to increase by 70 percent. Alternative approaches such as indoor farms, high tunnels, screen-houses, and greenhouse cultivation have been considered to be a viable alternative to increase the production and to support covering the global demand (Hu et al., 2016; Rayhan et al., 2020; Kaplan & Saltuk, 2021; Fernandez et al., 2022; Ampim et al., 2022).

Introduction of greenhouse technology was first in production of flowers, fruits and ornamental crops in the 17th century with the aim to optimize the practice of soil and water resources in Europe and it is expanding worldwide (Kirui, 2014). Singh et al. (2020) indicated that, nowadays greenhouse is an emerging technology for growing flowers which are high valued and perishable, as well as vegetable crops. As one of the fresh produce, vegetables are easily affected by the weather and seasonal impacts, which may result to market price fluactuation along with both farmers profit and consumers' loss of interest. So greenhouse reduces risks faced by farmers since it provides a sustainable microclimate for plants, thus enabling optimal plant development, extension of production duration, induction of earliness, and attaining increased and improved quality yields (Zhang et al., 2022).

In China 2016, the area under greenhouse vegetable cultivation had higher fresh yields, required less irrigation, maintained soil fertility, and better soil retention when compared to conventional vegetable cultivation so the area under greenhouse was increased to 21.5 percent and produced 30.5 percent of the total yields (Chang et al., 2011; Li et al., 2018; Geng et al., 2022). Kaplan and

Saltuk (2021) study in Batman Turkey determined that most of greenhouse vegetable producers income was above the poverty line.

Greenhouse cultivation according to Chang et al. (2011) benefits people by supplying out-of-season or improved quality vegetable to boost health while generating job possibilities and higher incomes. Narayan et al. (2022) added that greenhouse vegetable production is best for high quality produce, preventing pest and disease, and producing vegetables out of-season. In the case of Ogun State in Nigeria, it was confirmed that greenhouses benefited the farmers as 94.1 percent respondents reported that it increased their yields, 85.8 percent reported that their incomes were higher, and provided job opportunity for the youth who were (81.6 %) of the respondents (Oyediran et al., 2020).

However, Wayua et al. (2020) study in Kenya argued that greenhouse farmers faced many challenges and constraints, which prevented farmers to realise the full benefits of the technology leading to desertion of some of the greenhouses. Schreinemachers et al. (2018), comfimed that the main constraints in greenhouse cultivation comprise of pests and diseases, insufficient water supply and high initial expenditures for setting up and running the greenhouses.

Lesotho's government with donor support has promoted greenhouse vegetable cultivation as its technological-let intervention in its national strategic development plan 2018/19-2022/ 23 to promote climate smart agriculture (Ahmed & Pozarny, 2018). Bertelsmann-Scott et al. (2018) added that, the Horticulture Productivity and Trade Development (HPTD) project where 115 farmers were given greenhouse from Kenya was one of the project that was implemented through Lesotho's Aid for Trade programme. The initiatives demonstrated that Lesotho's environment was preferably suitable for greenhouse tunnel cultivation and majority of the farmers produced tomatoes, green peppers, cabbage, cucumbers and spinach of the highest quality.

Despite the efforts undertaken, Lesotho has not achieved food sufficiency, as is known with most developing nations. Bhalla and Mphale (2021), highlighted that a combination of the country's poor economic perfomance, low income, high food prices, and low food production has led to high rate of food insecurity. As per the current Intergrated Food Security Phase Classification (IPC, July-September 2022), an estimation of 229 000 people were facing severe food insecurity (IPC phase 3) and urgent action was needed to close food shortages, safeguard and restore livelihoods and stop acute malnutrition. Low productivity remains a major challenge. Reva and Giddings (2019), highlighted that even during the growing season, supermarkets and food stores in Lesotho stated that 80 percent of vegetables in their establishments were imported from South Africa. In addition, Bertelsmann-Scott et al. (2018) report showed that the output production of greenhouse vegetable farmers was not sufficient to result in neither reducing imports from South Africa nor combined exports.

Despite greenhouse adoption by many countries to increase productivity, data on how plastic greenhouse reduced poverty among smallholder farmers is scarce. The scholars have written about greenhouse tunnel and increased productivity and challenges of greenhouse technology (Mwangi, 2012; Wayua et al.,2020; Singh et al., 2020; Nainabasti et al., 2022) but there is no such study in Lesotho. There is lack of data in Lesotho on production of vegetable volume, revenue and yields.

1.3 Statement of the problem

The focus of the study is to investigate how greenhouse vegetable farming contribute to livelihoods making, improve living standard of smallholder farmers and intervention measures to promote greenhouse vegetable cultivation amongst smallholder farmers. The problem is that, the government and donors made investments to promote climate-smart agriculture among smallholder farmers in Lesotho, in an effort to improve greenhouse vegetable productivity in the

light of changing climatic conditions and poverty. These efforts have focused on adoption of greenhouse technology and embracing of high yielding varieties of vegetables, improved farmers' incomes and sustained livelihoods.

Despite these efforts, the existing literature shows that, Lesotho is experiencing high acute food insecurity and low productivity remains a major challenge to the extent that some farmers have abandoned the practice. The country is still importing vegetables from South African commercial farmers, whereas, studies have shown that greenhouse vegetable yields have been proven to be high elsewhere in the world. In addition, many studies have concentrated on greenhouse technology and environment, productivity and challenges but not in the case of Lesotho. This study investigates the extent to which greenhouses have reduced poverty among smallholder farmers from Qiloane community council.

1.4 Objectives

1.4.1 To assess the contribution of greenhouse vegetable farming to smallholder farmers' livelihood making.

1.4.2 To investigate the contribution of greenhouse vegetable farming to improving living standard of smallholder farmers.

1.4.3 To suggest intervention measures to assist greenhouse vegetable farming smallholder farmers.

1.5 Research questions

1.5.1 How does greenhouse vegetable farming contribute to livelihood making of smallholder farmers?

1.5.3 How does greenhouse vegetable farming improve the living standards of smallholder farmers?

1.5.4 What intervention measures put in place to assist greenhouse vegetable farming smallholder farmers?

1.6 Justification of the problem

This study is significant because it is going to contribute to the literature in Lesotho about the impacts of greenhouse vegetable farming. Furthermore, by investigating the contribution of greenhouse vegetable farming on smallholder livelihood making and standard of living for farmers practicing greenhouse, the data will inform the designing of interventions needed in addressing the challenges related to vegetable production in the country. Furthermore, it will advise public and private investments and promote donor funding in the sector.

1.7 Theoretical framework

The Sustainable Livelihood Framework (SLF) guides this study. According to Karkis (2021), the sustainable way of living depends on people's ability to create capacity and accomplish life objectives that are helpful to their wellbeing by utilising the resources that are already at their disposal. Sustainable livelihood addresses how the poor can cope, secure and overcome the stress of shocks (for example environmental impacts) in order to better their lives. Furthermore, when individuals are able to succefully adjust their ssests (social, physical, natural, human, and financial) and triumph over shocks like seasonal changes withiout depleting their base of natural resource, a livelihood is said to be sustainable.

The study used this framework as it relates to the objectives of the study. Greenhouse vegetable cultivation is considered in this study as the livelihood strategy or an asset that smallholder farmers adapt inorder to overcome the shocks and stress (environmental impacts like climate change, pests and diseases and the fast growing population) while still sustaining the resources for the future

generation. As confirmed by Czyzyk et al. (2014:7) that “greenhouses are designed to maintain a microclimate suitable to horticultural production that is also water-efficient.”

1.8 Definition of key terms

This study includes numerous key concepts, being greenhouse cultivation, greenhouse, smallholder farmers, poverty alleviation and poverty

Greenhouse cultivation: Greenhouse cultivation is a type of protected farming; where crops grow in controlled climate parameters build structures in order to produce year round, quality and increased produce (Ampim et al., 2022). According to Smitha et al. (2016), a greenhouse is a building with walls and roof structures of transparent materials like glass or plastic, used to grow crops that require regulated environmental conditions. Thus, greenhouse cultivation is the type of protected farming where crops grow in a plastic (polythene) material structure and a climate controlled condition such as temperature, humidity, light and wind to mention, but a few.

Greenhouse: According to Nordey et al. (2017), greenhouse is a type of protected cultivation techniques, which can be in a form of glass, framework materials, design, and the level of technology (low, medium or high) used to control the plant environment. Greenhouse is a building with glass walls and a roof that is widely used to plant seeds, vegetables, fruits and tobacco in a controlled climate (Rosni & Hashim, 2021). In the perspective of this research, greenhouse is a plastic building like structure that provides a favourable environmental condition and shelter for crop production.

Smallholder farmers: According to Ateka et al. (2021), they are farmers who cultivate less than 2 hectors, mainly rely on family labour, and with limited capital (physical,natural, financial, social, and human). Kamara et al. (2019), define smallholder farmers in Africa as cultivators who are

reliant on agriculture for financial livelihood and farm less than 2 hectors. And in the perspective of this research, smallholder farmers are farmers who occupy small land and have a maximum of three greenhouse plastic tunnels.

Poverty alleviation: According to Abdulai (2022), poverty alleviation is a series of action, tactics, interventions or measures implemented to address the threat of poverty. As it is defined by ill health, low earnings, inadequate nutrution, a lack of physical assets, and inadequate housing and living conditions, poverty is a complicated and multifaceted notion (Garade et al., 2016). For the purposes of this study, a public policy, project, or programme that aims to manage poverty is considered a measure of poverty alleviation.

Poverty: According to Usmanova et al. (2022), poverty is a multidimensional phenomenon that can be measured and defined in various approaches, which can be generally divided into two groups, being monetary and non-monetary approaches. Poverty is a multidimensional measurement including lack of access to education, medical care, housing and other social deprivation (Liu, et al., 2019). For the purposes of this research, poverty is a socio-economic condition charasterised by lack of resources and income necessary to meet basic human needs, such as food, shelter, clean water, health care, education, and clothing, to mention but a few.

1.9 Limitations

Some of the smallholder farmers were illiterate while some did not know English language, so the questionnaires and interviews were conducted in Sesotho. For those who were illiterate, the researcher read out the Sesotho questionnaires, which were later translated to English language for the purpose of the research. Some of the smallholder farmers were not residing in the villages of Qiloane council, so the researcher had to ask for their contacts from the workers of which some refused with them.

1.10 Research structure

After chapter 1, which is introducing the research problem and background of the study, the study have Chapter 2, which is the literature review. Chapter 2 reviews what other scholars have said about the greenhouse and poverty alleviation among smallholder farmers. Chapter 3, the research methodology, which involves the study site and sample, methods and instruments used when conducting the study. Chapter 4 is data presentation, analysis, and discussion of findings, while the last chapter, which is Chapter 5, is conclusion and recommendation.

