DETERMINANTS OF PRODUCTIVITY AMONG AFRICAN INDIGENOUS VEGETABLE FARMERS IN VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH AFRICA

VS MULAUDZI

orcid.org/0000-0001-7381-2171

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Supervisor: Prof. A. S. Oyekale

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Student number: 25245686

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DECLARATION

I Vuledzani Sheryl Mulaudzi hereby declare that the dissertation entitled, **DETERMINANTS OF PRODUCTIVITY OF AFRICAN INDIGENOUS VEGETABLE IN VHEMBE DISTRICT, LIMPOPO PROVINCE** submitted by me in fulfilment of the requirements for the degree Master of Science in Agricultural Economics in Economics at North-West University has not previously been submitted for any degree purposes at this or any other university. I declare that this is my own work in design and execution and all the information that has been sourced from other people's work has been clearly acknowledged and reflected in the list of references.

Signed at: *NORTH-WEST UNIVERSITY (MAFIKENG CAMPUS)*

Signature: ______________________ Date: 13/10/2017

Vuledzani Sheryl Mulaudzi

Supervisor: ______________________ Date 13/10/2017

Professor A.S Oyekale

DEDICATION

I dedicate this thesis to my parents for the tremendous support and encouragement they have shown me throughout my years of study. To my parents Cathrine and Seth Mulaudzi, your prayers and constant desire to know my progress allowed me to push ahead even in the hardest times. Thank you for all the sacrifices you made for me to go to school, there are no words to describe how grateful I am. Mudzimu avha tonde lini na lini.

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ABSTRACT

Agriculture remains the mainstay of many African economies. It continues to be a key tool for sustainable development, alleviation of poverty, generation of household income and food security in many developing countries, including South Africa. Therefore, the study was aimed at evaluating productivity and technical efficiency of African indigenous vegetable farmers in Vhembe district of Limpopo province. Farming constraints experienced by farmers in the study area were also explored.

The results from the analysis revealed 59.6 years as the average age of the farmers. About 43.9% of the farmers had a maximum of 13 years of schooling while the number of years of farming experience was relatively high with mean years of 30.9 years. Analysis of gender indicated that 64% of the respondents were female. The household size was uncovered to be 4.96 members on average. About 84% of the farmers lacked access to formal credit, while 92% had access to extension services.

Empirical results from Cobb-Douglas production function found area cultivated, fertiliser, seeds and labour to be the positive significant factors influencing productivity of indigenous vegetables farmers. The estimated elasticity of area cultivated, fertiliser, labour and seed inputs were found to be 0.22, 0.07, 0.09 and 0.002 respectively. Land was viewed as the most vital input determining productivity of vegetables with the highest elasticity.

Furthermore, results revealed that smallholder farmers in Vhembe district are technically efficient in the production of indigenous vegetables with the highest mean of 0.93% level. Variables which were found to be significant in determining technical efficiency were years of schooling, extension services, gender and access to irrigation system.

Farmers in Vhembe district were found to be facing numerous challenges when producing and marketing indigenous vegetables, of which the most common were shortage of water (79%), lack of improved seeds (66%), perishability of vegetables (58), poor access to high-value market (54%) and low selling price (54%).

In conclusion, based on the outcome of the study, it was recommended that farmers should expand land under indigenous vegetable cultivation in order to enhance productivity thereby maximizing profit. It was further recommended that in order to enhance extension services in the study area, training and practical workshop approach should be adopted. Constructing of boreholes was recommended as a possible solution to water scarcity problem in the area.

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LIST OF ACRONYMS

GDP	-	Gross Domestic Product
ALVs	-	African Leafy Vegetables
AIVs	-	African Indigenous Vegetables
TLVs	-	Traditional Leafy vegetables
ARC	-	Agricultural Research Council
DRDLR	-	Department of Rural Development and Land Reform
DAFF	-	Department of Agriculture Fishery and Forestry
FAO	-	Food and Agricultural Organisation
NRC	-	National Research Council
DFID	-	Department for International Development
TFP	-	Total Factor Productivity
TVC	-	Total Variable Cost
TFC	-	Total Fixed Cost
OLS	-	Ordinary Least Squares
AVC	-	Average Variable Cost
CRS	-	Constant Return to Scale
VRS	-	Variable Return to Scale
SFA	-	Stochastic Frontier Analysis
DEA	-	Data Envelopment Analysis
EHDA	-	Ethiopian Horticulture Development Agency
DoA	-	Department of Agriculture
GTEDA	-	Greater Tzaneen Economic Development Agency
SPSS	-	Statistical Package for the Social Sciences
VMP	-	Value of Marginal Product
MPP	-	Marginal Physical Product

CHAPTER ONE

INTRODUCTION

1.1 Background

Agriculture remains the spine of many African economies (Balarane and Oladele, 2012). As such many people across regions of Africa are dependent on agriculture for their livelihood and employment (Akram-Lodhi et al., 2008). Agriculture remains a basic tool for poverty alleviation and food insecurity, sustainable development and attainment of household income in most countries in Africa, including South Africa (Olwande *et al.*, 2009).

Over the past decades, despite a decrease in South African's Gross Domestic Product (GDP) from 7.1 in 1970 to 2.49 in 2014 (World bank, 2015), agriculture continues to be virtually significant to the economy. Approximately 16.9% of the population directly or indirectly depending on agriculture for their employment and income generation. In view of this development, South Africa has a dual farming system, consisting of well-developed commercial and small-scale communal farming system (Antwi and Seahlodi, 2011). Additionally 87% of the total arable land belongs to commercial farmers, which accounts for 95% of the total marketed produce, while smallholder farmers only occupy 13% of available arable land (Ngyangweni, 2000).

In South Africa precisely, vegetable production is a significant source of household revenue generation and food security for many smallholder farmers, producing a range of vegetables among which includes African indigenous vegetables (AIVs). Subsequently, utilisation of AIVs has been viewed to be as old as the history of modern man. For instance, Khoisanoid people who have resided in Southern Africa for at least 120 000 years ago, relied strongly on consumption of these plant species for their survival Odhav *et al.*, (2007).

Schippers (2000a) defined African Indigenous Vegetables (AIVs) as plant species whose leafy parts (which may include young, succulent stems and very young fruit) are consumed as vegetable. In other context, they are regarded as traditional leafy vegetables (TLVs) or African leafy vegetables (ALVs) (van Rensburg *et al.*, 2005). As a result, these terminologies are often used interchangeably among different scholars (Senyolo *et al.*, 2009; Backeberg, 2013; Chelanga, 2013).

Equally, people in South Africa use various terms to refer to these AIV species collectively. For example, they use expressions such as *Muroho* (Tshivenda), *Morogo* (Sesotho, isiPedi) and

Imfino (isiZulu, isiXhosa) (Njume *et al.*, 2014). Furthermore, Schippers (2000a)noted that many popular indigenous vegetables were collected and obtained from the wild fields as they grew naturally other than from cultivation using traditional horticultural husbandry. Additionally, Ebijuwa and Mabawonku (2015) argued that such wild crops were often viewed as weeds in commercial cropping systems but neat in smallholder farming systems.

Numerous varieties of African indigenous or leafy vegetable species exist and are utilised among small holder farmers. Some of these varieties were identified and advocated for by research institutions such as Agricultural Research Council (ARC) and Department of Rural Development and Land Reform (DRDLR). Table 1 illustrates a subset of some indigenous vegetable species that have been produced by farmers to enrich their livelihood. These vegetables are commonly used across many provinces of South Africa. However, many of these species (Nightshade, Chinese cabbage, Pumpkin leaves) are said to be highly common in Vhembe district, Limpopo Province (van Rensburg *et al.*, 2005).

Table 1: African indigenous vegetables species

English	**Tshivenda**	***Scientific name***
Nightshade	Muxe	*Solanum spp.*
Chinese cabbage	Mutshaini	*Brassica rapa subsp, Chinensis*
Pumpkin leaves	Fhuri	*Cucurbita pepo L., C Moschata (Duschesne ex Lam.) Poir., C. maxima Duch*
Amaranth	Vowa/ Thebe	*Amaranthus spp.*
Cowpea	Munawa	*Vigna unguiculata (L.) Walp*
Spider flower		*Cleome gynandra L.*
Jute mallow	Delele	*Corchorus olitorius L.*
Okra	Mandande	*Albelmoschus caillei (A. Chev.) Stevels, A. esculentus (L.) Moench*
Blackjack	Mushidzhi	*Bidens pilosa*
Bitter watermelon	Bvani	*Citrillus lanatus subsp.lanatus*

Source: Maundu *et al.*, (1999); Irungu *et al.*, (2007); Omiti*et al.*, (2009).

Nonetheless, for the purpose of this study, the three most common varieties, namely, African nightshade, Chinese cabbage, and Pumpkin leaves were focused upon and investigated in order to explore their productivity and technical efficiency in Vhembe districts. African nightshade, *muxe* in Tshivenda and *Umsobo* in isiXhosa are commonly distributed in many parts of South Africa and African countries where they mainly emerge as weeds in arable lands. More than 1500 species of nightshade exists, many of which are important throughout their multicultural distribution (van Rensburg *et al.*, 2005). Chinese cabbage known as *Mutshaina* in Tshivenda is one of the most well-known plant in the Vhembe district, where it greatly cultivated. Lastly, pumpkin leaves are extensively consumed in various parts of Africa. In South Africa, they are intermittently cultivated as a minor crop in maize fields in a process of intercropping; while it is known as Thanga in Tshivenda, it is referred to as Thaka in Sepedi.

Meanwhile, African indigenous vegetables (AIVs) have long been known in South African rural communities as an essential food that is consumed with starch staples (Lewu and Mavengahama, 2010).Subsequently, in the last five years, the consumption of these vegetables at household level has more than doubled in South Africa (Mnzava, 1997, Senyolo *et al.*, 2014). Meanwhile, before 2000, ALVs rarely appeared in formal retail stores as they were only marketed in back-street markets. In contrast, today they are produced and sold in large quantities in both formal and informal markets on daily basis (Irungu, 2007).

Hence, Yang and Keding (2009) argued that African Indigenous vegetables are an outstanding source of micronutrients such as; Vitamin A, Calcium, Manganese, Magnesium and Iron. Accordingly, it has been noted that such vegetables have been associated with the alleviation of micronutrients deficiency challenges in most countries and a consequential improvement in the health of the population, with a resultant effect in their standard of living. (Abukutsa, 2010). For instance, renowned studies on AIVs and nutrition in several developing countries have focused on optimal use of the underutilised AIVs at household levels. Other than nutritive value, (Madakadze *et al.*, 2004; Parawira and Muchuweti, 2008) submitted that AIVs is significant because of its provision of food security among farmers in both times of drought and poor harvest.

As food security challenges remain paramount in developing countries including South Africa, numerous numbers of people are affected by this. In South Africa alone, about 21.5% of the people are still living below the poverty line (World Bank, 2015) and about 25.9% of them still lack access to adequate food supplies among which are agricultural vegetable produce (De Cock, 2013). Moreover, it was reported that food security has deteriorated in some rural parts of South Africa particularly Kwazulu-Natal, Eastern Cape and Limpopo Province (Faber et al., 2011). Thus, improved production, consumption and marketing of traditional foods such as AIVs would be efficient in safeguarding food security for many South Africans.

It was also stated that in the next decades, population growth is expected to increase steadily(Statistics SA, 2014). Therefore, to feed the growing population, farmers in the rural area would have to intensify and diversify food production in order to meet the increasing demand for food. In consequence, in attempting to deal with food insecurity challenges, different stakeholders have strived to encourage production and consumption of African indigenous vegetables by farmers and both rural and urban households in South Africa. Such stakeholders include Health institutes, National Agriculture and Fishery Council (NAFC), Bureau of plant industry under Department of Agriculture, Department of Rural Development and Land Reform (DRDLR) and the Agricultural Research Council (ARC). From direct observation, it is safe to assume that their efforts have borne fruits. AIVs which at some stage were regarded primitive and old-fashioned have today become a delicacy in most South African homes. This is contrary to a decade ago when they were produced natively and commonly consumed by low class group (Maundu *et al.*, 1999).

Nevertheless, despite numerous efforts aimed at promoting food security and poverty reduction using African leafy vegetables, little has been done to explore productivity and efficiency of these vegetables, particularly, at a district level. It is therefore imperative to survey the factors influencing productivity and efficiency of AIVs and challenges faced by smallholder vegetable farmers in Vhembe district of Limpopo province.

1.2 Problem statement

African indigenous vegetables have been cultivated and consumed by various societies of South Africa and Africa in general for several years. However, introduction of exotic vegetables in conventional agriculture has seen a decrease in both production and consumption of these vegetables (Mnzava, 1997). Several provinces in South Africa, are faced with high levels of food insecurity and poverty, particularly the rural communities (Lewu and Mavengahama, 2010). This factor could be alleviated through enhancing production and marketing of indigenous vegetable among smallholder farmers. Various scholars in different countries attributed this decline to factors such as, inadequate fertiliser, lack of high quality seeds, low awareness of their economic potential, poor production techniques and poor marketing system among others (Onyango, 2002 and Njume *et al.*, 2014). Meanwhile, factors affecting production of indigenous vegetable farmers in some areas of Limpopo Province remains unknown. Therefore, this study investigated factors influencing production of indigenous vegetables in Vhembe district.

African Indigenous Vegetables (AIVs) play an important role in the economy of South Africa. They help reduce susceptibility of rural and urban household food insecurity, improve their standard of living and help improve the health status of the people (DAFF, 2011). The production of AIVs nonetheless has been reported to be declining at an alarming rate. This may be a result of limited support services including lack of funds acquisition, poor technical support and lack of access to relevant infrastructures (DAFF, 2011). This study will bring to the fore specific challenges faced by small holder farmers in Vhembe district leading to a decline in the production of AIVs as a way of attempting to find alternative solutions to overcome these challenges.

Farmers are unwilling to produce vegetables that cannot compete in the market place as this hinders them from generating substantial income. Despite the constraints faced with the production and marketing of AIVs, there seem to be an increase in the demand of seeds for these vegetables by farmers in South Africa particularly, smallholder farmers. Given that previously farmers were producing these vegetables mainly for household consumption, today there is a growing demand for high-quality seeds and improved production (Mmbengwa *et al.*, 2013). Furthermore, there has been a rising interest to market them and generate household income. There is therefore a need, to evaluate the driving force behind these recent changes.

Studies have shown that smallholder farmers in developing countries are unsuccessful when it comes to reaching optimum level of productivity as a result of inefficient allocation of resources (Abdulai, 2006). As such, optimal allocation of resources to improve production is significant. Subjective evidence suggests that, there are a number of factors responsible for the low vegetable production at the household level (Asogwa*et al.*, 2011). A question then arises as to how efficient farmers are using the available scarce resources at their disposal to produce maximum desired output. Thus, it is necessary to evaluate how farmers are currently allocating their resources in producing indigenous vegetables and make a substantial suggestion on how to best combine inputs to attain the highest potential output as a way of improving farmer's productivity thus, improving profit.

Technical efficiency have been briefly studied in developing countries (Speelman et al., 2008; Voster*et al.*, 2007; Mkhabela, 2005). Most studies analysed production efficiency of major staple foods, such as maize, rice and wheat (Abdulai and Huffman, 2000(a); Duvel *et al.*, 2003; Abdulai and Tietje, 2007(b); Asogwa *et al.*, 2011) barely focusing on vegetable crops. Moreover, in South Africa, little research has been done on production efficiency of vegetables particularly African indigenous vegetables. It is therefore unknown whether farmers in Vhembe district are efficient or not. This study is expected to close information gap and extend the scope of literature in production efficiency of AIVs.

Masarirambi *et al.*, (2009) stated that insufficient research has been carried out previously on African indigenous vegetables and there is generally lack of knowledge about their economic potential. This study is anticipated to add to a wider knowledge of the importance of these vegetables, their production and technical efficiencies, including their potential to generate household income. Furthermore, there are limited studies that solely focused on productivity and efficiency of indigenous vegetables in Limpopo Province, particularly in Vhembe district. This implies that factors influencing these concepts still remain largely unknown; hence, this study aims at addressing them.

1.3 Research questions, main and specific objectives

1.3 1 Research questions

i. What are the socio-demographic characteristics of African indigenous vegetable farmers in Vhembe district?
ii. What are the factors determining productivity of African indigenous vegetable farmers in Vhembe district?
iii. What are the factors explaining technical efficiency level of African indigenous vegetable farmers?
iv. What are the constraints facing African indigenous vegetable farmers in Vhembe district?

1.3.2 Main objective

The main objective of the study is to analyse determinants of productivity and technical efficiency among African indigenous vegetable farmers in Vhembe district, Limpopo province.

1.3.3 Specific objectives

In order to achieve the main objective of the study, the following specific objectives were used to:

i. Evaluate the socio-demographic characteristics of African indigenous vegetable farmers in Vhembe District.
ii. Investigate socio-demographic factors determining productivity of African indigenous vegetable farmers.
iii. Assess the factors explaining technical efficiency level of African indigenous vegetable farmers.
iv. Investigate constraints facing African indigenous vegetable farmers in the study area.

1.4 Research hypotheses

i. There is a negative association between socio-demographic factors and productivity of African Indigenous Vegetable farmers in Vhembe district.

ii. There socio-demographic factors are negatively influencing technical efficiency level of indigenous farmers in the study area.

1.5 Significance of the study

Little research has been done on AIVs in Vhembe district as a result; theories on vegetable production and efficiency are not clearly highlighted in the district. Among these few studies, most were oriented towards testing varieties, agronomy and health contribution of AIVs. This study is expected to add to a body of knowledge by intensely studying the concepts of productivity and efficiency. This study will therefore serve to provide literature for future authors aspiring to study the same concepts in other province of South Africa and Africa in general.

Factors influencing indigenous vegetables production and technical efficiency remains unknown, yet their production continues to decline. Therefore the study is aimed at investigating the current state of resource allocation on the production of small-scale vegetables. Through production and technical efficiency analysis, the best combination of input required to reach the highest output level was underlined. Subsequently, this research will be beneficial in recommending the best combination of resources to the farmers for optimum levels of production.

Likewise, the key motivation of the study is to benefit various players in the production system. Estimation of production efficiency and clearly highlighting production and marketing constraints facing small holder producers will assist policy makers and implementers in pointing out potential areas of improvement. By so doing, it will go a long way in enhancing vegetable production for both small and large-scale farmers. This in turn will contribute to a broader knowledge and understanding of the subject studied and advanced strategies in the repositioning of production system in order to benefit the development of small holder farmers and traders in Vhembe district and South Africa in general.

Additionally, this study investigated the challenges facing farmers in Vhembe district. Thus, the findings from this study will serve as a benchmark to assist policy makers and/or related stakeholders in redirecting policies associated with significant vegetable production and marketing for economic gain of farmers not only in the study area but also in South Africa as a whole.

1.6 Scope of the study

Attempting to analyse the whole indigenous vegetable production system may be viewed as an impossible action due to limitation of available resources and human capacity. Thus, the study was narrowed down to measuring the productivity and technical efficiency of selected indigenous vegetable (African nightshade, Chinese cabbage and Pumpkin leafs) farmers. Additionally, the study investigated constraints facing AIV farmers in the study area. Geographically the study was conducted in Vhembe district, which is one of the five districts in Limpopo province of South Africa. The study collected socio-demographic information, production and marketing information of AIV farmers. The outcome from this study could be employed in generalising the overall performance of AIVs farmers in the present market and economy in general.

1.7 Limitations and assumptions of the study

The study was exposed to numerous limitations, particularly during data collection stage. Lack of financial resources to move around the district when collecting research data, was a major limiting factor which resulted in a collection of small sample size as compared to the total number of farmers growing African indigenous vegetables in the study area. However, this limitation did not affect the outcomes of the study as it was overcome through self-compensating with regard to financial aspect in order to allow the data collection process to continue with ease. Another drawback was the accessibility of the respondents in the study area, wherein majority of farmers available were from the irrigation schemes other than dry-land scheme. However, in order to avoid biasness in the information, other information were gathered randomly from the farmers around the villages in Vhembe who are not included in any government schemes. It was assumed that the selected sample size is a true representation of the entire population and that interviewed farmers answered the questionnaires truthfully.

1.8 Organisation of the study

With the inclusion of a brief introduction of the study, the outstanding parts of the study are organised as follows. The second chapter discussed literature review (theoretical, analytical and conceptual framework). Chapter three fully described research methodology, clearly stating the study area, sampling procedures, research design and data analysis techniques employed in the study. Both socio-demographic and empirical outcomes of the study were discussed in details in chapter four and lastly, chapter five concluded, summarized and made recommendations based on the findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents relevant literature about production and technical efficiency of African indigenous vegetables and other related crops. It elaborates concepts that relates to this study and theories upon which it is based. The review includes socio-demographic factors and factors of production in relation with productivity and efficiency. The insight on the theoretical and conceptual framework is also included in this chapter.

2.1 The Status of African indigenous vegetables in Africa

African societies have depended heavily on indigenous vegetables for food security. However, introducing exotic crops has led to a decline in ALV's utilisation. Meanwhile, in most parts of the developed countries, indigenous vegetables are considered as weeds, in several underdeveloped and developing countries, they form part of day-to-day diets of many rural households. For instance, in extreme rural communities, utilisation of indigenous vegetables remains common, although they are slowly facing extinction (Van Rensburg *et al.*, 2005).It was reported that demand for AIVs have risen in Tanzania, Botswana and Zambia (Lyatuu *et al.*, 2009).As a result, their production, marketing and consumption are escalating due to people's awareness of their economic and health benefits (Schipper, 2002).

Conversely, in many African countries, indigenous vegetables have received slight attention when it comes to research and development. Their production is usually in small quantities, while farmers assume the role player in terms of technology development and genetic material. The primary aim why farmers produce vegetables is to meet the demand of household consumption, besides the objective of selling their products where there is surplus. The rising recognition of the indigenous vegetable nutritional benefits has triggered the demand for high-quality seed and efficient production. Nevertheless, these vegetables face a threat of extinction due to excessive harvesting without cultivation and their removal from fields as weed species. Consequently, these threats have enforced there-establishment of indigenous crops enterprises by various stakeholders. This was done with the aim of conserving indigenous vegetables and ensures that they are available for utilisation for generations to come (Mmbengwa *et al.*, 2013).

2.2 The utilisation of African indigenous vegetables in South Africa

Most African indigenous vegetables are believed to have originated in South Africa, in addition to those that were introduced into the country, all are now regarded as indigenised or naturalised (Mavengahama et al., 2013). South Africans have been utilising indigenous vegetables for long, particularly in rural communities. Different societies cultivate diverse species primarily for household consumption with little percentage of the produce reaching the formal or high-value markets for income generation. The use of indigenous vegetables continues to spread across South Africa, though westernisation has reduced their overall use. African indigenous vegetables have become daily food in places like Limpopo provinces (Vorster *et al*, 2005), but the common knowledge of indigenous food has been lost in many communities in the country (Lwoga *etal.*, 2010). This is due to factors such as change in lifestyle and negative stigma linked with utilisation of indigenous food (Musinguzi *et al.*, 2006). These crops are produced and marketed in small-scale and frequently produced by resource-poor households. Thus and so, Backeberg (2013) argued that these vegetables have advantages (such as drought and heat tolerance, ease of production, usually requiring less resources and are rich in micronutrients) over exotic vegetable species which are dominating supermarkets shelves today.

Demand for African nightshade has been increasing steadily primarily in urban communities due to promotional activities (Mmengwa *et al.,* 2013). In fact, in the past 50 years the status of nightshade has improved from which was sorely collected from the fields to that of a fresh produce vegetable collected from cultivation under irrigation by local smallholder producers in Vhembe district. Additionally it is currently traded by both minor retailers and large supermarket channels (van Averbeke and Juma, 2006). Cowpea is another indigenous crop that has experienced a growing demand, although its supply still remains limited (Mmbengwa *et al.*, 2013).

Continuous production and emerging markets of AIVs proposes that they are progressively being perceived as fairly profitable. As a result, this has encouraged the farmers to increase their supply because they have become aware of their value (Gruere *et al.*, 2006). Lately, scientific and commercial societies have revealed new transformed interest in these vegetables. It is stated that numerous institutes in the world have conducted research on indigenous leafy, seed, and tuber plants that are utilised as vegetables and pot herbs. Yet, outcome from these researches is disjointed and not well documented (Oelofse and Van Averbeke, 2012).

Identification, documentation and promotion of AIVs will empower communities in general and marginalized groups to produce their own food (Schippers, 2000a and Onyango, 2002a).

African indigenous vegetables fall under underutilised species, however their public awareness has continuously increased since they were first brought into the limelight by Global plan of action to preserve natural plant species (Gotor and Irungu, 2010). ALVs are regarded as underutilised as they have met the three internationally accepted conditions of underutilised crops: they are locally available but not globally available, knowledge and information about them is fragmented and their present utilisation is relatively partial in comparison with their recognised potential (Gruere *et al.*, 2006). The potential value of these indigenous crops is commonly higher than their perceived value; hence their uses are not fully exploited (Horna and Gruere, 2006).

2.3 Production of African indigenous vegetables (ALVs)

African indigenous vegetable production has its benefits due to their uniqueness as they are easy to grow since they require less advanced input; they can grow in low soil texture, they are pest and diseases resistance and have longer harvesting period (Ekesa *et al.*, 2009). Additionally, though these vegetables require small plots sizes and little resources, besides being practised by rural households, yet they produce substantial yield with robust nutritional value (NRC, 2006). ALVs do not require huge capital investment and they are regarded as the mainstay for food insecurity reduction and income generation (DFID and R4D, 2010).

Technology innovation can help improve productivity of smallholder vegetable farmers. Advancing and improving agricultural products will help ensure sustainable production. Both are critical in advancing the livelihood of farming in rural communities as smallholder farmers naturally under or over utilise resources during farming (Msuya et al., 2008). Several scholars have argued that the adoption of new advanced technologies to boost farmers' output would lead to increase in income, and consequentially hasten the development of the economy (Hayami and Ruttan, 1985). Nonetheless, it was emphasised that output growth is not only dependent on technology innovation but also on efficient utilisation of the available technologies (Nishimizu and Page, 1982).

Correspondingly, in the developing world, some new technologies have been barely successful in improving production efficiency. However, this has often been blamed on the lack of ability and/or willingness on the part of producers to adjust input levels because of their familiarity with traditional agricultural systems and/or presence of institutional constraints (Chaudhuri and Gupta, 1996). Similarly, Hadera and Emana (2007) recognise drought, diseases outbreak and scarcity of fertilisers and poor irrigation system as a drawback in producing vegetables in Ethiopia.

2.3.1 Factors of production influencing productivity

Land

In farming, the role played by land for cultivation is viewed as the key factor of production and the most important resource for the enhancement of production (Abdulai, 2006). Supporting this view, Irungu et al., (2007) mentioned that land is the most fundamental productive resource in the rural economy. The accessibility of land permits the producer to get high production output which will promote market supply thereby earning income. Lybbert (2004) also stated that the bigger total production area will yield high output. Meanwhile, in most countries, it has not been possible to increase production because the land needed for cultivation is becoming extremely scarce. This is further aggravated by the fact that most lands have lost their productive capacity, due to high and risingcost of land acquiring for cultivation.

According to Swinnen and Knops (2013), raising agricultural productivity involves making investment in the land itself. However, according to Nurah (1999) farm operators are not sure of the returns of the efforts and expenses which they put into improving the land. For instance, in most developing countries where land is a scarce resource, it has not been possible to increase the scale of vegetable production. According to Mengistu and De Stoop (2007), increase in population growth has in turn limited the available land for agricultural activities.

Labour

Apart from land, and capital, labour is another essential resource that is of great importance in vegetable production. Land cannot be productive without labour and capital. It was reported that commercial vegetable production is quite labour demanding (Nurah, 1999). As a result, many farmers will rely on family labour if the farm size is small. Most farmers therefore hire labour to supplement their own family labour supply. This is however contrary to indigenous vegetables which are said to require little or no resource for production. The larger the household size, the less hired labour will be required to compensate family labour. As stated by Ramaila *et al.*, (2011) even though land and labour productivity has been stagnant at 1.46%

and 2.67% per year respectively, this is still perceived as high when compared with other African countries.

Labour is the major factor of production in the traditional farming systems of South Africa and as such the utilisation and productivity of labours are key elements in increasing the agricultural output and incomes of small farmers. Equally, labour quality is an important factor of economic growth (Barro, 2001). It is assumed that increased labour quantity and quality are positively associated with higher production output (Loko, 2009). Farmers with a large pool of family labour may experience a great benefit in terms of utilising these labour resources at a significant time, particularly during peak cultivation seasons.

Capital (Farming equipment)

Vegetable production is capital intensive according to (Nurah, 1999), therefore, equipment is needed to till the land, to irrigate, to apply crop protection chemicals and to process the harvested products. In accordance with this, (Barro, 2001) mentioned the varied sources of acquiring capital for farming as savings, gifts, inheritance, outside equity capital, leasing, contract production and borrowing. Lack of long term low interest credit is a major constraint to vegetable production, more so for specialised vegetable farmers than for those producing cash crops (Anetor*et al.*, 2016). Human capital (farmer's education, age, gender) and physical capital (seed, fertiliser, land and herbicides) are also said to have a significant influence on vegetable production and technical efficiency (Idiong, 2007; Oladeebo and Fajuyigbe, 2007; Moses and Adebayo, 2007).

Seeds, fertilisers and pesticides

In the present day farming, the use of fertilisers and pesticide has become a common trait to many farmers, either small-scale or large-scale farmers. In a similar way, there is also a rising demand for high quality seeds in order to enhance agricultural production. Though there is an increasing demand for agricultural produce, their productivity in most regions of South Africa remains fairly low due to incidences of pest and diseases outbreak, including limited effective control measures. Additionally, low supply and utilisation of high quality seed leads to a substantial yield gap (Weinberger and Msuya, 2004). Furthermore, Kyi and Oppen (1999) conducted production efficiency study and found that the variety of seed used, competency of employed human resource and access of information by farmers were the significant determining factor of rice productivity.