1.11 Chapter summary

This chapter outlines the formation of the background of the study by examining the debates surrounding the greenhouse vegetable cultivation and poverty alleviation among smallholder farmers, which led to the research idea. The chapter also, unpacks the statement of the research problem, which clearly narrates the gaps that informed the basis of the research. The chapter also defines the objectives, which show the intention of this research. There is also, the theoretical framework, based on Sustainable Livelihood Framework, showing how the framework is relevent to this research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter review the literature on the impact of greenhouse tunnel vegetable cultivation on poverty alleviation among smallholder farmers. This chapter focuses on the literature from global to local viewpoint that is from international, regionally, national and specifically to Lesotho. Literature reviewed was on the contribution of climate-smart agriculture to poverty reduction, greenhouse cultivation and poverty reduction, and greenhouse cultivation and smallholder farmers.

2.2 Climate smart agriculture and poverty reduction

Climate-smart agriculture technologies have been adopted because of technological advancements and agricultural development, which includes reducing farming losses, optimising agricultural practices for higher yields, and preventing, observing, and early prediction of plant and animal diseases. Adesipo et al. (2020), refer to climate-smart agriculture as a transformational and justifiable form of agriculture that intend to enhance production in food systems by combining the three pillars of climate change (adaptation, resilience, and mitigation) with smart and new information. This type of agriculture does not only enhance farmer capacity with regard to cultivating techniques but also increases profits, lowers the vulnerability of systems, and improves the quality of systems output (farm products/ animals) by lessening greenhouse emission (GHG).

Numerous studies have demonstrated the viability of adopting climate-smart agriculture methods and technologies as a means of escaping poverty. For instance, in India, Agarwal et al. (2022), study show that for the adopters of Climate-Smart Agricultural Practices (CSAPs), livelihoods were improved as productive capacity of farmers resulted in increased income which improved their standard of living and decreased the likelyhood of male migrants in Bihar districts. In Georgia, Monem and Trembley (2022), report revealed that in rural Georgia, the Internation Fund for Agricultural Development (IFAD)'s Agriculture Modernization, Market Access and Resilience

(AMMAR) initiative enhanced earnings and decreased poverty for both men and women by enhancing agricultural productivity using greenhouses, mechanisation, drip irrigation, quality seedlings. In Bangladesh, FAO (2018) report on CSA case studies revealed that floating gardens, where farmers took an opportunity of prolonged floating season and produced vegetables and seedlings resulted in increased nutrition and food security for the community.

In West Africa, Abegunde et al. (2019), study revealed that the West Africa Agricultural Production Program (WAAPP) is the way out of poverty as it had increased productivity by around 150 percent and food production by more than three million tons for farmers who engaged in the project. In Ethiopia, Habtewold's (2021) study revealed that the usage of artificial fetilizer and the adoption of row planting techniques reduced depreviation score and one of its components, the standard of living. The study further revealed that technology has improved production gains, which has increased income and consumption while reducing multidimensional poverty. In Kenya, Ogada et al. (2020), showed that the adoption of drought-tolerant crops increased the household income by 83 percent, which implied that agricultural production was a significant source of income for people in the Nyando and enhanced the resilience of the households to climate risks.

However, CSA practices seem not to consider the people with little access to resources, time and knowledge like smallholder farmers. Jones et al. (2023) study in Tanzania concluded that CSA practices resulted in negative socio-economic impacts for farmers in terms of increased inputs cost and decreased profits which undercut access to food. Additionally, Senyolo et al. (2017), study in South Africa concluded that due to higher labour needs, high investment prices, and management intensity, CSA pratcticies (Conservation Agriculture, Rainwater Harvesting and Seed Varietise) were not advantageous in the country particularly for smallholder farmers. Further more, Murray et al. (2016) study in Malawi showed that despite the inspirations of women smallholder farmers

to engage in CSA, women smallholder farmers have either limited or no access to basic agricultural tools, transport, and rural energy. Gallant (2019), study in Malawi also revealed that, due to time consuming nature of CSA practicies, less access to inputs, knowledge, training, resources and services that facilitate barriers to CSA adoptation, women showed no interest in CSA practices than men who were able to adpot wider variety of practicies and more costly and advanced technolgical practicies.

In Lesotho, Ukaejiofo et al. (2018) report showed that climate smart agriculture intervention through keyhole gardens have reduced poverty as they have enhanced year-round production of nutritious vegetables and enhanced income available for household expenses for all groups of people including the elderly and those living with HIV. The report further showed that the climate smart wool and mohair promotion project (WAMPP), had optimistic impacts on reducing child mulnutrition and increasing climate-resilience of 250 000 households in the country.

The CSA practices seem to not consider smallholder farmers with little access to resources, knowledge and time. The studies also look at CSA technologies as a whole. Therefore, this study contributes to the body of knowledge on greenhouse technology as CSA innovation and its impact on poverty reduction among smallholder farmer in Lesotho.

2.3 Greenhouse tunnel cultivation and smallholder farmers

Greenhouse tunnel technology has provided smallholder farmers with a sustainable way to grow crops and increase crop yields. It extends growing season, helps manage efficient use of resources, and allows for diversification of crops.

2.3.1 Increased crop yields

Studies had shown that greenhouse tunnel cultivation provide controlled environment and allow smallholder farmers to grow crops at higher quantities, which leads to higher profits because they face fewer losses due to pest, diseases, and adverse weather condition. For instance, Malik et al. (2018) study in Pakistan showed that, avarage tomato yields in greenhouses were found to be 161.8 +/- 6.6 ton per hector compared to 10.07 +/- 0.4 in open field. This findings suggests that increasing tomato yields in greenhouses can help close the supply and demand gap of the country beside promoting import substitution.

In Europe studies had also revealed that greenhouse protected crops and reduced pre-harvest food losses resulting in increased yields, which led to export of greenhouse vegetable production (Ruijs & Benninga, 2020; Batziakas et al., 2020; Gul & Ozenc, 2020; Keco & Gjika, 2021). Additionally, in India, Khan and Khan (2020), found out that vegetables yield per acre in the tunnels were higher than those in open fields, as the production of tomatoes in tunnel was 117% above production in open field and cucumbers was 25% higher than open field. Batziakas et al. (2020), study in Kansas indicated that using tunnel technology to produce spinach could reduce pre-harvest food losses by increasing yields and extending the harvest window throughout the growing season.

Van der Spijk (2018), study in Kenya revealed that the highest level of greenhouse tomato production recorded was 160 000 kilograms compared to 72 000 kilograms for unprotected farming method, and 40 percent of farmers reported that their reason to engage in greenhouse was because of its high yield. Ateka et al. (2021) recent study in Kenya also revealed that, greenhouse tomato producers yield was 16.1 kilograms per square meter per year compered to 2.3 kilograms per square meter per year of unprotected farming smallholder producers, which is 13.8 kilograms per square meter difference between the two systems.

In Tanzania, for two seasons, in protected cultivation, farmers produced 9.85 compared to 6.80 kg/square meter of open field and 10.09 as opposed to 8.63kg/square meter of open field in each

season respectively, showing improved yields of smallholder farmers under the protected cultivation (greenhouses, nethouses, tunnels) (Nordey et al., 2020).

2.3.2 Crop protection

Greenhouse vegetable farming has the potential to protect smallholder farmers' crops against the vulnerability of abiotic factors (like poor soil, high temperature, erratic rainfall) and biotic factors such as different types of diseases, pests, and weeds, thus resulting in high quality produce that meet the market demands and command high prices (Goss, 2018). In the Mediterranean region, Nikolaou et al. (2021) showed that greenhouse was a mitigating measure to sustainable production and combating climate change. Additionally, in Taiwan, Liao et al. (2020), indicated that farmers adopted protected agriculture as a self-insurance approach to produce crops while minimising risks brought on by climate change. The study furthur revealed that, compared to non adopters, adopters of greenhouse cultivation achieved farm revenue increase ranging from 65.0 to 69.5 even when they were affected by natural disasters. Mehta et al. (2020), study in Himachel Pradesh (India) revealed that, the socio-economic circumstances of the farmers in the research area were significantly improved by protected agriculture, which also suited the agro-climatic conditions present in the mountainous terrain.

In Kenya, Murithi (2021), showed that greenhouse was an effective strategy to protect farmers crop loss against adverse climatic conditions. However, Nordey et al. (2017) asserted that in Sub-Saharan Africa, low-tech protected agriculture was incompatible in all climatic conditions in the region, and in order to adequately control pest, needed to be combined with other methods. Additionally, Ampim et al. (2022), emphasised that eventhough the temperature in tunnels is typically a couple of degrees warmer than the outside temperature, it was important to have a

standby portable heater or other type of heating to protect crops against unexpectedly low temperatures in the spring or fall.

In Mozambique, Capuano (2018), study showed that, almost half of the farmers the scholar interviewed, mentioned that in greenhouses their crops grow stronger, more resistant, and were more likely to survive. The study further revealed that 30 percent of the farmers reported that greenhouse protected their crops against weather and climate change.

Acccording to The Isle Man (2018) final project report in Mohale's Hoek district in Lesotho, smallholder farmers engaged in Action Aid project who were given greenhouses, were able to grow crops all year round and increased productivity. Morahanye (2020) study conducted in Leribe district in Lesotho also showed that greenhouse relieved farmers from climate change impacts by fortifying seedlings and increasing their incomes.

2.3.3 Extended growing season

Greenhouse tunnel farming can allow smallholder farmers to grow crops outside of their normal growing season, thus making smallholder farmers crops available even in off-season, which increase their income and food security. The cultivation of crops in off-season when demand is high and prices are high can give farmers earnings and expand consumers' options (Schreinemachers et al., 2016). According to Oyediran et al. (2020), through greenhouse technology, vegetable crops are available all year round in the market, thereby creating marketing and economic empowerment for rural dwellers mostly smallholder farmers. Kumar and Kumar (2020), study in India showed that income in off-season increased by 40% as protected cultivation enabled vegetables in peak-season and also extended the vegetable production seasons for an extended period than was possible under open field. Chaudhari and Chaudhari (2022), argue that, compared to traditional way of vegetable production, greenhouse tunnel cultivation extends the

growing seasons of crops with three times more production. In Meru county, Mugure's (2017) research showed that due to temperature and humidity regulation in greenhouse, crops grew faster and stronger throughout the early stages of plant development and growing season was extended up to eight month. In addition, in the United States, Midwest state of Indiana, Bruce et al. (2019) showed that the use of high tunnels had prolonged the growing season for farmers, as almost half of the respondents were able to harvest in the cooler months and planted earlier in spring. Hinrichs (2020), study in Mongolia showed that greenhouse farming enabled farmers to extent growing season by at least two months and allowed farmers to harvest two months earlier on average.

2.3.4 Efficient use of resources

Greenhouse tunnel farming is a sustainable way of farming which minimize climate effects as the atmosphere is regulated and inputs like pesticides, fertilizer, and water are used effectively. FAO (2021) indicated that, in closed-soilless production inside greenhouse, up to 50 percent of water use in production of agricultural crops, ornamental, and medicinal plants can be conserved. Aref (2016) emphasized that greenhouse cultivation technology accommodates areas where there is less or shortages of water and limited arable lands for cultivation. In India, studies have shown that protected cultivation resulted in water and soil conservation due to micro-irrigation installed, less use of pesticides, and right doses of fertilizer farmers used (Kumar et al., 2018; Pachiyappan et al., 2022). FAO (2021) research in the Arabian Peninsula showed that using greenhouse techniques like hydroponics and combined production and pest management had significantly increased water production, with slight or no use of pesticide.

Mallya (2019), study in Kinondoni, Tanzania showed that 35 percent of farmers claimed to have adopted greenhouse cultivation technology because it was easy to identify changes, and easy to do irrigation, as it preserved additional water by minimising evaporation rate. Nordey et al. (2020)

study in Tanzania also showed that smallholder farmers' pesticide use was also reduced in protected cultivation by 3.5 and 2.8 times in two seasons of farming. Rajagopal et al. (2017) study in Kenya, revealed that farmers' nutrition and food security were improved by greenhouse farming because it used water more effectively and produced yields that were five to ten times higher than those from open-fields.

Capuano (2018), study in Mozambique showed that, 89 percent of farmers revealed that greenhouses decreased the need for costly inputs like seeds and pesticides while conserving time and scarce resources such as water. In Zimbabwe, Scoones et al. (2019) study showed that due to drip irrigation linked to greenhouse, farmers were able to commercialise production while managing water use. Preez (2017), report indicated that due to controlled environment greenhouse had a potential to provide exact water and nutrients needed by plants and breaking free climatic and seasonal limitation that constrained traditional agriculture in Southern Africa. Pengelly et al. (2021), report in South Africa deduced that greenhouse was water-smart agricultural innovation technology with high returns for farmers.

2.3.5 Crop diversification

Greenhouse technology allow smallholder farmers to diversify their crop production and grow high value crops, which can result in increased incomes and reduced reliance on single crop. Ali et al. (2020),'s study in Balochistan showed that tunnel technology played an important role in GDP of the overall country by increased yields of tomatoes, and the socio-economic conditions for farmers. Ghimire et al. (2022), study found that farmers who were growing high number of varied vegetables in tunnels were securing more benefits and increased incomes for their households. Dhillon (2022), in Northen India showed that farmers were able to cultivate out of

season high value vegetables like tomatoes, cherry tomatoes, colourful capsiums, pole type french beans and so on in poly houses or walk-in tunnels.

Reva (2019) report in Lesotho showed that lettuce, tomatoes and cabbage were most popular crops grown by commercial farmers while most of smallholder farmers grow one to two crops under protected cultivation. Finmark Trust (2021), report in Lesotho, also indicated that tomatoes, cabbage and leafy greens were among the crops with high market demand in Maseru.

Greenhouse vegetable production seem to have benefited farmers' livelihoods in some regions like in the Europe and Asia but little is known in Southern African countries, especially Lesotho on how greenhouses have contributed to smallholder farmers livelihood. Therefore, the study intends to fill this gap by investigating how greenhouse vegetable cultivation has contributed to smallholder farmers in the Qiloane community council, and this information will be added to the literature in Lesotho.

2.4 Greenhouse tunnel cultivation and poverty reduction

Greenhouse tunnel cultivation has the potential to reduce poverty among smallholder by generating income, employment opportunities and improving nutrition and health as illustrated in the empirical literature below.

2.4.1 Income generation

Greenhouse cultivation has a significant positive impact on smallholder farmers' way of living due to its significant contribution to high revenue production particularly during off-season. Smallholder farmers are faced with many challenges either natural or synthetic that limit their ability to increase production and transition to profitable farming systems; as a result, they opt to

undertaking lower-risk and lower-yielding agricultural activities that perpetuate a cycle of poverty (Fan & Rue, 2020).

Studies have shown that greenhouse technology has played a significant role as an altenative for farmers to generate income. Schreinemachers et al. (2016) study showed that off-season production of vegetables increased smallholder farmers' seasonal incomes by 48% in Bangledesh. Ramasamy et al. (2021) study in Taiwan revealed that protected cultivation, filled the gap in the seasonal variations in vegetables during off-season and provided better income opportunities to smallholder farmers.

Punera et al. (2017) study in India showed that greenhouse cultivation made a significant impact on farmers' households by improving farmers' income by 65 percent. Kumar et al. (2018) showed that protected farming seemed to be profitable and investments were recovered more quickly as about 300 percent increase in the harvestable yields and about 1400 percent increase in net incomes were done in India. Prakash et al. (2020) in Maharashtra India showed that farmers net incomes were increased by 2.22 lakhs per year for 1000 square meter area. Pachiyappan et al. (2022) study in Western India also showed that, the cost of productivity of the produce under protected farming were high. Nonetheless, the net return was profitable as farmers using greenhouses cultivation were getting high yields of capsicum (137%) and sold the capsicum at nearly three times the price of capsicum produced under open field due to its improved quality in terms of colour and size.

Pandey (2019), study in Mustang, Nepal, showed that greenhouse vegetable farmers were able to rise their incomes by 30 percent and consume eight times the volume of vegetables they had consumed prior to acquiring the greenhouses; thus their produce increased. Aref (2016) study indicated that greenhouse farming increased the products of high value crops and generated more

income and due to this, greenhouse played an important role for the improvement of rural livelihoods in Injil district of Heart Province in Afghanistan.

Oyediran et al. (2020), study revealed that 75.7 percent of respondents reported that they have high income generation due to greenhouse cultivation in Nigeria. Likewise, Mburu et al. (2015) study in Kenya revealed that greenhouse farming had the ability to feed the general public and generate income as farmers were economically better off by producing vegetables and flowers for export in the tunnel. However, greenhouse crops turned to be more expensive and lead to profit loss as Aboaba et al. (2020) study in Nigeria showed that consumers were not willing to pay the extra cost in greenhouse vegetables as they considered the greenhouse vegetable produce luxary goods. They did this in spite of their awareness, and favourable observation of greenhouse vegetables, which led to producers' profit loss.

Mallya (2019) study in Tanzania showed that 80 percent of greenhouse farmers claimed adopting greenhouse cultivation technology because it was a good source of income as a minimum net profit of two million Tanzanian shillings net profit per cycle of production was made. Badimo (2020), study in Botswana revealed that the average farm income for high tunnel adopters was two times more than that of non-adopters. In Malawi, Howie and Simpson (2020) study showed that polythen tunnel increased productivity for farmers and provided reliable supply of tomatoes and fruits which the market demanded. However, in a recent study in Malawi, Nyalugwe et al. (2022) study indicated that due to makerting and input cost, 95.9 percent of tomato farmers grow tomatoes in an open field and very few 4.1 percent used greenhouses.

International Trade Center (2017), report indicated that, in Lesotho, the farmers who were participating in the project were able to make considerable incomes withiout the help of government as their monthly net income avaraged M1000 and one third of the farmers made

approximately three times that amount. According to Reva (2019) report, protected cultivation had the potential to increase farmers' profit of up to 1 million (US$71.428) per season, per hector (ha) in Lesotho.

2.4.2 Employment opportunities

Greenhouse cultivation contribute in increasing employment opportunities for smallholder farmers especially in off-season due to its year round production capacity. Since irrigation, weeding, and ventilation of greenhouses are everyday tasks that take around two hours a day, the availability of labour is a major consideration in greenhouse vegetable farming (Abadia et al., 2017). Protected cultivation does not only increases the country's economy by supplying both international and domestic markets but also helps in creation of employment opportunity for unemployed educated youth (AERC, 2017). Additionally, Rodricks (2022), study argued that protected vegetable production technologies provide an opportunity for self-employment which notably reduces expenditure spent on labour. In Western India, it was pointed out that protected cultivation had a potential to increase crop yields and quality and generated employment in Maharashtra (Pachiyappan et al., 2022). Aref (2016) study in Afghanistan showed that, greenhouse cultivation contributed in increasing employment opportunites to rural communities especially in off-seasons and slowed down young rural people migration to other countries. Liao et al. (2020) study showed that the implementation of protected agriculture resulted in a rise of 1.947 to 2.064 hired workers and farm operators'on-farm working days, indicating a proportional increase of 48 to 51 percent.

Choudhary (2016) in Himachal Pradesh (North India), revealed that government funding has allowed protected agriculture of more than 223 hector of land, creating a new agribusiness for the area's unemployed youth and rural masses. Mehta et al. (2020) recent study in Himachal Pradesh (North India), also showed that, when compared to open agriculture, labour usage patterns in

protected agriculture were nearly four times greater, significantly enhencing the job creation opportunities. Shashikala et al. (2022), study in Kalyan Karnataka region of Karnataka revealed that the annual income, material belongings, social position and employment generation of respondents who practiced proctected cultivation all saw significant improvement. The employment mean for men's days was increased by 105.8 percent in the area.

2.4.3 Improved health and nutrition

Greenhouse cultivation has a potential to produce highly nutritious crops, which are essential for health and nutrition security of smallholder farmers. According to Schreinemachers et al. (2018), vegetables are recognised as essential for food and nutrition as they are affordable sources of minirals and vitamin required for human health. Greenhouse vegetable production is in high demand because consumers perceive it as a source of healthy food for human consumption (Kimberly, 2016). Additionally, most consumers of today seek vegetables with great internal and exterior quality, free from pesticide residues and other agrochemicals (Bavec et al., 2017). Xiang et al. (2022) emphasised that regular consumption of vegetables provide virous substances to the human diets, such as essential fiber and a number of minerals, vitamins, phytochemicals, and secondary metabolics, in addition to preventing a number of noncommunicable diseases. In Nepal, Karki et al. (2020) study showed that greenhouse was an adaption measure to improve farmers' livelihood and mitigating climate-related risk. However, Li et al. (2019), study showed that farmers' health was significantly influenced by their prolonged exposure to high cumulative amounts of pesticides due to their extended labour in greenhouses in the northen region of China.

In Ghana, Ofori et al. (2022), study pointed out that, greenhouse tomato farming technology was a promising farm practice which ensured food and nutrition security in Ghana. Additionally, Adams et al. (2022) study in Ghana, argued that because of the perceived health benefits of

vegetables, freshness and nutritional quality, 82.8% of consumers consumed greenhouse vegetables. Ramasamy et al. (2021), are of the view that protected farming does not solely lead to marketable produce but also produce a high quality nutritious health promoting crops.