Further findings revealed that the level of production inefficiency of small-scale farmers who eschewed the application of fertilisers was higher than that of large-scale who utilised it. Amaza and Maurice (2005) evaluated factors affecting technical efficiency of vegetables-based production systems among farmers in Adamawa State. It was concluded that 20% of production efficiency could be increased by application of fertilisers, use of improved seeds, access to irrigation and through farmer education. The use of improved seed varieties has a positive impact of increasing production efficiency. Farmers' with better-quality seed are less inefficient as compared to farmers using indigenous seeds. Thus, this proves that there is often a positive significant relationship between seeds, fertilisers, pesticides and productivity.

2.3.2 Socio-demographic factors influencing production efficiency

Age

Age is said to be highly significant in influencing technical efficiency. The older the farmer, the more likely he or she has greater experience, as such it is assumed that they are wise in terms of resources usage and technical innovation adoption (Amos, 2007 and Ahmad et al., 2002). In contrast, young household heads are likely to have negative or positive impact on vegetable production and sales. Several scholars revealed that age has a significant impact on farmers' production efficiency in the study area (Coelli, 2000, Rahman, 2003, Amaza and Maurice, 2005 and Moses and Adebayo, 2007). Itis believed that older farmers have better knowledge and substantial experience; as such it is of great advantage when it comes to decision making and technology adoption. Oppositely, it was assumed that older farmers are expected to be the most resistant to adoption of new technologies and/or improved agricultural practices (Adugna, 2009).

Gender

In Africa, vegetable production is often linked with women. Nonetheless, recent findings demonstrate that once a particular crop shows a potential of higher returns and commercialisation, male producers become interested in producing and supplying that particular crop (Van Averbeke and Juma, 2006). Similarly the cultivation of African leafy vegetables are associated with the female gender, while their consumption has no gender discrimination. Rather, it has been noted that the rate at which women consume indigenous vegetables has no parallel with their collection, which is literally low; while the opposite can be said about the men. (van Rensburg, 2014; Hart and Vorster, 2006).Historically, the collection of leafy vegetables and indigenous knowledge connected to them was dominated by women amongst the Khoisan (Parsons, 1993) and Bantu-speaking tribes (van Rensburg *et al.*, 2004).

De Jong and Tsiachristas (2008) argued that incorporation of female into the labour force is likely to expand crop production. Correspondingly, it was discovered that female farmers were more efficient in potato production as compared to male farmers in the Netherlands. Contrary to the submission of De Jong and Tsiachristas (2008), McGuckin and Van Ark (2005) found that the high participation of women as a labour force will negatively influence productivity. It was added that this will be the case, especially when the participating females are older and spend less time on the farm. Quite oppositely, Tshiunza *et al.* (2001) found that male farmers participated more on vegetable markets compared to female, as male farmers tend to produce with the aim of marketing the produce.

Household size

Household size is estimated as the number of family members residing in a household. Its importance occupies a central place because the production of vegetables is regarded as a labour-intensive practice. The preparation of land, production, harvesting to marketing of farm produce are all a function of labour availability. Consequently, households having many family members in turn allocate and utilise them as labour force to enhance production and profit. On account of this, household size is positively correlated with productivity in that the larger the household, the greater the production to cater for the household consumption. However, household size negatively correlates with market supply and profit generation, in that produce that would have been supplied to the market to generate income are consumed by household members. Some scholars (Udry, 1996; Mekuria and Gezahagn, 2010; Haji, 2007) discovered a positive relationship between family size and households' gross income from groundnut production.

Years of education

Education is regarded as a tool that broadens human intelligence, as such it is expected to positively affect production and efficiency as it will enable the farmers to execute their duties wisely and effectively (Alene and Manyong, 2007). Likewise, literate farmers' easily adopt new agricultural practices and new technology as they are innovative and well-informed. Formal education promotes ease of acquiring information thereby improving farmer's superiority of decision making (Fakoya *et al.*, 2007).

Dhungana *et al.*, (2004) revealed that literate farmers with more years of schooling are expected to be more technically efficient as compared to their counterparts with less years of schooling or no formal education. This is possibly the case because literate farmers possess better farming skills, better knowledge and good farm planning capabilities. Balcombe *et al.*, (2008) and Tareen *et al.*, (2010) also reported similar results. In many aspects, when a farmer is highly educated it has been indicated that their level of understanding provides a competitive advantage in enhancing their produce (Yamada, 2005; Akinbile, 2007). In contrast, it was argued that education without proper agricultural training and/or access to best practice information contribute to negative production and post-harvest management of produce (Weir and knight, 2000). As such, this variable is hypothesised to positively impact the volume of vegetable sales.

Farming experience

Farmers with more experience are expected to produce more vegetable crops. Furthermore, they are anticipated to have knowledge and skills on better agricultural practices, as a result they are expected to reach high productivity and market most of their produce (Ayelech, 2011). Therefore, farming experience is expected to positively influence technical efficiency. In industries where technological innovation is the dominant factor that needs a large idiosyncratic investment and economies of size are limited, valuable experience may play a dominant role in ensuring technical efficiency.

Access to credit

Credit facilities, either formal or informal improve farmers' production and profit efficiency. Quoc Duy (2015) found access to credit to be negatively significant to technical inefficiency suggesting that credit access is predicted to enhance production efficiency of rice farmers. In actual fact, credit is able to relieve financial constraints in farming. Access to credit will allow for acquisition of additional inputs, which will tend to improve productivity (Hyuha *et al.*, 2007). Supplementary funds from credit institutions may be used to invest in crop production and may exacerbate adoption of advanced technologies (Nuryartono, 2005).

Farmers may access either formal (bank loan, credit card, etc.) or informal credit (family society, stokvel etc.). In a study conducted by Nuryartono (2005), the coefficient of access to formal credit on the inefficiency model was observed to be greater than that of informal credit. This indicates that acquisition of formal credit has a greater impact on production efficiency of rice as compared to informal credit. The outcome was in line with the findings of (Kebede, 2001; Nwaru, 2001; Ajibefun and Aderinola, 2003; Nguyen, 2003; Ogundari, 2008).

Access to extension services

Several factors contribute towards the development of agriculture, including extension as an institutional input. Extension services improve efficiency, as better management and information utilisation should lead to greater benefits to farmers. Extension services are often expected to contribute positively to farmers' success. However, its effectiveness is determined by how well services are provided or offered to farmers. Previous researches (Abate, 2007; Kassa, 2008) discovered that the extension execution in Ethiopia was constrained by numerous factors such as supply-push rather than demand-pull approach, poorly organized technology multiplication system, absence of institutional pluralism, low technology adoption rate, shortage of basic training for extension staff and largely the tendency of several extension stakeholders dealing with the transmission of knowledge to conduct their assignment in a top-down approach.

More frequently, information conveyed as part of extension services is offered as technological package comprising recommended practices. This is however viewed as a less sufficient way of enhancing knowledge and skill. More participatory methods were advocated to extend science-based knowledge and practices (Braun *et al.*, 2002). The empirical evidence on the influence of agricultural extension service on technical efficiency is mixed. For instance, Seyoum *et al.*, (1998) and Khairo and Battese (2005) found a positive significant relationship between access to extension services and technical efficiency. On the hand other studies conducted by Alene and Hassan, 2008; Alemu *etal.*, 2009 reported that agricultural extension participation has no influence on technical efficiency.

Access to marketing information

Market information is an important variable that influences production and technical efficiency. It is also expected to positively influence market supply of vegetables. Access to adequate information is associated with better decision making and ability to enter high-value markets. Farmers having access to market information have information on the product that is on high demand, price of the produce and concentration of the market (CIAT, 2004). Muhammed's research in 2011confirms that if wheat farmers had had access to market information, the amount of wheat supplied to the market could have been increased. Thus, the implication submitted is that farmers with access to dynamic production and marketing information may successfully produce more vegetables for market than those who have no access to marketing information.

Access to water and irrigation system

Irrigation has been used to increase production levels in many nations and is used for the production of a whole range of crops including vegetables (Hamdy et al., 2003). With the increasingly scarcity of fresh water resources available for agriculture, high population growth and urbanisation, the use of urban waste water in agriculture will increase, especially in arid and semi-arid countries (Van der Hoek, 2004). Worldwide, it is estimated that 18% of crop land is irrigated, producing 40% of the food (Gleick, 2000).

In some parts of the world, pollution from pesticides and fertilisers used in agriculture alone remains the key causes of poor water quality (Thorbum et al., 2013). According to Obuobie (2003), the origin of water or its quality is of slight concern to farmers. What is more vital to them is its continuous availability and their ability to afford it. According to van Averbeke *et al.*, (2011) irrigation refers to the artificial application of water to land for the purpose of enhancing plant production; therefore irrigation water can be abstracted from the source and conveyed to the field by farmers individually or in group as an irrigation scheme.

Climatic conditions, soil type and structure, plant type, and the irrigation techniques applied are among the main factors that influence the efficiency and effectiveness of irrigation practices. According to Anim et al., (2013) increasing water use efficiency should be one of the goals of vegetable producers. In South Africa, small-scale irrigation is seen as an important rural development factor, hence it has triggered introduction of Irrigation schemes under the department of agriculture to allow several farmers to benefit in one source of water using uniform irrigation system. With the growing demand for food and climate change on the other hand, many regions especially in Africa struggle to find enough freshwater to meet their needs. Therefore, growing water scarcity causes increasing pressure on farmers to allocate water more efficiently.

2.4 Marketing of African indigenous vegetables

Marketing of African indigenous vegetables has increasingly become important in areas surrounding South Africa, this is mainly due to the fact that South Africans have now realised their nutritional value (Meinzen-Dick *et al.*, 2001). Marketing is a critical aspect for the success of any type of farming enterprise, ipso facto farmers rely heavily on improved infrastructure, proper transportation, enhanced marketing channels to successfully sell their produce. Farmer's ability to reduce marketing gap and produce at a lower opportunity cost enhances market participation; accordingly, farmers becomes more profitable (Meinzen-Dick *et al.*, 2001).

Makhura (2001) investigated the transactional costs as barriers for participating in high-value market by smallholder farmers in the Northern Province of Swaziland. The findings indicated that numerous factors such as distance to the market, poor road infrastructure, lack of resources and shallow market information were the leading limitation for farmer's market access. Relatedly, Rios-Rull *et al.*, (2010) evaluated the relationship between market access and productivity on rural households. The outcome of the study advocated that despite the factors affecting market access, households with large amount of produce participated more in formal markets than households with lower level of agricultural produce.

Likewise, Ellis *et al,*(1983) stated that vegetable farmers are often rational and risk conscious and tend to undertake venture that guarantees them great returns on investment. Under developed rural farmers are faced with difficulties when it comes to participating in large commercial trading outlets as a result of lack of local market outlets to display their produce, lower selling price, multiple middlemen, lack of marketing information and overcrowded markets (Emana and Gebremedhin, 2007).

2.5 Conceptual framework

2.5.1 Productivity

Productivity is the ratio of output per unit of input (Färe, 1994).Partial input productivity, such as land productivity or labour productivity, cannot explain all the factors affecting productivity. Total- Factor Productivity (TFP) evaluates the part of an output that cannot be accounted for by traditionally measured inputs utilised; but its measurement is determined by how resourcefully the inputs are used in production. Examples are labour and capital (Sharpe, 2002). TFP analysis can identify change in output that is not attributed to change in traditional inputs. It can also measure change in productivity or input efficiency due to technological change, either advancement or transformation. Technological change causes efficiency increase on input that increases overall productivity afterward. Technology includes technology on input, mechanical, production system and output. It can affect productivity in a sense of the same or lesser input yielding greater output.

In addition to technological advancement, productivity can be affected by several internal and external factor of the farm. Main internal factor is farmer's ability to manage the farm, which is determined by factors such as education, experience, knowledge and skill. The external factor is supporting infrastructure- physical and non-physical (Fuglie, 2010; *Kumar et al.*, 2008; Weiping and Wang, 2007; Ashok and Balasubramanian, 2006; Hassapis and Kalyvitis, 2002; Nayak, 1999, Looney, 1994). It includes roads, irrigation, markets, research centres, consulting agencies, credit and financial institutions and agrarian system and policies. Consequently, some studies (Obwona, 2000; Son *et al.* 1993) have attempted to determine technical efficiency status of farmers in developing countries as it is important for policy formulation.

2.5.2 Efficiency

Efficiency remains a significant subject of empirical investigation predominantly in developing countries where majority of the farmers have scarce resources (Umoh 2006). The efficiency of vegetable production is very crucial in determining the returns on investment. Hence, Farrell (1957) defined production efficiency as the ability to produce a given level of output at the lowest cost. There are at least three different types of efficiency measures in economic theory. These are technical efficiency, allocative efficiency and economic efficiency.

Technical efficiency is an efficiency measurement used to estimate the success of a particular farm or enterprise in terms of applying the best practice in order to achieve the highest output level from a given input technology. Conversely, allocative efficiency measures a farms success based on selecting the best sets of inputs which are cost effective and consistent with the factor price to attain desirable level of output (Farrell, 1957). An enterprise economic efficiency measures the total efficiency which is defined as the product of technical and allocative efficiency (Bravo-Ureta and Rieger, 1991).

It should be emphasised that the question of efficiency in resource allocation in traditional agriculture is crucial. Besides the fact that it is widely held that efficiency is at the centre of agricultural production, it is equally fundamental because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources. Evidently, increasing population and wealth are resulting in rising pressure on key resources to satisfy growing demand. Per se, the physical, economic and geopolitical accessibility of resources and the efficiency and sustainability of their use are paramount concern worldwide (van den, 2011).

2.5.3 Technical efficiency

According to Esparon and Sturgess (1989), technical efficiency deals with efficiency in relation to factor-product transformation. For a farm to be regarded as technically efficient, it has to produce at the production frontier level. However, due to positive or negative factors, the farm can operate above or below the production frontier level respectively (Battese and Coelli, 1995). Efficiency measurement therefore attempts to detect farm specific factors which may restrict the farmers from not producing along the frontier. Technical efficiency goes beyond evaluation based on average production to one that is based on best performance among a given category (Battese and Coelli, 1995) though it is related to productivity where inputs are transformed into output.

Figure 1 below demonstrates conceptual framework which was adopted from Scherr, and Duron (2001); and Nkongu *et al.*, (2004). The framework shows the relationship between Agricultural production, efficiency and income. Conditioning factors influences the outcomes of the farmer vin the production world.