ITC (2017), report in Lesotho on evaluating the performance of Horticulture Production Development Project (HPDP), concluded that the beneficiaries who were given greenhouses benefited from the project as the mushroom production provided an opportunity for farmers to supplement their income from other sources and their food security.

The studies seem to be focusing on the range of greenhouse growers and do not focus on the contribution to smallholder farmers who are the main producers amongst rural dwellers. There is limited literature in Lesotho on how greenhouse has contributed to poverty reduction among smallholder farmers. Therefore,this study contributes to the literature in Lesotho and add to the literature on how greenhouse vegetable production contributed to poverty alleviation among smallholder farmers, looking at the income generation, employment and health and nutrition benefits brought by greenhouses in the Qiloane community council.

2.5 Chapter summary

This chapter has shown that CSA methods and technologies contribute to increased productivity, reduces farmer's vulnerability to climate and also reduce greenhouse emission (GHG). Greenhouse cultivation, as a CSA technology innovation is a sustainable way to free smallholder farmers from the clutches of poverty.

As a livelihood making strategy, greenhouse has the potential to protect crops vulnerability to environment, extending the growing season of crops, and improving the quality and quantity yields because crops are grown in the protected structure. Greenhouse technology allows smallholder

farmers to diversify their crop production and grow value crops, which increase income and reduce reliance on a single crop.

The chapter also shows that greenhouse vegetable cultivation has the potential to reduce poverty because it is a good source of income for farmers. Greenhouse cultivation contributes to employment opportunities due to its year round production capacity and health and nutrition security for farmers thus reducing poverty.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research area of this study, which is where the study was conducted. The research approach deployed in the study, research design, study population, sampling procedure, data collection methods, data collection procedure, and data analysis are all included in the methodology of this study. The chapter also gives ethical consideration.

3.2 Area of study

The study was conducted in the Qiloane community council, located in Thaba-Bosiu constituency in Maseru district. Maseru district has a population of 118 355 inhibitants of which 20191 are inhabitants of the Qiloane communty council. It is made up of 5334 households (Lesotho Bureau of Statistics, 2016). On the basis of agro-ecological formation, Lesotho is separated into four separate zones, the lowlands (20 -50km strip along the western border with South Africa) where elevation ranges from 1400- 1800 m (17%), the foothills with elevations of 1800-2000m (15%), the mountainous area (highlands) (59%), and the Senqu Orange river valley with elevations of 1400-1800m (9%) (Ministry of Social Development, 2022) . The Qiloane community council is located on the lowlands agro-ecological zone of Lesotho and is made up of 57 villages. The reason for choosing the Qiloane community council was motivated by the financial and time constraints of the researcher; accessibility of the information was easy.

3.3 Research approach

The research used mixed method approach, using the combination of quantitative research and qualitative research approaches to answer how greenhouse vegetable cultivation affect poverty alleviation among smallholder farmers in the Qiloane community council. A mixed method provides a holistic understanding of the issues under investigation and the strength in one method

complements the weakness in the other and vice versa (Christensen et al., 2015; Leedy & Ormrod, 2019; Leavy, 2023). Therefore, to provide a more accurate conclusion for this study, both of quantitative and qualitative techniques were combined. It was done to utilise the respective strengths to overcome the respective weakness of the two approaches (Dawadi et al., 2021).

Qualitative approach allowed the researcher to develop a thorough grasp of a subject, exploring the meanings individuals attribute to their lives, actions, conditions, and positions (Leavy, 2017). Therefore, the choice of qualitative approach in this study supported the aim of the study by unfolding and understanding study surroundings from the participants' way of thinking.

Quantitative approach determines and reports the way things are, and attempt to describe possible behaviour, attitudes, values and characteristics of such things (Leavy, 2023). The approach was also selected because it allowed the researcher to gather numerical data.

3.4 Research design

The researcher used the case study research design because it provided room for in-depth analysis as it only focused on one particular farming method. The case study was also utilised in order to generate viable and precise conclusions (Sekaran & Bougie, 2016), furthermore, it was a thorough, intense study that assisted in determining the effects of greenhouse vegetable farming amongst smallholder farmers. The study used the case of the Qiloane community council to assess how greenhouse vegetable cultivation impacted poverty alleviation among smallholder farmers.

3.5 Study population

The study was conducted in the villages of the Qiloane community council. The targeted population of this study consisted of, smallholder farmers who were engaged in greenhouse vegetable cultivation in Qiloane community council, the agriculture extension officers and the

village heads. The population of the study were people about whom the researcher wanted to contemplate (Babbie, 2014).

3.6 Sampling procedure

The study used purposive sampling procedure. Through the use of purposive sampling, the researcher was able to select cases that addressed study questions and satisfied the objectives (Babbie, 2014). The extension officers and village heads were purposively sampled as key-informants in this study. The extension officers were purposively sampled because they were mandated by the Ministry of Agriculture to help farmers in the community with agricultural activities. The village heads were also purposively sampled because as leaders of the community, their knowledge and understanding provided insight on the nature of the problem and gave recommendations to the challenges. In addition, the study used snowball to select smallholder farmers who were growing vegetables under greenhouse technology in the villages. According to Mohsin (2016), snowball allows one element of the population to be approached at a time, which in return refers the researcher to the other element of the population. Snowball helped the researcher to developing a particular sample population of greenhouse technology user as referrers.

3.7 Data collection methods

The study used face-to-face interviews, observation and closed ended questionnaires. In-depth interview was a suitable approach for this study as it facilitated the collection of detailed and comprehensive data, which was more representative of the phenomena and considered less biased compared to structured interview (Taylor et al., 2016). The face-to-face, interviews helped the researcher to engage farmers as literacy requirements were not an issue and allowed them to clarify further where needed. The interviews also helped to capture farmers' attitudes towards greenhouse

cultivation, which informed intervention measures to help greenhouse farmers. Ten respondents were interviewed in this study, being three Agriculture Extension officers, two village chiefs and five smallholder farmers.

The researcher used observation to record in detail, using her cellphone to capture photographs of smallholder farmer's greenhouses. According to Leavy (2017) in observation, researcher shift focus from one thing to another as new and potentially significant objects and events present themselves. Observations are often recorded in detail, perhaps with field notes or videotapes that capture the wide variety of ways in which people or other animal species act and interact (Leedy & Ormrod, 2019).

In addition, closed ended questionnaires were used because they assisted the researcher to engage some participants who were not able to read and write. The questionnaires helped in finding the statistical data, which captured greenhouse smallholder farmers' demographic information, income, crop yields, years that farmers were involved in greenhouse vegetable cultivation and other statistical information. The questionnaires were administered to eight respondents who were smallholder farmers in the greenhouse vegetable cultivation.

3.8 Data collection procedure

The researcher sought permission from the department of Development Studies at the National University of Lesotho, in order to proceed with data collection. The permission letter introduced the researcher to the village heads and authenticated the permission granted by the University to collect data. The letter was also used to get permission from the Ministry of Agriculture to interview the extension officers.

The respondents were informed that the information they provided was solely for the academic research, which was a prerequisite for the achievement of Master's degree at the National University of Lesotho. The respondents were told also of their right to pull out from the study at any time thereafter, the questionnaires were administered and some interviews were conducted. The questionnaires and interviews were in Sesotho during data collection and were translated back to English language after data collection. The interviews were held at farmers' and village heads' places and Agriculture Extension Officers' place of work, during the working hours. The interviews lasted for 30 to 45 minutes.

3.9 Ethical consideration

Ethics is an issue that must be taken into account at every step of the research design and execution process (Babbie, 2014). In this study, it was crucial for the researcher to take into account the ethical concerns that the respondents face. Ethical aspects that the researcher observed included informed consent, confidentiality, and honest publication of the findings.

3.9.1. Informed consent

In this study, the respondents were served with the letter explaining that the information obtained was to be preserved with utmost privacy and were given a choice to participate or not. According to Newman et al. (2021), a researcher should inform participats of all aspects of the research, in order for participants to make educated decision and decide whether to engage in the study or give their informed consent. Participants were informed of their right to withdraw from the study at any time. Respecting the rights and dignity of research participants allows them a choice on being part of the study (Christensen et al., 2015).

3.9.2 Confidentiality

In this study, the researcher considered the participants' confidentiality. Confidentiality represents an agreement formed between participants and a researcher prohibits the researcher to disclose participants' identity (Cooper & McNair, 2015). The researcher is to protect the participants' privacy and confidentiality by destroying and preventing unauthorized access to data, which might be linked about the participants' identity (Leedy & Ormrod, 2015). In this study, the respondents were given the reassurance by the researcher that the data they submitted would only be used for the purpose of the research. The audio tapes were clouded and kept in a computer file, then, destroyed later after the study was completed.

3.9.3 Honest Publication of findings

In addition to observing ethical concerns involving the respondents, the respondent should be watchful of ethical concerns that relate to data analysis and reporting (Louw, 2014). The researcher in this study presented the research findings in a manner that reflected the real responses of the respondents.

3.10 Data analysis

Quantitative data obtained using the questionnaire was analysed using Microsoft excel software. The steps followed were data editing, coding, and information entry into the computer, which produced the final report. The results were presented using frequencies, pie charts, and graphs.

On the other hand, qualitative data obtained through interviews was analysed using thematic approach, using ATLAS.ti software. An inductive thematic approach was employed where merging themes were identified and linked. The procedures involved familiarization yourself with

the data, creating first code, looking for themes, revising the themes, identifying them and producing the final report.

3.11 Chapter summary

The chapter presented the research methodology that was utilized in the collection of data. Various data collection methods have been discussed and justified in order to indicate their appropriate use in the study. Data analysis aspects were also elaborated in this chapter. The chapter also outlined the ethics considered when collecting data in this study.

CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents, analyses and discusses data collected from the field on greenhouse tunnel vegetable cultivation and poverty reduction amongst smallholder farmers in the Qiloane Community Council. The chapter is organised into three sections. The first section will present data on the contribution of greenhouse vegetable production on smallholder farmers' livelihood making. The following theme would be on the contribution of greenhouse vegetable cultivation on improving smallholder farmers' living standard, and section three is the intervention measures to assist greenhouse vegetable cultivation smallholder farmers.

4.2 The contribution of greenhouse tunnel on smallholder farmers' livelihood making at the Qiloane community council

The smallholder farmers, extension officers and village heads were asked on the contribution of greenhouse vegetable production to livelihood making of smallholder farmers. The main findings of the study revealed that greenhouses have contributed to respondents' livelihood making by extension of growing season, protection of crops, efficient use of resources, enhanced yields and quality, and crop variety as discussed below.

4.2.1 Extended growing season

The respondents mentioned that greenhouse created microclimate for their crops, which extended their growing season by protecting crops from climate change. When asked the advantages of using greenhouse, all of the respondents considered greenhouse helpful to them, as they were able to plant crops for a longer period. One of the respondent said:

Greenhouse tunnel has allowed me to grow crops for a longer period. The green pepper inside was planted two years back, and during winter, it becomes dry but when it is hot it grows again. That means I have also saved on buying the seeds (Interview with a smallholder farmer 3, 16th April 2023).

The respondents also revealed that they were able to make more than one harvest in the greenhouse tunnels each year. Table 4.1 shows the number of harvest the smallholder farmers made each year when using greenhouse cultivation. The results showed that 5 (62.5%) of the farmers were making 2 harvests per year in their greenhouse tunnels, 2 (25%) made 3 harvests and 1 (12.5%) made more than 3 harvest per year.

Number of harvest per year	**Frequency**	**Percentage**
1	0	0
2	5	62.5%
3	2	25%
More than 3	1	12.5%

Table 4.1: The harvest greenhouse tunnel vegetable cultivation smallholder farmers make each year in the Qiloane community council.

The results showed that greenhouse technology allowed farmers to produce all year round by rotating crops in the tunnels. Greenhouse tunnels extented the growing season for farmers allowing them to make more than one haverst per year because it created a microclimate for the crops. This allowed the smallholder farmers to increase yields, leading to more consistent income streams.

The findings are in line with the study previously conducted by Chaudhari and Chaudhari (2022), who argue that, compared to traditional way of vegetable production, greenhouse tunnel cultivation extends the growing seasons of crops with three times more production. Similarly, in Meru county, Mugure's (2017) research showed that due to temperature and humidity regulation in greenhouse, crops grew faster and stronger during the initial stages of plant growth and growing season was extended up to eight months. In addition, in the United States, Midwest state of Indiana, Bruce et al. (2019) showed that the use of high tunnels had prolonged the growing season for farmers as nearly half of the respondents were able to harvest in the cooler months and planted earlier in spring. Likewise, Hinrichs (2020), study in Mongolia showed that greenhouse farming enabled farmers to extent growing season by at least two months and allowed farmers to harvest two months earlier on average.

4.2.2 Crop protection

The study revealed that greenhouse tunnels protected smallholder farmers' crops against the adverse weather conditions such as frost, excessive rain, wind, or extreme temperatures (as shown by figure 4.1). The respondents mentioned that greenhouse tunnels reduced the risk of their crop damage, which resulted in good marketability of greenhouse tunnel's crops hence, good economic performance of greenhouse tunnels. This is clearly narrated in the following interview with a smallholder farmer:

> *Greenhouse has protected my crops against adverse climate conditions, which led to high yields of tomatoes due to the worm temperature inside* (Interview with smallholder farmer 4, 17th April 2023).

Figure 4.1 Greenhouse tunnel protected structure.

Source: Photo taken by the researcher during fieldwork, April 2023.

Figure 4.2 shows the perception of farmers in terms of the economic performance of the greenhouse technology. The findings shows that 2 (25%) of smallholder farmers participants find the economic performance of greenhouse tunnel excellent, 5 (62.5%) farmers find economic performance of greenhouse tunnel good and 1(12.5%) of farmers find the economic performance of greenhouse satisfying. None of the farmers found economic performance of greenhouse tunnel poor.

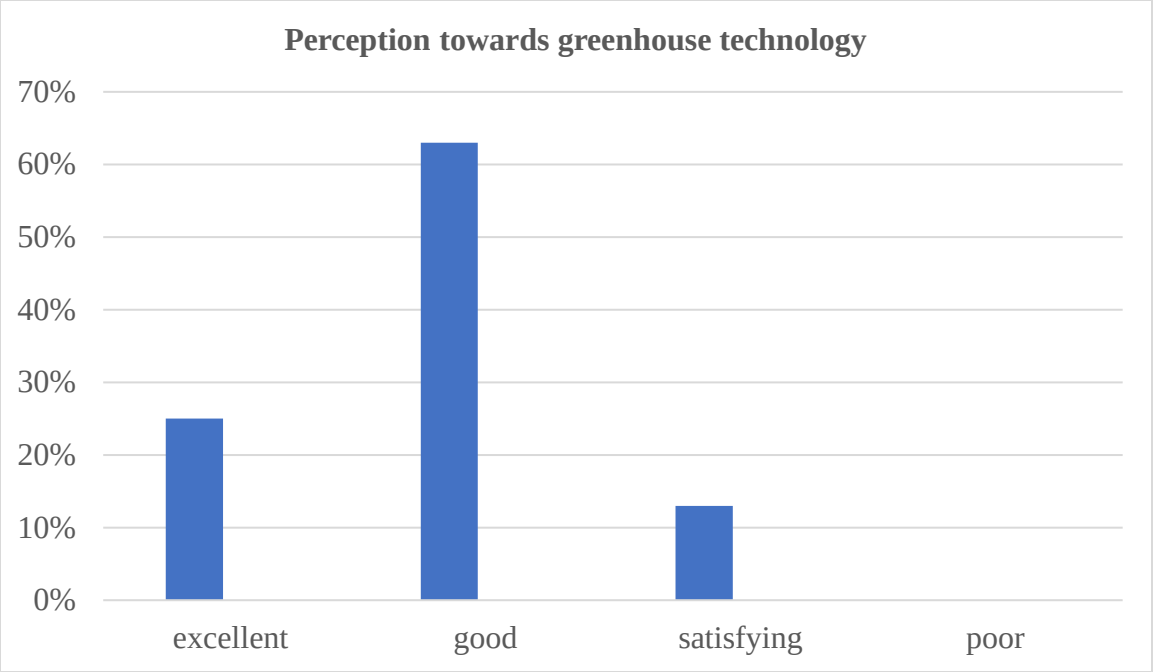

Figure 4.2: The economic performance of greenhouse tunnels.

The results showed that greenhouse tunnels act as a barrier against climate, the enclosed environment reduced the risk of crop damage, resulting in higher yields. The protected structure of greenhouse tunnel has allowed crops to grow faster and allowed smallholder farmers to grow their crops for a longer period. The smallholder farmers were satisfied with economic performance of greenhouse technology production as none of the respondents claimed greenhouse tunnels to be useless system.

The results of the study are concurrent with Nikolaou et al. (2021) study, which showed that greenhouse was a metigating measure to sustainable production and combating climate change in the Mediterranean region. Similarly, Murithi et al. (2021) who carried out a study in Kenya and found out that greenhouse was effective strategy to protect farmers crops loss against adverse climatic variations. The study findings also conforms to the findings observed by Mallya (2019), that majority of the respondents perceived greenhouse cultivation technology to be good and

appealing option for promoting agricultural activities and none of the respondents claimed greenhouse to be an un helpful system. In addition, Morahanye (2020) study conducted in Leribe district in Lesotho also showed that greenhouse relieved farmers from climate change impact by fortifying seedlings and increasing their incomes.

4.2.3 Efficient resource utilization

The respondents mentioned that greenhouse tunnels helped conserve resources by reducing water usage through drip irrigation systems (as shown by figure 4.3). The respondents also mentioned that drip irrigation helped them to reduce water wastage and weed attack on crops as they were watering directly on the plants. This is clearly demonstrated by the words of a smallholder farmer:

> *I consider greenhouse tunnel cost effective because I do not spend much on watering the crops, it keeps moisture and because of the drip irrigation that come with it, I only water at the plant. Even weeds do not grow easily* (Interview with smallholder farmer 3, 16th April 2023).

Figure 4.3 Irrigation system in the greenhouse.

Source: Photo taken by the researcher during fieldwork, April 2023.

The researcher found the use of greenhouse tunnels contributing to sustainable agricultural practices, and reducing the environmental impact of farming activities by saving water resource. The results are in line with Mburu et al. (2015) who did a study in Kenya, which found out that there was 80% water utilization by small-scale farmers using greenhouse technology. Pengelly et al. (2021), report in South Africa deduced that greenhouse was water-smart agricultural innovation technology with high returns for farmers. Likewise KC et al. (2021), study in Nepal showed that as tunnels were equiped with drip irrigation systems that helped during shortage and dry seasons and chemicals were administered in a regulated manner, adopting tunnels helped with the efficient use of scarce resources such as water, fertilizers, pesticides and labour.

4.2.4 Enhanced yield and quality

The findings showed that the use of greenhouse tunnels had contributed to high yields of vegetable. The technology prolonged the production allowing farmers to grow and harvest the crops continuously contributing to increased production of crops. For instance, one of the smallholder farmers said:

> *Greenhouse technology has increased crop yields. I once planted green pepper in the greenhouse tunnel and outside and the one in the tunnel was making yields continuously but the one outside died* (Interview with smallholder farmer 1, 25th April 2023).

The study findings thus reflect that adverse weather conditions such as rainfall and temperature, climate shocks like drought, hailing contribute to crop failure. Greenhouse tunnel farming mitigates the effects of these conditions. The greenhouse reduces the exposure of crops to the risks, which increases farmers produce and consequently increases the welfare of smallholder farmers. Due to the drip irrigation system installed in the greenhouse tunnel and the protection against climate shocks, the tunnels are able to keep moisture and save water usage.

The findings are consistent with Batziakas et al. (2020), in their study of Kansas which indicated that by providing food availability through increasing yield and a longer harvest window during the growing season, spinach production using tunnel technology can lower preharvest food losses. Similarly, Khan and Khan (2020), found out that yield per acre of vegetables grown in the tunnels was higher than that of vegetables grown in open field, as the production of tomatoes in tunnels was 117% above production in open field and cucumber was 25% higher than open field.

4.2.5 Crop variety

The respondents stated that greenhouse allowed them to cultivate a wide range of crops, including high-value and varieties that may not be suitable for open-fields cultivation. Data analysis reveals that tomato and cabbage were the leading vegetables that farmers grow with 75%, followed by

radish and pepper by 50%, and cucumber, lettuce and spinach are 25% respectively, while green beans and chilli are 13% (See figure 4.3).