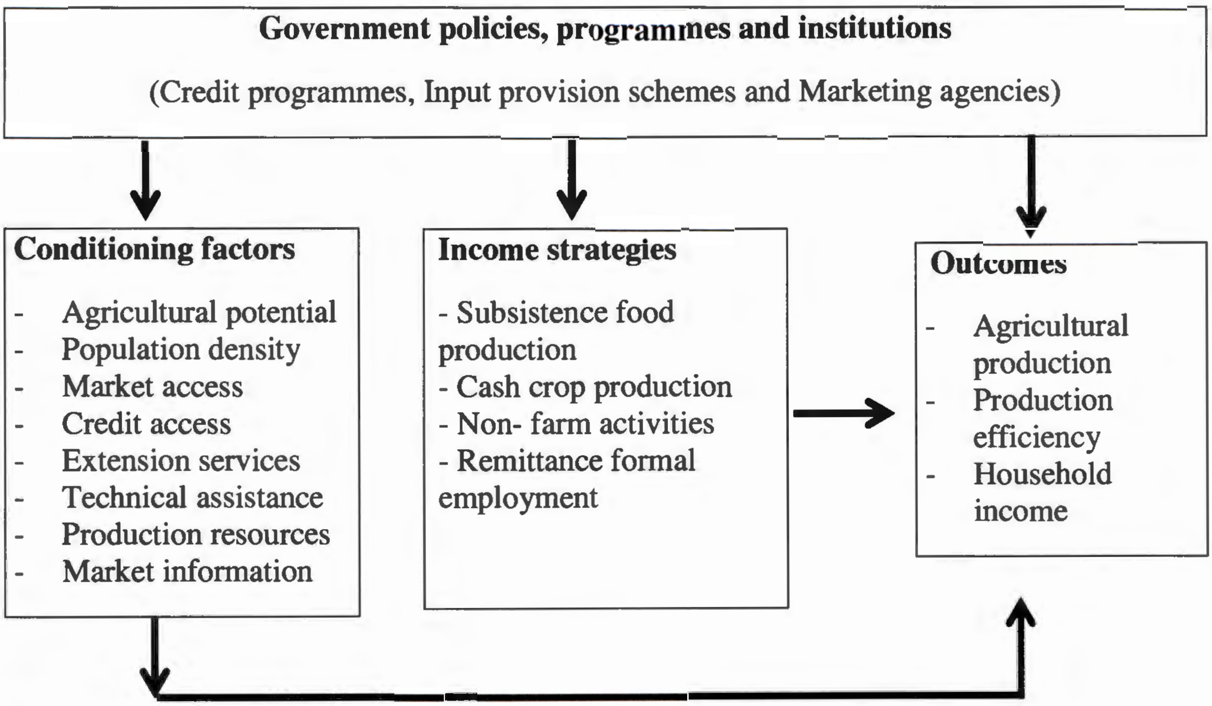

Figure 1: Conceptual framework for productivity and efficiency of AIVs.

Source: Adopted from Pender et al., (2001); and Nkongu *et al.*, (2004).

2.6 Methodological framework

2.6.1 Measure of Productivity

Productivity can be measured using different methods; a corresponding approach is the Total factor productivity. TFP is the ratio of the output to the Total Variable Cost (TVC). This model does not take the role of Total Fixed Cost (TFC) into consideration, since it is constant and does not have any effects on the profit maximisation. Total factor productivity is a concept that measures productivity by explaining factors other than inputs that affect output. Those factors may be socio-economic such as age, gender, farming experience, market access or interaction with extension officer. Therefore, in this study TFP and Ordinary least square (OLS) regression model will be used to analyse factors determining productivity of AIV farmers other than quasi-fixed factors such as land, labour and input capital.

Total factor model can be specified as:

$$TFP = \frac{Y}{TVC} = \frac{Y}{\sum P_i X_i} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 1$$

But since

$AVC = \frac{TVC}{Y}$, then 2

$$TFP = \frac{Y}{TVC} = \frac{1}{AVC} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3$$

$$AVC = \frac{TVC}{Y} = \frac{Y}{\sum P_i X_i} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 4$$

Where Y = quantity of output in kg and TVC = Total Variable Cost (R), P_i = unit price of variable input and X = quantity of variable input. This is given as TFP = Y_i/P_iX_i

TFP = $\sum P_i/\sum P_iX_i$ (Kg/R), where

TFP = total factor productivity for the *ith* farmer

Yi = quantity of indigenous vegetables produced by *ith* farmer

Xi = quantity of the *ith* variable input used

$\sum$ = summation

To determine determinants of indigenous vegetable farmer's productivity (TFP) in Limpopo, OLS regression model will be applied. The model is specified as follows:

$$TFP = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \dots\dots\dots \beta_nX_n + \varepsilon_i \dots\dots\dots 5$$

Where,

TFP = total factor productivity for the *ith* farmer (output value/input cost)

2.6.2 Measure of Technical efficiency

The model to measure technical efficiency has been widely accepted and applied since its inception by (Aigner *et al.*, 1977). The model was prolonged, signifying that the technical inefficiency effects could be further expressed as a linear function of explanatory variables, reflecting farm-specific characteristics (Battese and Coelli, 1995). The model is able to represent the relationship of an output to input as this gives an indication to the level of productivity. It decomposes the error term into two-sided random error that captures the random effects outside the control of the farm and one-sided efficiency component. The technique suits an agricultural production largely influenced by randomly exogenous shocks.

The model simultaneously estimates the individual technical efficiency of the respondent farmers as well as determinants of technical efficiency (Battese and Coelli, 1995). The stochastic frontier production function assumes the presence of technical inefficiency of production. The greater the amount by which the realized production falls short, the greater the level of technical inefficiency. The range of TE is 0 to 1. TE = 1 implies that the farm is producing on its production frontier and is said to be technically efficient.

Stochastic frontier production accommodates the catch in random variations, so that the measure is more consistent. The model incorporates a composed error structure with a two-sided symmetric component and one-sided component. The one-sided component reflects inefficiency, while the two-sided error captures the random effects outside the control of the production unit, including measurement error and other statistical noise typical of empirical relationship (Tawfik and Muller, 2010).

The general model can be written as:

$$Y = f(X_{\alpha}; \beta)e^{\varepsilon}$$

Whereby:

Y = the quantity of agricultural product

X_{α} = A vector of input and other explanatory variables quantities

β = A vector of unknown parameter to be estimated

e = Error term

$\mathcal{E}$ = Stochastic disturbance term consisting of two independent elements U and V

Where

$\mathcal{E} = U + V$

U = are assumed to be independent and identically distributed random errors which have normal distribution with mean zero and unknown variance σ_v^2

V = are non-negative unobservable random variations in the economic environment facing the production units, reflecting luck, weather, machine breakdown and variable input quality; measurement errors; and omitted variables from the functional form (Aigner et al., 1977). Then the frontier of the farm, is given by:

$$Y = f(X_{\alpha}; \beta)e^{(u+v)}$$

Measure of efficiency for each farm can be calculated as:

$TE = exp. |E(V|\varepsilon)$

Whereby: $V = f(Z_b;\ \delta)$

Z_b = A vector of farm specific factors, and

δ = A vector of parameters

The function is linearized so that it can be possible to use the maximum log-likelihood function for both parameters of stochastic frontier and the inefficiency effects model can be consistently estimated by maximum livelihood procedure.

2.7 Empirical literature review

2.7.1 Empirical review of productivity and efficiency

Sharpe (2002) adopted Total Factor Productivity (TFP) to capture the determinants of productivity of fluted pumpkin (*Telfaira occidentalis* Hook.F) farmers. Following Key and McBride (2003); Adebukola *et al.*, (2008) and Ukoha *et al.*, (2010), individual farm TFP can be measured as the inverse of unit variable cost. This methodology ignores the role of Total Fixed Costs (TFC) as this does not affect both the profit maximisation and the resource-use efficiency conditions. To determine factors influencing fluted pumpkin farmer's productivity in the study area, Ordinary Least Square (OLS) regression method was applied. The results showed that cost of labour, educational status, cost of fertiliser used, frequency of extension visits and farming experience significantly affected productivity of pumpkin farmers. The results were in agreement with findings of Udoh and Akpan (2007) and Omonona and Babalola (2007)on vegetable production in the Southern Nigeria that increased input usage leads to high productivity.

Xaba and Masuku (2012) discovered level of education, land under vegetable production and type of marketing agency as the determinants of vegetable production. This was however contrary to Usman (2013) findings. The study submitted that inadequate farm credit, poor storage, processing facilities and inadequate extension services were the major factors influencing dry season tomato production farmers. Shapiro (1983) concluded that other than extension and education, government can improve productivity among efficient farmers through adoption of new technology and investment.

Numerous other studies have been conducted using parametric or non-parametric analysis approaches (Idiong, 2007; Moses and Adebayo, 2007; Oladebo and Fajuyigbe, 2007). The outcomes proposed that farmer's age, years of schooling, cooperative or farmers' association membership and access to credit were the positive and significant determinants of efficiency. Additionally, physical capital, such as seed, size of land and quality of herbicide and/or fertiliser used were also determined as factors that influence efficiency of rice production(Moses and Adebayo, 2007).

Tijani (2006) estimated production efficiency on rice farms in Osun State, Nigeria. Socio-economic factors which were likely to influence production efficiency were explored through the application of stochastic frontier production function approach applied to primary data. A translog production function revealed that the levels of technical efficiency ranged from 29.4% to 98.2% with a mean of 86.6%,a suggestion that average rice output falls 13.4% short of the maximum possible level. The study continued to reveal that use of traditional preparation methods and off-farm income were the positive and significant factors in influencing rice production efficiencies. It was therefore concluded that in a short-run there is a possibility to increase technical efficiencies on rice farm in the study area.

Shrestha *et al.*, 2014 conducted a study to analyse production efficiency of smallholder vegetable farms in eastern hill, Nepal. Results of maximum likelihood estimates of stochastic frontier analysis showed that the mean technical efficiency score was 0.77. The implication was that production could be increased by 23% by solely enhancing vegetable farming practices. The production was contributed to by factors such as, land, labour, seed, compost, fertiliser, pesticide, farm capital, seed types, credit, technical support and gender of the household head.

Adekanye and Oyekale (2015) revealed that sweet potato production was affected by efficient use of resources and technology. Farm size, hired labour, fertiliser and herbicides were factors found to be positive and statistically significant to sweet potato production. Obwona (2000) also found evidence of technical inefficiency among vegetable farmers in developing countries and recommended that government must put more effort into education, improved extension services, social change and support. This will improve resources allocation by smallholder farmers and their counterparts thereby accomplishing higher efficiency levels.

Helfand (2003) applied similar approach as Lyubow and Jensen (1998) to examine factors affecting productive efficiency in Brazil Centre-West. The outcomes of the study confirmed that the use of contemporary inputs such as fertilisers, pesticides, irrigation system, soil conversation and access to credit institutions were the determinants responsible for variations in the level of inefficiency between plantations.

Efficiency in agricultural production has been widely studied (Coelli and Battese, 1996; Kyi and Oppen, 1999; Coelli, 2002; Rahman, 2003; Amaza and Maurice, 2005, Moses and Adebayo). Rahman (2003) investigated profit efficiencies among Bangladeshi rice farmers using a stochastic profit frontier and inefficiency effects model to calculate technical, allocative and efficiency levels. Levels of inefficiencies were found to be higher. Differences in inefficiency levels were a result of poor infrastructure, poor soil fertility, farmers' experience, access to extension services, and share of non-agricultural income.

2.7.2 Review of previous studies on technical efficiency and its determinates

Various studies done on technical efficiency of smallholder farmers had associated variable such as, age, farmers' years of schooling, household size, gender, access to extension services, size of the land, access to credit, access to marketing information, formal market access and accessibility of resources such as, fertilisers, pesticides, herbicides and improved seeds which negatively or positively influence technical efficiency (Amos, 2007; Ahmand *et al.*, 2002; Tchale and Sauer, 2007 and Basnayake and Gunaratne, 2002).

For instance, Mokgalabone (2015) conducted a study to analyse technical and allocative efficiency of smallholder maize farmers in Tzaneen municipality of Limpopo province using a Cobb-Douglas and logistic regression approach. The results from Cobb-Douglas production function revealed that farmers were technically efficient in the production of maize with 71% level. On the other hand, logistic regression recognised level of education, experience in farming, access to irrigation, purchase of hybrid seed, access to credit and extension visits as important factors positively and significantly influencing efficiency of farmers.

Likewise, Khai and Yabe (2011) estimated technical efficiency of rice production. The efficiency score was found to be 81.6% on average. The study proved that the most significant factors which had a positive impact on technical efficiency level were years of schooling, irrigation system and intensive labour. Cobb-Douglas production frontier analysis was adopted in the study.

Relatedly, Heshmati and Mulugeta (1996) investigated technical efficiency of Ugandan Matoke farms and discovered that farmers' experienced decreasing return to scale with technical efficiency mean of 65%. This implied that for farmers to be technical efficient they need to increase their efficiency by 35%. However, there was no significant difference in technical efficiency and farm sizes. This implies that farmers can still increase their technical efficiency without having to extend the area under cultivation.

Correspondingly, technical efficiency of peasant farmers in Ethiopian agricultural sector was estimated by Nsanzungwako *et al.*, (1996). Stochastic frontier production function was employed to measure technical efficiency production. However, the author in the study left out important variable such as labour, age, education and farming experience regardless of their significance to the study. Such variables might have played a significant role in influencing technical efficiency in the study area.

Similarly, Msuya and Ashimogo (2005) estimated technical efficiency of sugarcane production and the determinants of efficiency among farmers in Tanzania. Cobb-Douglas production frontier which assumed to have truncated normal distribution was adapted to measure technical efficiency. The outcome of the estimation revealed that there was positive significant relationship between technical efficiency and age, education and experience. This implies that farmer's age and experience played a significant role in ensuring that farmers are technical efficient. Furthermore, increasing farmer's level of education is likely to lead to increase in technical efficiency in sugarcane production.

Still from the perspective of Cobb-Douglas production, Hlongwane and Belete (2005) quantified level of technical efficiency of smallholder farmers in Dikgale and Sepitsi irrigation scheme with cowpea and maize being the major crops produced by the farmers. After the examination, the researchers discovered that there was a significant difference in technical efficiency of both schemes and positive association between productivity and farm size at both irrigation schemes.

Similarly, Binam *et al.*, (2004) explored determinants of groundnut and maize farmers in Cameroon. Cobb-Douglas production function was also employed to discover the mean technical efficiencies to be 73% and 77% respectively. It was concluded that social capital, distance to the market, access to credit and extension services are significant factors explaining the differences in the technical efficiencies levels of the crops.

In the meantime, according to the results from the study of Seidu *et al.*, (2006), factors like availability of credit, household size and non-farm employment were the significant determinants of technical efficiency of smallholder rice farmers in the East region of Ghana. The analysis of the study was achieved through the use of stochastic production function and maximum likelihood estimated method. The results further showed that farmers were technically inefficient as they produce 34% on an average, which was far below the maximum output.

Quite differently, Bakhsh *et al.*, (2007) argued that factors such as irrigation, labour and locations contributed towards high yield while fertiliser contributed negatively to yield in the production process. Cobb-Douglas production function was adapted by the authors to examine technical efficiency among bitter gourd growers. The outcome indicated technical efficiency mean of 60%, demarcating a great potential to escalate the yield of bitter gourd with the use of innovative technologies and resources. Instead, inefficiency effect model revealed that the age of the farmers was positively significant to technical inefficiency whereas household size, fertilisers and plant protection measures were found to negatively affect technical inefficiency.