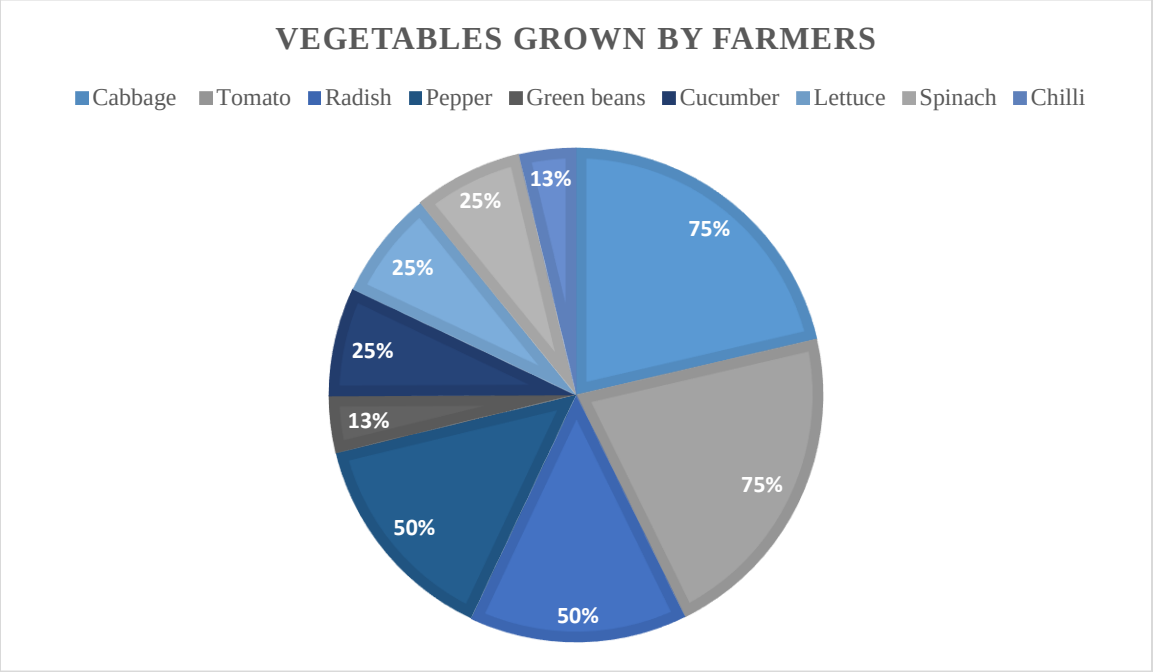

Figure 4.3 Vegetables grown by smallholder farmers in the greenhouse at the Qiloane community council.

Generally, one can say that, most of tunnel produced crops planted by the smallholder farmers were the ones highly demanded daily by the consumers and were fast moving in the market. Tomato and cabbage became the leading vegetables grown in the community followed by radish and pepper. Greenhouse tunnels allowed farmers to grow crops that were not suitable for open field in the country, and this diversification of crops enabled farmers to tap into niche markets, meet customer demands and reduce farmers' dependence on single crop.

The findings confirms Finmark Trust (2021), report in Lesotho, which indicated that tomatoes, cabbage and leafy greens were among the crops with high market demand in Maseru. The results

are also consistent with that of Ali et al. (2020) study in Balochistan that showed that tunnel technology played an important role in GDP of the overall country by increased yields for tomatoes and the socio-economic conditions for farmers. Ghimire et al. (2022), study found that farmers who were growing high number of vegetable types in tunnels were securing more benefits and increased incomes for their households. Similarly, Dhillon (2022), in Northen India showed that farmers were able to cultivate out of season high value vegetables like tomato, cherry tomato, colourful capsium, pole type french beans and so on in poly houses or walk-in tunnels.

4.3 The contribution of greenhouse tunnel vegetable cultivation to farmers' living standards in the Qiloane community council

When researching the contribution of greenhouse tunnel vegetable cultivation in improving the living standard of smallholder farmers, the respondents showed that, the benefits they get from using tunnels are that of increased income generation, employment opportunity, food security and knowledge and skill development.

4.3.1 Increased Income generation

The study showed that the smallholder farmers were able to generate income from the use of greenhouse tunnels. When asked what they do with the money generated from the tunnels, majority of smallholder farmers mentioned that they invested back into farming through buying seeds, fertilizers and pesticides. As one farmer explained:

> *I save money I generate from the greenhouse farming for the next planting season; I buy seed, fertilizers and pesticide. I have bought the car that I am using to deliver my crops to the market* (Interview with smallholder farmer 4, 17th April 2023).

Some of the smallholder farmers mentioned that they were able to pay school fees for their children. They further confirmed that they were able to support their families with the other portion of the income.

Figure 4.4 below shows the estimated income made by farmers per crop, per season in their greenhouse tunnel. The study shows that the farmers in the study were able to make an income of up to M100 000 for tomatoes, M100 000 for cabbage, M80 000 for radish and M70 000 for pepper without subtracting the expenses. The results shows that tunnels has contributed to a great extent in the income generation of the farmers.

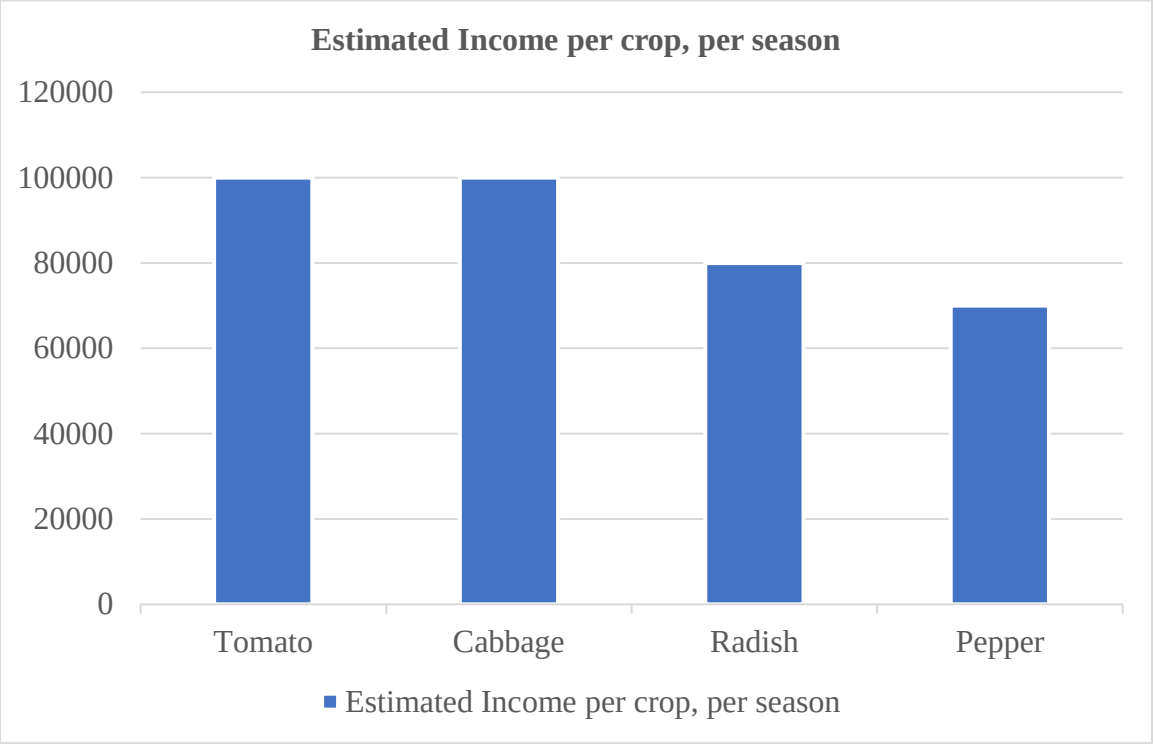

Figure 4.4 Income that greenhouse vegetable cultivation smallholder farmers make per crop, per season.

It can be analysed that greenhouse tunnel provided smallholder farmers with an opportunity to grow high-value crops and extended their growing season. This led to increased crop yields and

higher-quality produce, allowing farmers to fetch better prices in the market. The additional income generated from the selling greenhouse tunnel grown crops helped the financial stability of smallholder farmers, which contributed to a better standard of living.

The study findings are in line with Kumar and Kumar (2020), study which showed that income in off-season increased by 40% as protected cultivation enabled vegetables in off-season and also extended the vegetable growing seasons for a much longer period than was possible under open field. Likewise, Mburu et al. (2015) study in Kenya revealed that greenhouse farming had the potential to feed the population and generate income as farmers were economically better off by producing vegetables and flowers for export in the tunnel. In addition, in Botswana, Badimo (2020) study revealed that the average farm income for high tunnel adopters was two times more than that of non-adopters.

4.3.2 Employment opportunity

The respondents reported that the tunnels have enabled them to hire more employees to help with ploughing, harvesting, security, and management of their farms. They mentioned that ever since the use of greenhouse tunnels they have employed many people especially during ploughing season as the workload increased in the tunnels. One of the smallholder farmers even indicated to have employed one of the graduate from the local university to manage and to help with his skills of agriculture on the use of greenhouse technology. One of the village heads mentioned:

> *The community members have benefited from the tunnel farmers as they are hired. The young men who are not working in the community are given jobs there* (Interview with village head 2, 13th April 2023).

It can be deduced that greenhouse cultivation gives an opportunity for employment as majority of the respondents reported that they have increased the labourers ever since they have started greenhouse tunnel production. The jobs that were derived from the greenhouse tunnels are seasonal as the smallholder farmers revealed that they employed one permanent person and when the workload increases, for instance, during ploughing season and harvest of other vegetables like tomatoes, they hired temporary employees.

The study results are consistent with Rodricks (2022), who argued that protected vegetable production technologies provide an opportunity for self employment which notably reduces expenditure spent on labour. In another study in western India, it was pointed out that protected cultivation had a potential to increase crop yields and quality and generated employment in Maharashtra (Pachiyappan et al., 2022).

4.3.3 Improved Food security

The respondents indicated that growing vegetables all year round in their greenhouse tunnels has contributed to their healthy way of living as they included vegetables in their diet. The respondents further mentioned that greenhouse tunnels have contributed to the availability of vegetable crops. The community had also benefited, as they do not have to travel long distances to get vegetables. This becomes clear in the following interview excerpt with a village head:

> *The community members have benefited from greenhouse tunnel farming because they are able to find vegetables in the village; the vulnerable villagers are even given the vegetables that are not good for the market free* (Interview with village head 1, 13th April 2023).

The results showed that greenhouse tunnels have potential to improve food security for smallholder farmers, as the crops were available all year round and the farmers were able to access, and afford

crops with the income they generated from the tunnels. Greenhouse tunnels had offered smallholder farmers a means to produce a consistent supply of fresh and nutritious food throughout a year. By providing a controlled environment that protected crops from adverse weather conditions and insects, greenhouse tunnels reduced the risk of crop failure. This ensured a reliable food supply for farmers and their families, which contributed to improved food and nutrition security.

A similar study in Ghana by Ofori et al. (2022) pointed out that, greenhouse tomato farming technology was a promising farming practice which ensured food and nutrition security. ITC (2017), report in Lesotho on evaluating the performance of Horticulture Production Development Project (HPDP), concluded that the beneficiaries who were given greenhouse benefited from the project as the mushroom production provided an opportunity for farmers to suppliment their income from other sources and their food security.

4.3.4 Knowledge and skill development

The respondent reported that adopting greenhouse tunnel technology necessitated them to acquire new skills and knowledge related to tunnel management, crop cultivation, and pest control. Furthermore, the respondents pointed out that they make use of the knowledge they acquire from extension officers. The respondents even revealed that they were able to produce their own organic method of pest management. The respondents mentioned that they shared their knowledge with each other. This is clearly elaborated from the following interview excerpt:

> *We support each other as greenhouse tunnel farmers by working together as a society, sharing our knowledge on how to deal with the challenges we face. I also read a lot so that I can see what solution to come up with when challenges arises* (Interview with smallholder farmer 5, 26th April 2023).

The results showed that adoption of tunnel technology had empowered the smallholder farmers with skills development and knowledge. This had enhanced their capacity to adopt to changing agricultural practices and improved their overall livelihood prospects. The findings are in line with preceding results which state that introducing agricultural technologies empower smallholder farmers as they are the most disadvantaged farmers with small land and more vulnerable to climate change.

Hinrichs (2020), concurs with this reasoning and further states that women participation in greenhouse farming in Mongolia enabled them to higher marginal production of leafy greens which were grown closer to their homes. Furthermore, Khan (2022), emphasised that tunnel farming is a capital intensive bussiness that can result in profitability and high returns by raising production cost depending on farmers' knowledge and skills of agriculture and farming hence, training of smallholder farmers on the technology is important. In addition, Yaseen, et al. (2020),'s study in District Sargodha showed that knowledge level of farmers played an important role in increasing tunnel productivity, as farmers knew the appropriate time for sowing and which crops to grow.

4.4 The intervention measures to assist greenhouse tunnel vegetable farming smallholder farmers in Qiloane community council

In this section, the chapter offer the suggestions on the intervention measures that can be employed to address the challenges facing smallholder farmers engaging in greenhouse tunnel vegetable production. The respondents suggested that installation of ventilation and temperature control, availability of agricultural materials and subsidies on seed and fertilizer, training, and access to markets can be the intervention measures that can be implemented to address the challenges the smallholder farmers engaging in greenhouse tunnel vegetable cultivation face in the study area.

4.4.1 Installation of temperature control/ ventilation

The researcher established from the respondents that smallholder farmers engaging in greenhouse tunnel production faced the challenge of high temperatures. The respondents reported that the high temperatures in the greenhouse tunnels caused a high infestation of diseases and pest in the tunnel. One of the respondent also stated:

> *The diseases and pest in the tunnels multiply fast because it is hot inside. I cannot carry on with my daily activities inside the tunnels especially during summer due to heat inside* (Interview with smallholder farmer 5, 26th April 2023).

The respondents suggested that the installation of temperature or ventilation could be the solution to high temperatures inside the greenhouse tunnel. The respondents mentioned that the temperature controller would allow them to be able to grow off-season crops, as they were not able to produce tomato during winter season.

The results of this study show that the installation of ventilation can address the challenges of high temperature inside the greenhouse tunnel. The installation of ventilation can help the farmers to meet or fetch the demand and high prices of off-season crops in the market.

The findings confirm IFAD (2019) report on Lesotho country starageic oppportunity programmes 2020-2024, that the incidences of diseases and pest due to high temperatures and drought in the country led to crop failure. The findings are also in line with Nordey et al. (2017) study in Sub-Saharan Africa, which found that not all climatic conditions were suited for low technology protected horticulture in the region, and in order to adequately control pests needed to be combined with other methods. Additionally, Ampim et al. (2022), emphasised that despite the fact that temperatures inside tunnels are often a few degrees higher than outside, it was important to have

basic portable heater or other heating devices to protect crops from unexpectedly low temperatures in the spring or fall.

4.4.2 Available agricultural inputs and subsidies

The respondents stated that planting in the tunnels was expensive, in terms of labour, seeds, fertilizer and pesticides. The respondent revealed that the number of smallholder farmers engaging in greenhouse tunnels were not increasing, as the farmers were not able to afford the tunnels. The farmers got the tunnel from Smallholder Agriculture Development Project (SADP), which require the farmers to have a certain percentage of capital in order to qualify for greenhouse tunnel. Moreover, the farmers pointed out that the percentage was too high for them to reach. The respondents also mentioned that the pesticides were expensive and unavailable in the country. One of the respondent mentioned:

> *When the farmers face diseases, they come to us for advice and some of the pesticides we advise them to use are unavailable in the country, they have to go to South Africa to find them and that add to their expenses* (Interview with extension officer 1, 19th April 2023).

The respondents revealed that their greenhouse tunnels were harbor for diseases and pests, tomatoes for example, were affected by leaf miner (Tuta absolute) which multiplied in high rate that within one night the whole tunnel can be filled with it, and this caused yield losses. The respondents suggested that availability of pesticide, seeds and fertilizers in the country could be an intervention measure. They even stated that, since these agricultural inputs were expensive, subsidies would be a better solution.

The analysis of this study is that greenhouse tunnels can create a favourable environment for pest and diseases, proper pests and diseases management strategies such as crop rotation, biological

control methods and regular monitoring are essential to minimize losses. Subsidies would help the farmers to see the profitability of greenhouse technology since the agricultural inputs were expensive.

The study results are concurrent with Ghimire et al. (2022) study in Nepal, which showed that provision of continued technical support, input supply and market information were essential to sustain the technology adoption, as farmers who did not receive training and not engaged in marketing activities were likely to discontinue poly house technology. The study results are also in agreement with Ibishi and Musliu (2022), study in Kosovo, which concluded that government grants helped the greenhouse farmers to engage and recognise the potential of greenhouse vegetable cultivation, due to more income the garantees made per season.

4.4.3 Training

Lack of knowledge and skills were another challenge that the respondents mentioned. The respondents pointed out that they were not able to manage their crops well as the latest attack of diseases and pest affected their production. This is highlighted in the following interview excerpt with a smallholder farmer:

> *Capital shortage made my cabbage to be attacked by diseases during their last stage of growth, it was growing well but it did not make it to the market because I did not have money to buy the pesticide anymore* (Interview with smallholder farmer 5, 26th April 2023).

The respondents reported that lack of support from the extension services is another challenge they are facing. The respondents suggested that training is a solution to the challenges. The key informants stated that training of extension staff so that they can be able to train and give enough support to farmers is the solution.

The results of this study shows that building extension employees' abilities to use current or better technologies and practices as a success facilitator must be given a top priority. A technology's performance is less uncertain when information is readily available; therefore, successful extension services help farmers adjust their opinions of new technology thereby facilitating its adoption.

The findings are in agreement with Khan (2022) study which, was assesing the benefit-cost ratio of two high tunnels at the National Agriculture Research Centre project side in Pakistan, and found out that, the technical incompetence of smallholder farmers contributed to lower yields at the project hence only 10 percent of vegetables were sold out by the farmers. Another study in Tunisia, Dhehibi et al. (2020), indicated that the most effective strategy for tranferring agricultural technology to improve smallholder farmers' livelihoods was ranked as technical training in agricultural technology. Furthermore, Yaseen et al. (2020),'s study in District Saegodha deduced that tunnel farmers lacked knowledge on how to overcome the increasing attack of insects, diseases and pest which led to high import of vegetables in the country.

4.4.4 Access to market

The respondents revealed that they were struggling to make profit for their greenhouse tunnel grown vegetables because their produce were not sold at the price they as producers made. The supermarkets were the ones deriving the prices. The respondents stated that not being able to produce according to the standards was the problem so selling to individuals at their villages was an option. The respondents also expressed that they were not satisfied with the large supermarkets that imported vegetables from the South African producers even when the local produce was abundance. In order to address these challenges, the respondents suggested that access to market

would help them to be able to sell their produce, and being able to access the same seed so that they will be able to plant the same crops, as tunnel growers will also help them.

The results show that access to market can be a solution to address the challenges faced by farmers. Farmers tend to sell their produce in village and petty traders with lower prices. Linking farmers to market can help them to be able to access better prices. The study results are in collaboration with those of Kafle and Shrestha (2017), in Nepal, who noted that greenhouse tomato farmers faced price variation and monopoly of price fixation, as traders decided prices irrespective of the prevalent price,due to not grading crops. Similarly, Vulauwe et al. (2020) study, concur that linking smallholder farmers to output and input markets in Southern Africa can enable them to sell produce product at a favourable prices and avoid being short-changed by middlemen.

4.5 Chapter summary

The chapter presented, analysed and discussed data on how greenhouse vegetable cultivation affected poverty reduction among smallholder farmers in the Qiloane community council. From the research findings, it is evident that greenhouse technology has a potential contribution to smallholder farmers' livelihood making by protecting crops from adverse weather conditions, increased yields and quality, crop variety, and efficient use of water resources.

Greenhouse vegetable cultivation generally contributed to smallholder farmers' living standards by increasing income, employment opportunities, and skills development. By providing a controlled environment that protected crops from adverse weather conditions, greenhouse cultivation had reduced crop failure, which ensured reliable food supply for farmers and their families, thus, contributing to improved food and nutrition security.

The main challenges identified include; high temperature, high infestation of diseases and pest, expensive and unavailable agricultural inputs, and lack of knowledge and support from extension officers. The smallholder farmers suggested to be provided with training, availability of agricultural inputs and subsidies, installation of temperature controller or ventilation, and access to markets in order for them to see profitability of greenhouse vegetable cultivation.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter begins with relating the Sustainable Livelihood Framework to the study findings. The chapter then draw a conclusion of the study findings based on the objectives of the study and put forth recommendations for future policy.

This study assessed the impact of greenhouse tunnel vegetable production on poverty reduction amongst smallholder farmers in the Qiloane community council using sustainable livelihood framework. The study asserts that the sustainable livelihood framework is an essential framework to understand how the smallholder farmers make use of their assets, and being able to overcome shocks and stress to provide a sustainable livelihood without destroying the natural base. The sustainable livelihood framework provides an insight of the way the smallholder farmers can combine their resources, assets or types of capital to come up with livelihood strategies in order to achieve the desired livelihood outcome in a specific context of vulnerability.

In this study, the smallholder farmers in the Qiloane community council were able to use greenhouse as an asset to protect their crops from the vulnerability of climate and able to make use of it to better their lives. By making efficient use of water resources, smallholder farmers are able to make use of greenhouse to sustain their livelihood without destroying the natural resources. The farmers were able to make use of greenhouse tunnels to overcome the shocks, and seasonality of crops by extending their growing season. The farmers are able to use capital to sustain their livelihood, which include human capital, social capital and financial capital to mention a few.

5.2 Conclusion

The study sought to find whether greenhouse tunnel vegetable cultivation contributed to smallholder farmers' livelihood making. Greenhouse tunnels has proven to be substantially

increasing crop yields for smallholder farmers in the study area by allowing the farmers to grow crops year round while at the same time decreasing water consumption. The study therefore, concludes that greenhouse technology has a potential to contribute to sustainable agricultural practices for smallholder farmers. Further, growing crops under greenhouse tunnels conditions can enhance the quality, yields, and enable smallholder farmers to cultivate crops over a long period. As a result, it is concluded that greenhouse tunnel cultivation has the potential to contribute to smallholder farmers' livelihood making by extended growing season, crop protection, efficient use of resource utilization, and enhanced yields.