By utilising the same analytical tool, Baloyi *et al.*, (2011) explored technical efficiency levels and factors influencing technical efficiency of maize production in Ga-Mothiba community of Limpopo province. The author employed Cobb-Douglas production function to investigate the level of technical efficiency and logistic regression model to evaluate determinants of technical efficiency. It was discovered that smallholder farmers in the community experienced technical inefficiency due to the decreasing returns to scale. Through logistic regression model, it was found that education level, household income, farming experience, area cultivated, cost of tractor per hours and fertiliser application were positively related to technical efficiency.

Also, the study conducted by Kyei *et al.*, (2011) demonstrated that the age of the farmers was observed as the most vital variable influencing technical efficiency of vegetable farmers in Ghana. The study employed stochastic production frontier function and inefficiency determinants based on socio-economic variables of individual farmers to analyse the data.

Oyewo (2011) explored technical efficiency of maize producing farmers in Oyo State, Nigeria. The author specifically focussed on the variables determining the variations in efficiency index. The inferential statistics stochastic frontier production model was used as a yardstick to determine the relationship between the maize output and the level of input in the study. Empirical results showed that the size of the farm and seeds were statistically significant in influencing the technical efficiency of the farmers in the study area. This implies that increasing farm size and the using high quality seeds will go a long way in ensuring that farmers are technically efficient in producing maize.

In a similar way, Dlamini *et al.*, (2010) applied stochastic production frontier function model of the Cobb-Douglas to incorporate a model for the technical inefficiency effects. The outcome of the study shows that smallholder sugarcane farmers in Swaziland over-utilized land. The results also revealed that technical inefficiency decreased with the size of the land, years of schooling and age of the farmers. However, an increase in technical efficiency was observed when sugarcane farmers engaged in off-farm income earning activities.

From a distinct angle, Speelman *et al.*, (2008) examined the efficiency with which water was used in small-scale irrigation schemes in the North-West Province, South Africa and explored its determinants. The study adapted Data Envelopment Analysis techniques to calculate farm-level technical efficiency measures and sub-vector efficiencies for water use. The outcome showed that under Constant Returns to Scale (CRS) and Variable Return to Scale (VRS) specification, substantial technical inefficiencies of 49% and 16% respectively existed among farmers. This is a clear indication that water was not used efficiently in the study area therefore, this calls for the use of advanced water saving techniques to ensure availability of water in a long run.

2.7.3 Empirical review of constraints facing smallholder farmers

Farmers are now faced with numerous challenges when producing agricultural crops, particularly vegetables. Many scholars worldwide have studied and analysed challenges or constraints that are most common with smallholder vegetable farmers. Bezabih and Hadera (2007) recognised impact of pest, drought and shortage of fertilisers as the major challenges of vegetable production in Eastern Ethiopia. Additionally, they reported post-harvest losses as another major constraint faced in the country. This constraint is triggered by farmer's limited knowledge on how to handle the product from the time of harvest until the product reaches the market. There is lack of farmer's training in many countries in how to sort, grade, package and store the produce in a way that will reduce quality loss.

Another major constraint that vegetable farmers are faced with is the lack of access to market. Vegetable crops are known to be perishable in nature as such they require to enter the market immediately after harvest. Alternatively, they require post- harvest processing with an appropriate processing method which will maintain the quality of the produce. In a study done by Million and Belay (2004), it was found that lacking market outlets to sell the produce, lack of storage facilities to store the produce in order to prevent food deterioration and lack of marketing information are some of the important constraints in vegetable production. In addition, they highlighted capital investment to acquire necessary inputs and high transportation cost when moving the produce from the farm gate to the market place as other challenges that farmers are likely to face.

Another scholar, who has investigated production and marketing constraint faced by vegetable farmers, was Weldslassie (2007). It was discovered that production constraints experienced by farmers included shortage of commercial fertiliser, shortage of water supply for irrigation and shortage of quality seeds. Intensive competition among traders and lower selling prices were major marketing drawbacks experienced by farmers. When the market is too concentrated with suppliers selling similar produce, it triggers competition among farmers, as a result other farmers are forced to reduce their selling price and a recovering strategy in order to avoid product losses.

Smallholder farmers are faced with difficulties when it comes to physically accessing retail markets due to their inability to compete in new marketing environment. Farmers lack market intelligence which hinders them from easily entering high-value market. They lack business and negotiating skills and experience, and a collective organisation to give them the business acumen they need to interact on equal terms with other generally larger and stronger market intermediaries (Heinemann, 2002).

For production to take place, resources have to be available. The major resources required in agricultural production are land, labour and capital. Consequently, producing for the market calls for these resources to be present in desired quantity. Irregular access of these assets impacts farmers' opportunities to enter markets which would benefit them in a long-run. Smallholder farmers' quantity and quality of produce to be traded also has an impact of farmers' inability to easily access market (Bienabe *et al.,* 2004). Those farmers who attempts to enter markets, lack regularity when it comes to producing for the markets due to insufficient access to production resources.

Another challenge facing Smallholder vegetable farmers is that their production system is normally based on low input – low output system. The use of advanced technologies, improved agricultural practises, modified seeds varieties and plant protection materials for example is not common in the small-scale farmers sector. Access to technical training and extension services on improved crop husbandry techniques is irregular with small-scale farmer mostly in rural setting and this result in lower or average productivity attainable (EHDA, 2011).

Distance to the market place, poor infrastructure, lack of transport, poor access to asset together with lack of market information lead to high transactional costs (Hease and Kirsten, 2003). High transactional costs transition to poor market access due to lack of social capital. Producers with more social capital are in a better position to enter a more capital-intensive marketing activity, whereas those with poor social network face major market entry barriers (Kherallah and Kirsten, 2000). Lack of transportation result in loose of quality and late delivery, which in turn lead to lower selling prices and loss of surpluses (Louw *et al.*, 2004).Minimizing transaction cost will go a long way in improving access to high-value market in developing countries, particularly smallholder farmers.

Smallholder farmers lack access to on-farm infrastructure such as store-rooms and cold-rooms to ensure that the produce is in good condition after harvest. Lack of infrastructure such as pack house and processing facilities will also affect the produce; hence, farmers may be forced to produce less in fear of losing their produce quality due to lack of storage and ready market. Access to storage facilities would improve farmers' flexibility in selling their produce thus, enhancing their bargaining power(Bienable *et al.*, 2004).

Another common problem facing smallholder farmers in developing countries is lack of market information. Farmers have very limited information about the demand in the market, product prices and date of sales. They often gather information through contacts among one another, however the accuracy of the information is not guaranteed, since those actors might be exhibiting "opportunistic behaviour" (Bienabe *et al.*, 2004). This tends to reduce farmers ability to trade their products efficiently and to derive the full benefit from the marketable part of their production. In other instances, farmers lack production information, wherein they tend to over utilise or underutilise their resources during the production stage. This affects farmers' production efficiency.

2.8 Summary of the chapter

Previous studies that explored productivity of different agricultural crops in various countries were reviewed in relation to this study. It was discovered that several authors were more focused on exploring yield and its determinants. Consequently in their findings, they omitted information on the combination on inputs used to attain the yield. This study will therefore, illustrate the best combination of inputs to use in order to achieve higher production yield of indigenous vegetables.

On the other hand, technical efficiency was widely studied across different countries including South Africa. Majority of studies employed stochastic frontier production function and Cobb-Douglas production function in their analysis. Various factors were found to have influence on technical efficiency of farmers producing different crops particularly vegetables. However, it was observed that variables such as gender and access to irrigation system were partially explored by different authors, which implies that their significance in affecting technical efficiency was overlooked. This study will look in details at the effects these variables have on technical efficiency of indigenous vegetables.

In conclusion, empirical review was done on challenges facing smallholder farmers' when producing and marketing vegetables across the African countries. This study therefore focuses predominantly on the challenges facing African indigenous vegetable farmers in Vhembe district of Limpopo Province.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter clearly describes the study area, study population, data collection techniques, sample and sampling technique, research design, analytical procedure, variable definitions and measures and ethical consideration. Theoretical foundations and empirical specification of models of stochastic frontier (in estimating productivity and technical efficiency) and inefficiency index (in estimating production efficiency level) of African indigenous vegetable farmers are also demarcated in this chapter.

3.1 Description of the study area

South Africa comprises a dual agricultural economy with a well-built commercial farming system and subsistence farming system as a dominant sector. Agricultural activities range from crop production, animal production to a mixed farming system (DoA, 2007). South Africa consists of a number of farming regions based on the climatic conditions, soil structure, natural vegetation and various agricultural practices. The country has high potential arable land of 22% and approximately 1.3 million hectares under irrigation. However, water scarcity is still the most common problem limiting agricultural production in the country. Rainfall is unevenly distributed across different regions in the country with nearly 50% of water used for agricultural activities (Aliber, 2003). Primarily, agriculture account for approximately 3% of South Africa's Gross Domestic Product (DoA, 2003).

3.1.1 Limpopo province

The study on determinants of productivity and technical efficiency of African indigenous vegetables was carried out in Vhembe district, Limpopo province. The province is located in the Northern part of South Africa. It is adjacent to the Gauteng, Mpumalanga and North-west province and shares the boarders with various Southern African countries such as Botswana, Mozambique and Zimbabwe. Limpopo province covers an area of 12.3 million hectares accounting for 10.2% of the country's total surface area. This is proportionally the largest rural population in the country and its capital city is Polokwane which was formally known as Pietersburg (GTEDA, 2010). Limpopo province is said to be the second poorest province in South Africa(Faber et al., 2011). It is consists of five districts viz: Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg district.

Figure 2: Map of South Africa, Limpopo Province Source: www.mapquest.com

3.1.2 Vhembe district

The study was conducted in Vhembe district of Limpopo Province. Vhembe district is one of the five districts in Limpopo Province. Extending over 21 121 15km^2, Vhembe district is situated in the northern part of Limpopo Province. The Kruger National Park lies to the east, while the north and north-west shares international borders with Zimbabwe and Botswana respectively. The district administrative capital is Thohoyandou. A large percentage of employment in the district is constituted by community service, followed by trade and lastly the agricultural sector. It has a population of 1, 232,218 people with 90% of the population residing in rural areas(Vhembe district municipality profile, 2011).

Both commercial and subsistence farming takes place in Vhembe district. Though the land is very fertile and well-suited for agricultural activities, a large portion of it still falls under tribal authorities and as a result it is left unutilised, which then hinders production and development. Nevertheless, there are great opportunities for developing viable sustainable agricultural projects. There is relatively lack of supply of ground and surface water resources. The current available water schemes are not functioning well, besides they were intended to serve smaller population size.

Meanwhile, Vhembe district is regarded as the origin of most African indigenous vegetables in South Africa, where farmers have been growing and harvesting them for decades. There are 10 irrigation schemes with approximately 730 smallholder farmers producing these vegetables in a limited land size(Vhembe district municipality profile, 2011). The district experiences summer rainfall and the vegetables are grown during both summer and winter. Majority of vegetables in the district are grown under irrigation. As such the research was conducted in smallholder irrigation schemes in Vhembe district which were created as part of the government initiative to promote rural sustainable development. Smallholder farmers in these irrigation schemes are growing both the selected vegetables (African Nightshade, Cowpea and Pumpkin leaf) for the purpose of this survey. Schemes which had access to irrigation for production of the selected crops were using short furrow irrigation system with plots size ranging between 1.2ha to 1.7ha.

Amongst the all five districts in Limpopo province, production of African indigenous vegetables is more dominant in Vhembe district. People leaving in rural areas of Vhembe district rely heavily on the consumption of these vegetables, which many of them are now collecting from cultivation as opposed to harvesting from the wild fields. Figure 3.2 gives a clear outline of the study area which is the Vhembe district consisting of four local municipalities, viz. Thulamela, Makhado, Mutale and Musina municipality.

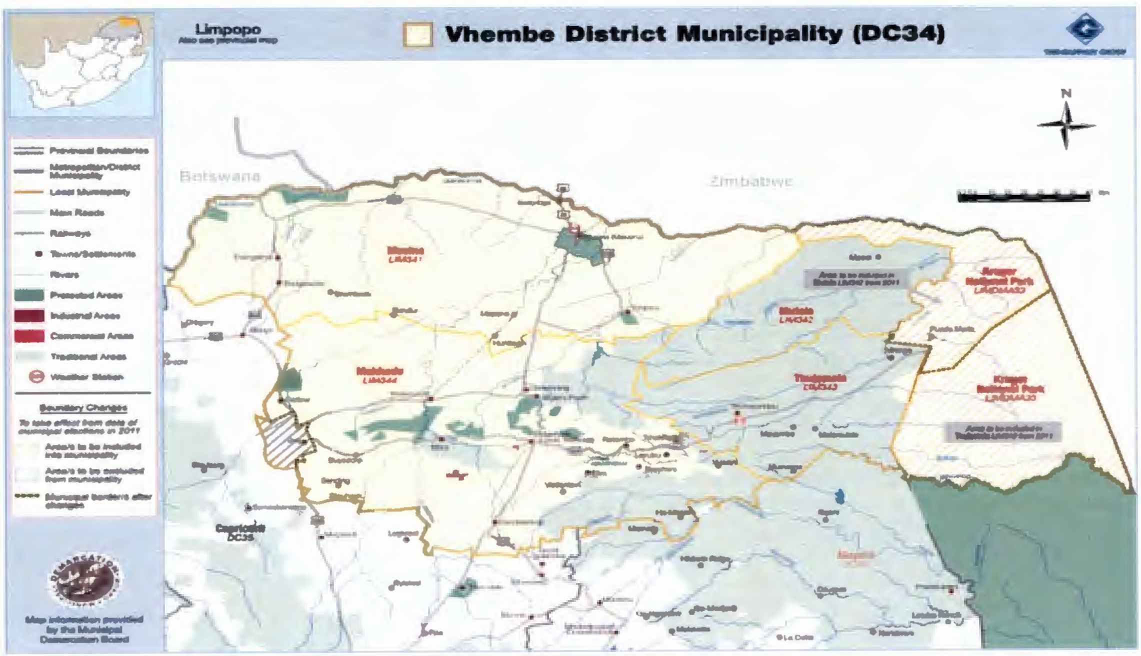

Figure 3: Map of Limpopo province, Vhembe district Source: www.mapquest.com

3.2 Description of the selected crops for the study

This study is based on three most common varieties of African indigenous vegetables, namely, African nightshade, Chinese cabbage, and Pumpkin leaves in order to explore their productivity and technical efficiency in Vhembe districts. African nightshade, *muxe* in Tshivenda and

Umsobo in isiXhosa is commonly distributed in many parts of South Africa and other African countries where they were mainly collected as weeds in arable lands. More than 1500 species of nightshade exists, many of which are important throughout their multicultural distribution (van Rensburg *et al*., 2007). Chinese cabbage known as *Mutshaina* in Tshivenda is one of the most common vegetables in the Vhembe district, where it is collected from cultivation. Lastly, pumpkin leaves are extensively utilised in various parts of South Africa. In South Africa, they are intermittently cultivated as a minor crop in maize field in a process of intercropping. Some of these vegetables did not originate in South Africa, but they were introduced into the country from other parts of Africa and are now indigenised.

3.3 Data collection technique

The study made use of primary data which was collected from smallholder indigenous vegetable farmers in Vhembe district of Limpopo Province. Data collection was carried out using a structured questionnaire which was designed for both open and close-ended questions in line with the study objectives. The socio-economic data such as age of respondents, gender, years of education, source of finance, farming experience, source of irrigation water, irrigation system and farmer's occupation was captured. Vegetable production and technical efficiency data such as size of area cultivated, hired labour, amount of seed, fertiliser and pesticide and price of seeds, pesticide, fertiliser used was also collected. Lastly, the questionnaire captured both production and marketing challenges faced by vegetable farmers in Vhembe district.

3.4 Sample and Sampling technique

The study adopted multi-stage and purposive sampling procedures (Strydom, 2005) to draw a representative sample of 120 African indigenous vegetable farmers in Vhembe district, Limpopo Province. Multi stage sampling refers to sampling procedure whereby large populations are divided into stages using smaller sampling units at each stage while purposive sampling also known as Judgement, selective or subjective is a non-probability sampling technique which takes place where subject or elements chosen for the sample are based on the researcher's judgement and/or a specific purpose (Black, 2010).

The first stage of multi-purpose sampling entailed selecting Vhembe district from five districts in Limpopo Province based on a prior knowledge that it is the most dominated with indigenous vegetables farmers as compared to other districts. In the second stage, three irrigation and one dry land schemes, namely, Dzindi, Khumbe, Phalmaryville and Tshidzini respectively were purposely selected based on the substantial number of farmers producing the selected crops of the study (African nightshades, Chinese cabbage and Pumpkin leaf). At the last stage, proportional number of farmers was selected randomly according to the total number of farmers in each scheme.

In order to avoid biasness of information, farmers who are not part of any government schemes were also randomly selected to be part of the final sample size. As a result of errors in completing questionnaires and missing information, 114 questionnaires were useful for the final analysis in this study. Table 2 below shows the total number of farmers selected from each irrigation and dry-land scheme constituting to the final sample size.

Table 2: Distribution of farmers according to Schemes and Villages in Vhembe district

Scheme/Village	Frequency (114)	Percentage (100)
Dzindi Irrigation scheme	28	24.6
Khumbe Irrigation scheme	33	28.9
Phalmaryville Irrigation scheme	20	17.5
Tshidzini Dryland scheme`	16	14.0
Local villages	17	14.9

Source: Vhembe administration data (2016)

3.5 Research design

The study was designed to take mixed research approach (both quantitative and qualitative approach). The study used a cross-sectional survey research design as its framework to direct data collection process. According to Bryman (2008), cross-sectional survey research design is the gathering of information primarily using questions on a pre-designed questionnaire to obtain quantitative or qualitative data at a point in time. It also determines the relationship between two variables (independent and explanatory variables) in a population and of which, the relationship between different socio-economic factors and productivity and efficiency of AIVs is the focal point in this study.

3.6 Analytical Procedure

The data was entered and analysed using SPSS version 23.0, STATA version 12.0 and FRONTIER 4.1csoftware. Descriptive statistics such as frequencies, percentages, minimum, mean, maximum and standard deviation were examined using SPSS. The econometric models were tested using STATA 12.0 and FRONTIER 4.1c software. The first analysis involved determination of factors influencing productivity of African indigenous vegetables. This objective was achieved using STATA, with farmer's productivity being the dependent variable and socio-demographic factors as independent variables. The second analysis involved determination of factors affecting technical efficiency and analysis of technical efficiency index of ALV. This objective was achieved using both STATA and FRONTIER software, where determinants of technical efficiency were achieved using STATA and efficiency index using FRONTIER. Lastly, the third objective which entails investigation of constraints ALV farmers are likely to face when producing and marketing their produce where highlighted using SPPS software.

Different econometric models where employed to analyse the objectives of the study. Descriptive statistics was used to analyse socio-demographic factors of indigenous vegetable farmers in the study. The second objective of productivity of ALV farmers was attained using a stochastic production frontier function derived from a Cobb Douglas function. Maximum likelihood estimates derived from stochastic translog production function was used to evaluate the third objectives which dealt with factors determining technical efficiency and efficiency indexes used. The constraints faced by indigenous vegetable farmers in Vhembe district which was the third objectives was simply evaluated by applying descriptive statistics. The socio-demographic factors which were adopted in this study include: Age, gender, household size, years of education, farming experience, credit access, farmer's occupation, access to extension services, source of water, irrigation system and access to formal retail market.

3.6.1 Estimation of productivity of AIVs farmers

Stochastic Frontier Analysis (SFA) was created back in 1977 by Aigner *et al*., (1977) and Meeusen and van denbroeck (1977) and it was later modified by Jondrow *et al*., (1982). SFA, is formally known for defining efficiency levels for cross-sectional data. It also elaborate associated link between inputs and outputs levels in a study through the use of two error terms. First error term is known as the traditional normal error term whereby the variance is constant and the average is zero (Coelli, 1996). The second error term is referred to as the maximum likelihood estimation of the production function that determines inefficiency levels.

The second objective was achieved by computing technical efficiency through the application of stochastic Cobb Douglas production function. For the purpose of this study, it is assumed that AIV production is dependent of size of land under indigenous vegetables cultivated, hired labour, source of irrigation water, irrigation system, and amount of seeds, fertilisers and pesticides. Therefore, productivity is measured following physical production relations derived from the Cobb-Douglas production function of Equation (1). Thus, the specific model estimated is given by:

$$Y = AX_1^{\beta_{1_1}} X_2^{\beta_2} \dots\dots\dots\dots\dots\dots X_n^{\beta_n} v \dots\dots\dots\dots (1)$$

Where β_1 and β_2 are factor coefficients or output elasticity, $\beta_1 + \beta_2 = 1$ simply means production has constant return to scale, implying that multiplying the use of Labour (X4) and land (X12) leads to double yield Y. If $\beta_1 + \beta_2 > 1$ implies increasing returns to scale; $\beta_1 + \beta_2 < 1$ inidactes decreasing return to scale. Y is the estimated output, whileX_n are inputs used in production. "A" is referred to as the average total productivity since it increases all factor marginal products simultaneously (McCloskey, 1972). In this study empirical stochastic frontier Cobb Douglas production function was modified to determine the effect of socio-demographic variables on indigenous vegetables (Nightshade, Pumpkin leave and Chinese cabbage) production. The function of Cobb-Douglas and Translog can be specified as follows (Van Passeel *et al.*, 2009):

Cobb-Douglas function:

$$LnY = LnA + \sum_{i=1}^{n} \beta_i LnX_i + \varepsilon \dots\dots\dots\dots (2)$$

Where A, α andβ_i are parameters to be estimated. Following Chukwuji and his counterparts (2006),

Translog function:

$$logY_1 = \beta_0 + \beta_1 logX_1 + \beta_2 logX_2 + \beta_3 logX_3 + \beta_4 logX_4 + \beta_5 logX_5 + V_i - U_i \dots\dots\dots (3)$$

Where

Y	=	Quantity of African indigenous vegetables produced in kilogrammes (kg)
X_1	=	Land under vegetable cultivation (Square metres)
X_2	=	Amount of fertilisers in kilogrammes (kg)
X_3	=	Amount of pesticides in litres (*l*)
X_4	=	Hired labour used (man/days)
X_5	=	Amount of seeds planted (g)

A = Constant / Total factor productivity

u = Random error term

In this study, the function is linearized in order to ensure that it is possible to utilise maximum log-likelihood function for both parameters of stochastic frontier and the inefficiency effects model and can be consistently estimated by maximum likelihood procedure. The error term in equation (2) is composed of two components (Aigner *et al.*, 1977):

$$\varepsilon_i = v_i - u_i$$

Where: v_i is the symmetric component that caters for random variation in output as a result of factors which are beyond the control of the farmers like unexpected diseases outbreak and extreme weather condition and which is said to be independently and identically distributed with N(0,δ_v^2); *ui* captures technical inefficiency in production and is also assumed to be an independently and identically distributed non-negative truncation of the N(,$\varphi\delta_u^2$) distribution. In this research, *ui* is assumed to be half-normal distributed as specified by Greene (2008).

3.6.2 Technical efficiency model

The stochastic frontier production function takes into account the existence of technical inefficiency of production Jondrow *et al.*, (1982). Therefore, to obtain production efficiency of indigenous vegetables farmers; a technical efficiency estimation of farmers' performance is used. The technical efficiency of a farmer refers to the capability of producing substantial yield from a given set of input. The measure of stochastic production frontier is built on the theory that any inconsistencies from the production frontier are regarded as random elements showing measurement error, statistical noise and farmers'-specific inefficiency element (Ogundele and Okoruwa, 2006). Thus, the function is defined as:

$Y_i = f(x_i; \beta) \exp(v_i - u_i)$.. (4)

Where Y_i is the yield of the *ith* farmer, x_i is the inputs cost utilised in production, β is a 1 x M vector of coefficients, v_i shows random errors which is assumed to be distributed IID N(0,δ_v^2), and u_i is the technical inefficiency which is said to be non-negative of the half normal distribution N(,$\varphi\delta_u^2$). TE of an individual farmer is defined in terms of the ration of output to frontier output, given the existing technology. Hence, the formula is given as:

$$TE = \frac{Y_i}{Y^*} = \frac{f(x_i;\beta)e^{(v_i - u_i)}}{f(x_i;\beta)e^{v_i}} \quad \text{...} (5)$$

Where Y_i is the observed output and $Y^*$is the frontier output.

If *ui= 0*, it means that vegetable production lies on the stochastic frontier and production is technically efficient. If *ui > 0*, it implies vegetable production lies below the frontier and is inefficient. Inefficiency in production could result from the quality and availability of labour and land, the use of capital and materials, and unhealthy interactions between these factors.

Inefficiency frontier effects model:

The technical inefficiency effects are assumed to be defined by

$$U_i = \partial_0 + \partial_1(\text{Age}) + \partial_2(\text{Gender}) + \partial_3(\text{Years of Schooling}) + \partial_4(\text{Access to credit}) + \partial_5(\text{Access to ectension services}) + \partial_6(\text{Farming experience}) + \partial_7(\text{Source of irrigation water}) + \partial_8(\text{Irrigation system}) + \text{W}_\text{i}$$

3.6.3 Marginal effects of production

Marginal physical product (*MPP_i*) of every factor of production is also computed for each factor of production. Marginal effect was computed after frontier analysis using STATA software. Results from equation (2) give Beta (*βi*)

$$\frac{\partial lnY}{\partial lnX} = \left(\frac{\frac{1}{Y} * \partial Y}{\frac{1}{X} * \partial X}\right) = \left(\frac{X}{Y} * \frac{\partial Y}{\partial X}\right) = \beta_i \quad \text{...} (6)$$

Estimating the coefficient from (5), the marginal product MPP_i of the i^{th}factor X is calculated as;

$$MP_i = \frac{\partial Y}{\partial X} = \beta_i \frac{Y}{X_i} \quad \text{..} (7)$$

But $AP = \frac{Y}{X_i}$

Where Y is the geometric average of vegetable output; X_i is the geometric average of input *i*; β_i is the OLS estimated coefficient of input. The value of marginal product of input *i* (*VMPi*) could be attained by multiplying marginal physical product (*MPPi*) by the price of output (*Py*). Thus,

$VMP_i = MP_i * P_y$ ....(8)

Model specification of marginal effects;

If $VMPi > Pxi$, the inputs are said to be under-utilised and profit could be increased by raising the use of that particular input. Contrariwise, if $VMPi<Pxi$, the input is over-utilised and reducing the use of that input could increase profit. Lastly, Optimum allocative efficiency and maximum profit is reached when $VMPi = Pxi$ (Chavas *et al.*, 2005).

Stochastic frontier analysis took indigenous vegetable production (in kilogrammes) as the dependent variables. Explanatory variables estimated for productivity analysis on Cobb-Douglas stochastic frontier production functions are the primary factors of production (Area under AIV cultivation, fertilisers, pesticides, seed and hired labour). Interaction effect model was demonstrated as the interaction of the basic factors of production in order to detect how different inputs separately and combined influence productivity of indigenous vegetables.

Socio-demographic factors suspected to influence technical efficiency level of ALV farmers were: age, gender, years of education, purpose of farming, access to credit, extension services, farming experience, source of irrigation water and irrigation system (advance technology). Technical efficiency index was estimated where minimum, maximum and average efficiency level of farmers was identified in order to detect how efficiently farmers are allocating their resources. Marginal effect (marginal product)was also estimated to identify how change in inputs affect vegetable production. All the independent variables adopted for the analysis of this study are listed in Table 3 below.

Table 3: Description of the independent variables

Variables	Coding system	Expected
Productivity		
X_1 =Area cultivated	Land under AIVs cultivation (in ha)	+
X_2 = Fertiliser	Quantity of fertiliser (in kilogrammes)	+
X_3 = Pesticide	Quantity of pesticides (chemical in litres)	-/+
X_4= Hired labour	Man (in days)	+
X_5 = Seeds	Quantity of seed (per grams)	/-+
Socio-demographic factors/ Inefficiencies index		
∂_1 = Age	Number of years	-
∂_2= Gender	1 = male, 0 = female	-/+
∂_3 = Years of schooling	Number of years	+
∂_4 = Access to credit	1 = Yes, 0 = No	+
∂_5 = Extension services	1 = Yes, 0 = No	+
∂_6= Farmers experience	Numbers of years growing AIVs	+
∂_7 = Source of irrigation	1= Irrigation scheme, 0 = Dry-land	+
∂_8= Access to irrigation	1 = Advanced technology, 0 = No	-/+

3.7 Conclusion

This chapter focused on the methodology of the study. It included detailed description of the study area, data collection methods, analytical procedures and description of selected explanatory variables. In order to answer the research questions stated in chapter one, quantitative technique were used to better understand socio-demographic factors influencing productivity and technical efficiency of indigenous vegetable farmers. Results presents in this chapter are based also on statistical analysis using Cobb-Douglas production function.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter discusses the results of the study and interpretation of the analytical findings. The results include a detailed discussion of socio-demographic characteristics of African indigenous vegetable growing farmers in Vhembe district. Empirical results are also discussed in accordance with the study objectives.

4.1 Socio-demographic characteristics of AIV farmers in Vhembe District

The result in **Table 4** shows that the majority of farmers growing indigenous vegetables in the study area are relatively old, this is emphasised by 40.6 % of farmers being between 61 and 80 years old. Age plays a vital role in farming as older farmers tend to have more years of farming experience, which may positively influence production efficiency (Obopile et al., 2008).Analysis of gender indicated that women comprised 56.1% of the respondents, which is evident that vegetable production is still a primarily female dominant enterprise (Van Averbeke and Juma, 2006). Results further shows that majority (57.9%) of the farmers had household sizes of 4 to 6 members, which implies that most farmers had numerous members to potentially allocate as the family labour during the production season.

About 43.9% had maximum of 13 years of schooling, which entails that they had either primary or no formal education. This may have a negative influence on farming because it has the potential of reducing technical efficiency (Ajewole and Folayan, 2008). This is underpins by Fakoya *et al.* (2007) who posit that farmers who are literate are more likely to be receptive to new technology, in addition to trying new agricultural practices. Furthermore, education is significant as it enables the farmers to take more knowledgeable decision on production and distribution of their produce to the market (Lefophane et al., 2013). A substantial number of the farmers (91.2%) were farming on a full-time basis, an explicit indication that majority of them lacked formal employment. This could have a positive influence on productivity and technical efficiency as farmers are fully committed to their day-to-day activities.