The study sufficiently answered the research question on the contribution of greenhouse vegetable cultivation to improving smallholder farmers' living standards. By increased incomes for smallholder farmers in the study area, the study concludes that greenhouse cultivation has helped farmers to be able to meet their everyday needs. The study further deduces that greenhouse farming is a cost effective way of farming which leads to improved economic wellbeing of the smallholder farmers, which can also contribute to the country's economy. Greenhouse farming has empowered smallholder farmers with skill and knowledge to use agricultural technology. The study concludes that, greenhouse vegetable cultivation has a potential to create employment and increasing income generation thereby improving the livelihood of smallholder farmers in the greenhouse vegetable value chain.

It is further concluded that whilst the greenhouse tunnel contributes to smallholder farmers' livelihood making and living standards, there are challenges that hindered the use of tunnels such as high temperature, high disease and pest infestation rate, water log, unavailable pesticides, expensive agricultural inputs and lack of knowledge. The study argues that there is a need to provide smallholder farmers with necessary input packages, frequent farm visits and training in

order to see the full potential of greenhouse tunnel cultivation. Furthermore, smallholder farmers need installation of temperature controller or ventilation in the greenhouse tunnel to produce off-season crops and to control high temperatures in the greenhouse tunnel.

5.3 Recommendation

The following recommendations are based on the opinions expressed in the findings of the present study:

- The installation of temperature controller to help farmers to be able to control temperatures in the greenhouse tunnels, which can also lead to off-season crop production, can be a solution. The high temperatures that lead to high infestation of diseases and pest can be controlled in the greenhouse tunnels if the temperature controller is installed.
- Participatory engagement of all stakeholders including, farmers, extension officers, research facilities etc., is encouraged. There is a need for education and training of extension officers and smallholder farmers to stay updated on the lasted advancements in greenhouse tunnel vegetable farming techniques through workshops, seminars and online resources. Learning from experienced farmers and seeking help from extension services or local horticulture experts to enhance the knowledge and skills of farmers.
- The implementation of integrated pest management strategies to control disease and pest effectively is required. Regularly inspecting plants for signs of infestation or disease, and responding appropriately such as using organic pesticides, or employing physical barriers like net or screens to protect crops.
- Market oriented approach will also help the smallholder farmer so that they will be able to produce crops that are needed by the market, the standard that is needed by the big

retailers and food suppliers in order to see the profitability of the greenhouse tunnel technology.

- Close monitoring of the success and impact of the greenhouse tunnels to understand the potential of the initiative to contribute to agriculture transformation and livelihoods, and attract increased investment.

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APPENDICES

Appendix 1

RESEARCH ETHICS CONSENT FORM

PART 1: GENERAL INFORMATION ABOUT THE STUDY

I am Malerato Elizabeth Morato, a student at the National University of Lesotho under the faculty of Humanities. I am conducting a study on *'Greenhouse vegetable cultivation and its impact on poverty alleviation among smallholder farmers in the Qiloane Community Council'***.** The purpose of the study is to assess how greenhouse vegetable farming contributes to livelihoods making, improves living standards of smallholder farmers and suggests intervention measures that can be implemented to address challenges facing greenhouse vegetable cultivation among smallholder farmers.

You are invited to take part in this study on a volunteer basis. If you disagree with the study's methodology, you have freedom to leave at any time without penalty. You have the right to clarification and questions during participation. If you agree to take part, you will be asked to complete a questionnaire and respond to interview questions that seek out pertinent information about the subject.

Although you might not directly gain anything from taking part in the questionnaires and interviews, the data you provide helps to enlighten the appropriate policy makers regarding greenhouse cultivation in the country. The information you provide will be utilised for academic purposes.

I can guarantee you that any information you provide me while taking part in this study will be kept absolutely private. Any data that could be used to identify you in the study will be deleted

when it has been finished and assessed. Your identity will not appear in any report that summarises the study's findings.

PART II: Certificate of Consent

I have read the aforementioned details, I had the chance to ask questions about them and all of my inquiries have received satisfactory responses. I thus agree to freely engage in this study as a respondent.

Name of participant……..

Signature of participant…….

Researcher's signature……

Date……

Day/month/year

Appendix 2

Questionnaire guide for smallholder farmers

My name is Malerato Elizabeth Morato and the questionnaire is intended to collect data for academic research, prerequisite for the attainment of MA Development Studies at the Nation University of Lesotho. I am researching on 'Greenhouse vegetable cultivation and poverty alleviation among smallholder farmers in the Qiloane community council and I would like to ask a few questions about the subject to understand what impact the greenhouse vegetable cultivation has on poverty alleviation.

1. Name.....
2. Age.....
3. Gender: Male ( ) Female ( )
4. Marital status: (i) Married ( ) (ii) Divorced ( ) (iii) Single ( ) (iv) Widow ( )
5. Highest education attained.....
6. Household size..... number of children in the household.....
7. How big is your greenhouse: (i) 10m x 15m ( ) (ii) 10m x 30m ( ) (iii) Up to I acre ( ) (iv) More than 1 acre ( )
8. How many years have you been engaged in greenhouse vegetable farming? (i) Less than six months ( ) (ii) Less than 1 year ( ) (iii) 1-3 years ( ) (iv) More than 3 years ( )
9. Which vegetables do you grow in your greenhouse?.....
10. How many harvests do you make each year? (i) 1 ( ) (ii) 2 ( ) (iii) 3 ( ) (iv) More than 3 ( )
11. What is the estimated income per crop, per season? Mention crop....., income after selling.....

12. How can you rate economic performance of greenhouse technology? (i) Excellent ( ) (ii) Good ( ) (iii) Satisfying ( ) (iv) Poor ( )

Appendix 3

Interview guide for smallholder farmers

Greetings and introduction

My name is Malerato Elizabeth Morato and this interview is intended to collect data for academic research, prerequisite for the attainment of MA Development Studies at the National University of Lesotho. I am researching on greenhouse vegetable cultivation and poverty alleviation amongst smallholder farmers in Qiloane community council. I would like to ask you a few questions about the subject to capture your perspectives as smallholders in the community. The interview will take between 30 to 45 minutes.

Questions

The contribution of greenhouse vegetable farming to smallholder farmers' livelihood making

1. Are you able to produce crops all year round in the greenhouse?
2. Do you rotate crops?
3. What are the advantages of using greenhouse technology?
4. What are the disadvantages of greenhouse technology?
5. Which pest management method do you use?
6. Are there any challenges hindering your farming activities since you started practicing greenhouse farming?
7. How is the marketability of the crops under greenhouse?
8. What systems other than greenhouse do you use for growing vegetables?
9. Which of the systems is easier?
10. Which crops grow better in greenhouse?

11. Are you satisfied with the use of greenhouse?

The contribution of greenhouse vegetable farming to improving living standards

12. What are the advantages of using greenhouse technology?
13. Do you generate income from the project?
14. What do you do with the income generated from the greenhouse?
15. Have you increased or decreased the labourers since the use of greenhouse?
16. How has your household improved through greenhouse vegetable cultivation? Please elaborate
17. How have these changes in your household affected your way of living?
18. Would you consider the use of greenhouse farming cost-effective?
19. Have the economic wellbeing of the family members been increased after involving in greenhouse vegetable cultivation?

Intervention measures to assist greenhouse vegetable farming smallholder farmers.

20. What do you think contributes to the failure/success of greenhouse vegetable cultivation activities as a smallholder farmer?
21. What kind of support related to greenhouse vegetable cultivation do you get and from whom?
22. In your opinion, what are solutions for improving greenhouse vegetable cultivation for smallholder farmers?

Appendix 4

Interview guide for extension officers

I am Malerato Elizabeth Morato and the interview is intended to collect data for academic research, prerequisite for the attainment of MA Development Studies at the National University of Lesotho. I am researching on greenhouse vegetable cultivation and poverty alleviation amongst smallholder farmers in the Qiloane community council and would like to ask you a few questions about the subject to capture your perspectives as extension officer in the community. The interview will take between 10 to 20 minutes.

Questions

Section A

Demographics

Name.....

Age.....

Gender: Male ( ) Female ( )

Highest education attained.....

How long have you been an extension officer? .....

Section B

Extension officers

The contribution of greenhouse vegetable farming to smallholder farmer's livelihood making

1. How long have you been working with smallholder farmers in this community?
2. How many greenhouses are you assisting the vegetable farmers with?
3. Are the numbers increasing or decreasing?
4. What do you think contributed to increase or decrease of farmers?

The contribution of greenhouse vegetable farming to improving living standards

5. How often do you visit the farmers?
6. How are the lives of farmers improved through greenhouse vegetable cultivation?
7. How does greenhouse vegetable cultivation contribute to farmers' income generation?
8. What benefits do the farmers obtain from greenhouse vegetation?
9. What challenges are the vegetable farmers face?

To suggest intervention measures to assist greenhouse vegetable farmers' smallholder farmers.

10. Which existing strategies are available for addressing challenges faced by smallholder vegetable farmers?
11. What are the challenges or successes of the strategies?
12. Is there a continuous monitoring with/of smallholder farmers after the strategies?
13. Do you think you have given enough support to these farmers?
14. What do you think needs to be done to address the challenges faced by these farmers?

Appendix 5

Village heads interview guide

I am Malerato Elizabeth Morato and the interview is intended to collect data for academic research, prerequisite for the attainment of MA Development Studies at the National University of Lesotho. I am researching on greenhouse vegetable cultivation and poverty alleviation amongst smallholder farmers in the Qiloane community council and would like to ask you a few questions about the subject to capture your perspectives as village heads in the community. The interview will take between 10 to 20 minutes.

Questions

Demographics

Name.....

Age.....

Gender: Male ( ) Female ( )

Highest education attained.....

Section B

The contribution of greenhouse to smallholder farmers' livelihood making

1. Do you have members in your village that are involved in greenhouse vegetable farming?
2. How many village members are involved?
3. Through your observation, do you see the numbers increasing or decreasing?

4. What do you think contributed to the increase of farmers using greenhouse? / What do you think contributed to decrease of farmers?

The contribution of greenhouse to improving farmers' living standard

5. Is there improvements you can see in farmers' lives since their involvement in greenhouse farming?
6. How are the village members benefiting from the greenhouse farming?
7. What are the challenges that farmers are facing?

To suggest intervention measures to assist greenhouse farmers

8. What existing intervention strategies has been done to assist greenhouse smallholder farmers in your village?
9. Do you see any improvement brought by the strategies?
10. What benefits are brought by the strategies? Alternatively, what challenges?
11. What do you think can be done to address the challenges faced by smallholder farmers engaging in greenhouse vegetable cultivation in your village?