Farming experience was relatively high with 29.8%of the farmers having farming experience of more than 45 years closely followed by 22.8% of farmers having 16 to 30 years of farming with indigenous vegetables. This suggests that farming practice of indigenous vegetables is old and common in the study area. Intrinsically, farmers who have the fundamental and vast experience in their field are expected to influence agricultural productivity when it comes to the quality of the produce as well as income generation, and consequentially increasing production efficiency (Msuya and Ashimogo, 2005). About 47.4% of the farmer's finance needed to operate the farm was obtained from farm savings, closely followed by pensioners' grant (45%), and formal employment which represents the least at 4%. Furthermore, 76.3% of the farmers indicated that their primary purpose of farming is generating household income as opposed to household consumption. Majority (71%) of smallholder vegetable farmers had access to irrigation system in the study area. This could potential have a positive impact of productivity and technical efficiency of indigenous vegetable farmers, as adaptation of irrigation technology is expected to assist farmers to hedge against production risks (Koundouri et al., 2006).

Table 4: Frequency distribution of socio-demographic characteristics of ALV farmers

Variables	Frequency	Percentage
Total	**114**	**100**
Age (years)		
21 – 40	20	17.7
41 – 60	37	30.7
61 – 80	45	40.6
>80	12	9.9
Gender		
Male	50	43.9
Female	64	56.1
Household size		
≤3	26	22.8
4 – 6	66	57.9
≥7	22	19.4
Years of Schooling		
0 – 13	49	43.9
13 – 18	43	37.7
Tertiary	21	18.4
Occupation		
Farming full-time	104	91.2
Formal employment	3	2.6
Other businesses	7	6.1
Primary purpose of farming		
Consumption	27	23.7
Business	87	76.3
Total	114	100
Farming experience		
1 – 15	37	32.5
16 – 30	26	22.8
31 – 45	17	14.9
≥45	34	29.8
Source of finance		
Formal employment	4	3.5
Pensioner's grant	45	39.5
Other businesses	7	6.1
Others	4	3.5
Access to Irrigation system		
Yes	81	71.1
No	33	28.9

Source: Author's analysis(2016)

4.2 Frequency distribution of Access to credit and extension service

Tables 5 indicates that insufficient access to formal credit by majority (73.7%) of indigenous vegetable farmers is a clear indication that credit access still remains a primary concern to farmers in Vhembe district. As such, it is quite evident that lack of access to credit by majority of the farmers is likely to negatively affect their productivity and efficiency level. Nuryartono (2005) emphasised that supplementary funds from credit institutions are vital as they enable the farmer to invest more in crop production, primarily in new technology adoption. Results further revealed that among the farmers who had access to credit, only 7.9% had access to formal credit while 8.8% and 9.6% of the farmers stated that they borrow money from family societies and friends respectively. According to the study conducted by Nguyen (2003) and Ogundari (2008) it was found that farmers who had access to formal credit were more efficient that farmers with informal credit. Among the farmers who did not have access to credit, about 37.7% of them expressed that they did not need the credit and had no desires to acquire it, while 22.1% showed the desire to access it, however they do not qualify. A smaller proportion of the farmers (14.9%) had no knowledge of how to acquire formal credit; this might be a result of lack of information in some rural communities.

It was further discovered that 80.7% of the indigenous vegetable farmers had access to extension services. This indicates that extension officer's visits are common in the study area, which implies that farmers are well trained and equipped with sound knowledge of agricultural practices which may in-turn make them efficient. A confirmation is presented in the findings of Khairo and Battese (2005) who discovered a positive relationship between technical efficiency and extension services. Majority of the farmers, precisely 50.0% indicated that the main extension services that they receive are inputs (fertilisers and pesticides) provision, while 20.2% and 10.5% declared that they primarily receive training on production techniques and marketing techniques respectively. However, some farmers(19.3%) were unable to access extension services, essentially because they do not know about them (7.0%), they do not need them (9.6%) and that they were not available in their areas (2.6%). Lack of credit accessibility and/or credit information can be attributed to lack of access to extension service, as some of the farmers highly depend on agricultural extensions or advisors for such information.

Table 5: Frequency distribution of access to credit and extension services

Variables	Frequency	Percentage
Total	**114**	**100**
Access to credit		
Yes	30	26.3
No	84	73.7
If yes, what is your source of credit?		
Bank loan	9	7.9
Family society	10	8.8
Friends	11	9.6
If no, what is your reason for not accessing credit?		
I donot qualify	24	21.1
I donot need it	43	37.7
I donot know how to access it	17	14.9
Access to extension services		
Yes	92	80.7
No	22	19.3
If yes, what type of services do you primarily receive?		
Inputs provision	57	50
Production training	23	20.2
Marketing information	12	10.5
If no, what is the reason for not accessing extension services?	8	7.0
I don't know about it	11	9.6
I don't need it	3	2.6
They are not available	92	80.7

Source: Author's analysis (2016)

4.3 Frequency distribution of marketing characteristics of AIVs farmers

The results in Table 6revealed that 64.0% of indigenous vegetable farmers in Vhembe district had access to marketing information. The implication is that the farmers are well equipped with advanced information and strategies on how to access lucrative markets for their produce, which subsequently enables them to increase profit. The farmers revealed that they receive marketing information from various sources, 19.3% primarily receive information from extension officers, an aggregate of 23.7% claim that they obtain information from other farmers, 17.5% from buyers and just a proportion of 3.5% receive from other sources such as social media, friends etc. Furthermore, the responses of the farmers on the type of marketing information received shows that 21.9% receive information on which vegetable is in high demand, while18.4% state that they acquire knowledge on the date of sale and 15.8% on the produce selling price.

The analysis of how the farmers market their produce shows that a substantial fraction of 83.3% had no market contractual agreement with any formal retail outlets or organisation; while 48.2% of the farmers expressed that they had a ready market and that they always find buyers for their vegetables. The opposite was the case with 51.8% of the farmers. A relatively low number of farmers (21.9%) stated that they find it difficult to access buyers for their produce, while 39.5% find it easier, 38.6% enjoy fair access to buyers. Accessibility of buyers is a fundamental determinant of crop production as every producer wishes to produce a product that grantees them a ready available market (Lu et al., 2008).

Due to the large number of farmers producing indigenous vegetable in the study area, they tend to compete for the market while selling their produce. As a result, a percentage of 49.1 of the farmers confirmed that they experience high competition when attempting to sell their produce. This may influence their productivity, since the level of production is determined by the ability to sell the produce. Vegetable farmers in Vhembe district compete on various aspects, the majority (20.2%) of farmers stated that they compete based on the quality of the produce;8.8% compete based on the quantity of produce, 14.9 % contest on prices and 5.7% on value adding. This means that for a farmer to have a competitive advantage over other farmers, he/she should have acquired better marketing information on these aspects.

Likewise, the result illustrated that smallholders are still faced with difficulties when it comes to entering high-value market. For example, only 22.8% of the farmers are able to sell their produce to formal retail stores. On the other hand, a large proportion of 77.2% who are unable to enter formal retail markets stated that they primarily sell their produce at farm gate, local village and local town: 32.5%, 17.5% and 27.25 respectively. This is likely to have a negative impact on vegetable farmer's productivity and efficiency as production level is dependent on the ability to sell the produce. Rios-Rull *et al.*, (2008) found a positive relationship between market access and productivity, advocating that farmers who have access to the market turn to produce more for the market than farmers without access to market.

Table 6: Frequency distribution of marketing characteristics of AIVs farmers

Variables	Frequency	Percentage
Total	**114**	**100**
Access to market information		
Yes	73	64.0
No	41	36.0
If yes, what is your source of market information?		
Extension officers	22	19.3
Other farmers	27	23.7
Buyers	20	17.5
Others (social media, friends etc.)	4	3.5
If yes, what type of market information do you receive?		
Products on demand	25	21.9
Prices	18	15.8
Date of sales	21	18.4
Others (value additions, contract market etc.)	9	7.9
Do you have market contractual agreement?		
Yes	19	16.7
No	95	83.3
Do you always find buyers to purchase your produce?		
Yes	55	48.2
No	59	51.8
How accessible are the buyers?		
Easy	45	39.5
Fair	44	38.6
Difficult	25	21.9
Do you consider market competition High/Low?		
High	56	49.1
Low	58	50.9
On which aspect do you compete with other farmers?		
Quality of produce	23	20.2
Quantity of produce	10	8.8
Prices	17	14.9
Value adding	6	5.7
Do you have access to high-value market?		
Yes	26	22.8
No	88	77.2
Where do you primarily sell you produce?		
Farm gate	37	32.5
Local villages	20	17.5
Local town	31	27.2
Formal retail stores	26	22.8

Source: Author's analysis (2016)

4.4 Summary statistics of exogenous variables

Table 7 clearly depicts the mean, minimum, maximum and standard deviation of exogenous variables used in the study for productivity and technical efficiency analysis of African indigenous vegetables. Mean age, household size, education and farming experience were discovered to be 59.65 years, 4.9 persons, 13.35 years of schooling and 30.9 years of farming respectively. The log of total yield was observed to be 6.72kg per hectare on average, with a minimum of 5.19kg and maximum of 8.04kg.

Farmers adopted inputs such as improved seeds, fertilisers and pesticides in their vegetable production. Average seed quantity of farmers was found to be 135.5 grams per hectare, while the average of fertilisers was 125 kilogrammes per hectare and pesticides were an average of 10 litres per hectare. Farmers in the study area had a minimum land size under vegetable cultivation of 0.25ha, while the maximum was found to be 0.80ha with an average of 0.53ha. This indicates that small land portion was allocated for indigenous vegetable production by majority of farmers. This may negatively affect productivity and technical efficiency, as land size is a significant variable in influencing the level of production. This can be advocated by Obwona (2006) who found size of land to be the most significant determinants of technical efficiency.

Farmers had an average of 2 hired labours, while some farmers had none and others had a maximum of 4. This can be attributed to the fact that a large portion of the farmers had large household size; consequently they altered some of the members into family labourers, rather than hiring labourers. This can be viewed as an advantage for farmers as it will enable them to reduce production costs, thereby increasing technical efficiency (Bhavan and Maheswaranathan, 2012).

The investigation also showed that fertilisers contributed the greatest portion of the total cost in the production of indigenous vegetable compared to other inputs. On the other hand, seeds contributed the least cost; this may be due to the fact that most small-holder farmers are still using indigenous seeds which were saved from previous season as opposed to modified seeds varieties obtained from the market. Average cost of hired labour was found to be R156.6 per man/day while the cost of pesticide was R364.5 per litres. It was discovered that farmers were growing either two or three of the selected vegetables namely; African nightshade, Pumpkin leaves or Chinese cabbage.

Table 7: Summary statistics of exogenous variables

Variables	Description	Mean	Std. dev.	Min.	Max.
Socio-demographic					
Age	Age of household head (Years)	59.6	15.80	32	91
Household size	Number of persons in the household	4.90	1.78	2	9
Education	Years of schooling of head	13.3	6.88	0	24
Farming experience	Years of farming of household of head	30.9	20.9	3	70
Production					
In Total yield	Total output produced in (kg/ha)	6.72	0.49	5.19	8.04
Land used	Land cultivated in hectares (ha)	0.53	0.36	0.25	0.80
Seeds	Quantity of seed in (grams/ha)	135.5	90.7	0	500
Fertiliser	Quantity of fertilisers in(kg/ha)	2.45	0.92	1	7
Pesticide	Quantity of pesticide in (litres/ha)	2.23	1.07	1	8
Hired labours	Quantity of labour per (man/day)	2	0.71	0	4
Crops cultivated	Category of vegetables planted average	2.5	0.82	2	3
Total costs					
Cost of seeds	Ave. price of seed per (grams)	58.4	127.4	0	450
Cost of Fertilisers	Ave. price of fertiliser per (50Kg/ZAR)	739.8	248.7	300	1792
Cost of Pesticides	Ave price of pesticide per (5litre/ZAR)	364.5	150.7	120	720
Cost of Hired labour	Unit cost of labour per man/day (ZAR)	156.6	79.4	0	400

Source: Author's analysis (2016)

4.5 Estimates of production frontier function

The elasticity of production refers to percentage change in output when there is variation in variable input. In other terms, it estimates the receptiveness of increase or decrease in output as a result of change in quantity of input. The results in **Table 8** capture variable outcomes from Cobb-Douglas stochastic production frontier function. Productivity was computed using significant parameter of log likelihood in the half-normal model $\lambda = \sigma_u / \sigma_v$. Results revealed that variable coefficients were significant at 1%, 5% and 10% level of significance. Variables land size/area cultivated, fertiliser, labour and seeds were found to be statistically significant in increasing productivity. The elasticity of some variables was found to be lower than one, implying that a unit increase in that respective input will lead to an increase in vegetable yield by less than one.

4.5.1 Area cultivated

Land size seemed to be the most fundamental variable influencing production of indigenous vegetables in Vhembe district with the highest elasticity compared to other inputs. It was found to be significant at 5% levelon **Table 8**. Elasticity of area under indigenous vegetable cultivation was observed to be 0.222, implying that for every 10% increase in area cultivated, the yield will rise by 2.2%. This outcome is consistent with the findings of Douglas (2005), Baloyi *et al.*, (2011) and Amos (2007) who discovered that the elasticity of land was greater than one. Contrary to this finding, Bozoglu and Ceyhan (2007) found a negative relationship between size of land and productivity advocating that small farm size are easy to manage and requires little inputs in production.

4.5.2 Fertilisers

The elasticity of fertiliser was found to be 0.075 and it was positively significant at 10% level towards influencing vegetable production. This result suggests that for every 10% increase application of fertilisers, yield will increase by 0.75%. As a result fertiliser plays a significant role in enhancing productivity. For instance, the findings of Ogundari (2008) and Baloyi *et al.*, (2011) underscored the results of this study.

4.5.3 Hired labours

The results showed that variable hired labour was highly important in influencing vegetable production at 1% significance level. Elasticity of 0.090 was observed, with the implication that for every 10% increase in the number of hired labour production of vegetables will increase by 0.90%. This outcome is in line with the findings of (Loko, 2009) and (Barro, 2001) who advocated that increasing labour quantity is positively associated with higher production output. Additionally, in a study done by Chirwa (2007), hired labour was the only variable which was found to be significant in increasing productivity.

4.5.4 Seed

Another variable which was found to be sensitive towards vegetable production was seed, which was found to be highly significant at 1% level. The elasticity of seed was discovered to be 0.003, indicating that every 10% increase in the units of seed with other inputs held constant will increase the production yield of indigenous vegetables by 0.03%. However, Weinberger and Msuya (2004) argued that lack of supply and utilisation of high quality seeds leads to a large yield gap.

4.5.5 Discussion of results

Results revealed that pesticide is not a significant factor in influencing productivity. This implies that increasing or decreasing pesticides application will not have a significant impact on vegetable productivity. It can be concluded that it is essential for farmers to increase their area under cultivation of indigenous vegetables in order to obtain higher returns from production. Seed appear to be the least important variable in increasing production yield. This might be due to farmer's lack of access to high quality seed varieties, and as such depend largely on recycled seeds Douglas (2005). He further stated that, recycled seeds lose some potential of better yield as compared to improved seeds.

Moreover, the total elasticity was found to be equal to 0.407, indicating that yield will increases by less than one per cent provided all inputs were increased by 10% simultaneously. This indicates decreasing return to scale. Based on the outcomes of this objective, the hypothesis that; there are no significant factors influencing productivity of African indigenous vegetables in Vhembe district was rejected.

Table 8: Empirical results from Cobb-Douglas stochastic production frontier function

Variables	Parameters	Coefficient	T-statistics
Production function			
Constant	X_0	5.8409***	16.08
Area cultivated	X_1	0.2215**	2.11
Fertiliser	X_2	0.0745*	1.68
Pesticide	X_3	0.0167	0.43
Labour	X_4	0.0902***	3.00
Seeds	X_5	0.0025***	6.02
Interaction effect			
Land*land	X_{LL}	1.1655***	4.86
Fertiliser*fertiliser	X_{FF}	0.0275**	2.38
Pesticide*pesticide	X_{PP}	-0.0332**	-2.32
Labour*labour	X_{LaLa}	0.0395**	2.75
Seed*seed	X_{SS}	-3.7606*	-1.73
Land*fertiliser	X_{LF}	-0.2575	-1.95
Land*pesticide	X_{LP}	0.0566***	0.55
Land*labour	X_{LLa}	-0.5000***	-3.11
Land*seed	X_{LS}	0.0023	0.95
Labour*seed	X_{LS}	-0.0001 -	0.08
Fertiliser*seed	X_{FS}	0.0014***	3.89
Labour*fertiliser	X_{LaF}	-0.1241***	-3.73
Labour*pesticide	X_{LaP}	0.0995**	2.70
Land*fertiliser*seed	X_{LFS}	-0.0015**	-1.78
Land*labour*fertiliser	X_{LLaF}	0.1477	2.77
Variance parameters			
sigma_v		2.8662	
Sigma_u		0.5255	
Sigma2		0.3583	
Lambda (λ)		1.8335	
Wald chi2(9)		38.86	
Likelihood		-63.177	
Number of observation		114	

***, **, * = t-ratio significant at 1%, 5% and 10% level respectively,

Ln= Natural log to base two

Source: Author's analysis (2016)

4.6 Parameter estimates on Interaction effects model

The bottom part of **Table 8** articulates outcome on interaction effect model, in order to observe how doubling one input will have an effect on vegetable production and how combining different inputs with the exception of fixed inputs will affect vegetable productivity. The result indicates that increasing land under vegetable cultivation was highly significant in increasing productivity at 1% level. This implies that doubling the area under indigenous vegetable cultivation will increase productivity by 1.16. This was the case with fertiliser, where it was discovered to have a positive relationship with productivity. The implication is that doubling the use of fertiliser will increase productivity by 0.02 as it is an essential resource in production because it has the potential to increase the growth of vegetables. This was consistent with the finding of (Amaza and Maurice, 2005) who concluded that that fertiliser is a key to enhancing production yield and that 20% of production could be increased by increasing the application of fertilisers.

Doubling the use of labour on the other hand was found to be highly significant at 1% level in determining productivity. Increasing the number of hired labour will contribute to an increase in production output because having more labourers to supplement family labour implies that activities will be easily completed and on time hence enhancing production. Barro, 2001 stated that labour is a major factor of production in traditional farming systems as such labourers are key elements in increasing productivity.

Doubling the application of pesticide was found to be negatively related to productivity. Meaning increasing the use of pesticide will decrease productivity share, since applying more chemicals may affect the crop or soil fertility. Similarly, doubling seed was also found to have a negative impact, since adding more seed on the same cultivation area may results in replication of plants hence they will compete for nutrient which in turn affects production. This can be attributed to the law of diminishing marginal return which states that incremental of single input variable, there is a point at which the marginal increase in output begins to decrease, holding all other inputs constant (Greenwald and Stiglitz, 1993).

Combination of land and pesticide was found to be positively significant in influencing production of ALVs. While land and labour were negatively associated with production of AIVs, this may be the case as most farmers with smaller land size tend to depend more on family labour than hired labour. Additionally, combination of fertiliser and seed was found to be positive and highly significant at 1%, indicating that increasing units of fertiliser and seed, other inputs kept constant will lead to a rise in production.

Labour and fertiliser however, were found to be significant and negatively related, suggesting an increase in both units of labour and fertiliser will cause a decline in output produced. It is therefore essential that farmers increase unit of one of these inputs at a time. Conversely, combination of labour and pesticide were found to be positively related to vegetable production while combination of land, fertiliser and seed was negatively related to vegetable production. It can be said that not all combination of inputs yield the best outcome. Farmers should therefore select input combination or double input that guarantees them an increase in productivity.

4.7 Estimates of Marginal effects for Indigenous vegetables production

Marginal effects, also called instantaneous rate of change is the computation of a certain variable while other variables are held constant (Robins et al., 1999). The magnitude of marginal effect depends on the values of the other variables and their coefficients. Marginal effects of African indigenous vegetable production was estimated. For production to be maximised the value of marginal product should be equivalent to the respective unit factor price; hence, optimal efficiency is reached (*MPi* = *Pxi*). Additionally if *MPi* > *Pxi*, the input is underused and farm profit can be raised by increasing the use of this input. Conversely, if *MPi* < *Pxi*, the input is overused and to raise farm production its use should be reduced.

Table 9 below shows the outcome of marginal effects of indigenous vegetable production. The results reveal that land, fertilisers and hired labour input were underutilised as their marginal product is greater than the marginal factor. The farmer should therefore increase the use of fertiliser and hired labour and expand area under vegetable cultivation in order to attain the highest returns in production and profit. On the other hand, seeds and other farm material (tractor, hoes etc.) appeared to be over-utilised; hence the farmers should reduce their use in order to maximise production.

Table 9: Estimate of value of marginal effects after frontier

African Indigenous vegetables					
Marginal product (*MPi*)	**dy/dx**	**SE**	**Marginal factor (*Pxi*)**	**dy/dx**	**SE**
Area cultivated	0.690	0.070	Cost of land	0.670	0.080
Quantity of fertiliser	-0.037	0.083	Cost of fertiliser	-0.007	0.097
Quantity of pesticide	0.035	0.064	Cost of pesticide	0.030	0.056
Quantity of seeds	0.193	0.057	Cost of seeds	0.205	0.062
Quantity of labours	0.194	0.052	Cost of labour	0.109	0.058
Other farm materials	0.0003	0.0003	Cost of other farm material	-0.0009	0.0003

Source: Author' s analysis (2016)

4.8 Estimates of technical efficiency index

The result technical efficiency index scores on **Table 10** were obtained using the Stochastic Frontier Analysis. The outcome shows a slight variation in efficiency levels among the vegetable farmers. The predicted efficiency level ranges between 0.74 and 0.99 with a mean efficiency level of 0.93. The variation in efficiency might be a result of socio-demographic factors of the selected farmer such as years of schooling, access to credit, source of irrigation and access to extension services which will be discussed momentarily. These factors are likely to have an impact on the farmer's ability to use available technology and efficiently allocate major resources (Haji, 2007).

The majority of the farmers (46.4%) had an efficiency score of greater than 95% which was followed by 21.4% vegetable farmers ranging from 0.91 to 0.95. Very limited farmers (5.3%) had efficiency score of less than 0.75, closely followed by 7.0% of the farmers with a range of 0.76 to 0.80. This outcomes shows that farmers in Vhembe district are efficient in terms of their resource allocation and there is only 7% chance of increasing technical efficiency of indigenous vegetables production .

Furthermore, the lowest efficiency level was uncovered to be 74% which is 26% below the production frontier, however such a farmer is still considered to be technically efficient since efficiency is above 50%. The highest level of technical efficiency was 99% which is only 1% below from the production efficient frontier. In reality production rarely operates at 100% level of efficiency, hence 99% is considered as the highest level of production efficiency. The average level of efficiency of indigenous vegetable farmers was found to be substantially high at 93%. This was however contrary to other studies conducted where average vegetable production efficiency was found to be a bit lower as compared to this study. For instance, Shrestha *et al.*, (2014) conducted a study on technically efficiency of smallholder vegetable farms and found efficiency of 77%. Likewise, Abdulai (2006) found vegetable production efficiency of 88.7%.

The average efficiency (93%) is a clear indication of efficient allocation of resources used by indigenous vegetable farmers in Vhembe district of Limpopo province. This means that technical efficiency can be accelerated by only 7% with the same level of inputs without increasing the costs of production.

Table 10: Distribution of technical efficiency index score

Efficiency level	Number of farmers	Percentage
≤0.75	6	5.3
0.76 – 0.80	8	7.0
0.81 – 0.85	10	8.7
0.86 – 0.90	13	11.2
0.91 – 0.95	24	21.4
>0.95	53	46.4
Total	114	100
Mean	0.93	
Minimum	0.74	
Maximum	0.99	

Source: Author's analysis (2016)

4.9 Factors determining technical efficiency of AIVs

Technical inefficiency effect model was used to explain the factors determining technical efficiency levels, the results are shown on **Table 11below.** Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output; hence the opposite is technically inefficiency. Technical efficiency and factors determining technical efficiency has been widely studied and diverse results have been reported. Various socio-demographic factors influencing technical efficiency of indigenous vegetable farmers in Vhembe district are discovered. Variable gender, years of schooling, extension services and access to irrigation system were found to be significant in explaining technical efficiency of indigenous vegetable farmers in the study area. Other variables such as age, access to credit and farming experience which were expected to influence technical efficiency were found to be statistically insignificant in determining technical efficiency.

4.9.1 Gender

The result indicated that the coefficient for gender was statistically different from zero and negatively related to technical inefficiency. This implies that gender reduces technical inefficiency of farmers thereby making them efficient in vegetable production. Conversely, Ekunwe and Emokaro (2009) found a positive relationship between technical efficiency and gender of the household head. The study found out that 64% of the farmers in the Vhembe district were female, meaning vegetable production is pre-dominated by female farmers and historically, it was revealed that the collecting of leafy vegetables was a female dominant practice among rural dwellers(van Rensburg *et al.*, 2004). This suggests that female-headed households are more efficient than those headed by men.

Similar results were found in the classic study by Quisumbing (1996), who applied several methods of efficiency and confirmed that female-headed families were indeed more efficient in agricultural production. However, this was contrary to the submission of Tshiunza *et al.* (2001) which stated that male farmers are more efficient than female farmers as they produce mostly with the purpose of selling and generate income as oppose to against household consumption.

4.9.2 Years of education

Years of schooling were found to be positive and statistically significant (at 5%) in increasing technical inefficiency, this was against the expected sign. Education is assumed to exacerbate new technologies adoption and improved agricultural practice which tends to enhance production efficiency (Amos, 2007).Thus, improving education level of farmers will in turn reduce technical inefficiency. About 49% of the respondents had less than 13years of schooling in Vhembe district which implied that they either had primary education or no education, making them less literate, hence the presence of technical inefficiency.

Education is said to be a vital driver of efficiency, it impacts knowledge, and thereby affording more informed farming decisions. It is advantageous to farmers when it comes to choosing the best farming methods, sufficient allocation of scarce resources and attaining high production yield. The result implies that an additional year of education will lead to 0.14 decrease in technical inefficiency level, provided the other factors are held constant. Contrariwise, findings by Hyuha *et al.*, (2007) showed that education decreased technical inefficiency and it was recommended that introduction of youth development programmes in farming will improve future production. Huang *et al.*, (2014)on the other hand discovered that education was positively associated with technical efficiency, stating that imparting education or encouraging farmers to acquire formal education will help improve speedy adoption of technology and better marketing of agricultural produce. Additionally, Wier and Knight (2000) found a strong positive relationship between educational level and technical efficiency of vegetable farmers.

4.9.3 Extension services

Conflicting with the expected sign, access to extension services was positively significant in determining technical inefficiency. Table 11 below shows that availability of extension services was highly significant at 1% level. This seems to imply that increasing extension services by one unit will increase technical inefficiency by 0.63. This is contrary to the findings of some researchers (Shrestha *et al.*, 2014; Khairo and Battese, 2005, Owens *et al.*, 2001 O'Neill and Mathews, 2000) who found an inverse significant relationship between technical support and technical inefficiency. With an understanding that technical support will enable farmers to be more alert and adopt updated technology to enhance vegetable production leading to better income generation.

However, the finding were inconsistent with the results of Alene and Hassan (2008), including Alemu *et al.* (2009) who concluded that extension services access has no impact on technical efficiency. Access to extension services or visits does not necessarily imply effectiveness or good quality of the services. Although majority of farmers in Vhembe district had access to extension services, there was lack of effective production training workshops, consistent visit and provision of necessary inputs such as modified seeds.

4.9.4 Access to irrigation system

Irrigation system was found to be negatively associated with technical inefficiency (Table 11).This was in accordance to the expected sign, as farmers who had access to irrigation were more efficient than farmers without irrigation. Equally, farmers who belonged to an irrigation scheme and had access to advanced irrigation system were more technically efficient, than farmers who belonged to dry land schemes and had no access to irrigation system. It was argued that adopting advanced irrigation technology will activate increase in yield and efficiency (Kuznets, 1996).

4.9.5 Discussion of the results

The results revealed that indigenous vegetable farmers in Vhembe district are technically efficient with an average of 93%. It further showed that there is 7% opportunity to increase efficiency in order to achieve the highest production yield. The analysis of factors determining technical efficiency of the respondents showed that variable gender and access to irrigation system were negatively associated to technical inefficiency. The outcome further demarcated that years of schooling and access extension services were negatively related to technical inefficiency implying that increasing years of schooling and access to effective extension services will increase technical efficiency level of indigenous vegetable farmers in Vhembe district. The second hypothesis which states that there are no socio-demographic factors influencing technical efficiency level of indigenous farmers in the study area was therefore rejected.

Table 11: Estimates of inefficiency effect model

Inefficiency effect	**Coefficient**	**t-value**
Constant(∂_0)	6.7082***	13.20
Age (∂_1)	0.0046	0.96
Gender (∂_2)	-0.1630**	-0.96
Years of schooling (∂_3)	0.1444**	2.10
Purpose of farming (∂_4)	-0.0975	-1.01
Credit access (∂_5)	-0.0572	-0.61
Extension service (∂_6)	0.6327***	4.69
Farming experience (∂_7)	0.0001	0.05
Access to high-value market (∂_8)	0.0224	0.43
Access to Irrigation system (∂_9)	-0.2709***	-3.57
Wald chi2	47.09	
Log likelihood	-896.47	

Source: Authors analysis (2016) Sig at 10%, **Sig at 5%, ***Sig 1%

4.10 Constraints faced by indigenous vegetable farmers in Vhembe district.

Farmers in Vhembe district are faced with numerous challenges that inhibit their attainments of full farming potential. These challenges hinder them from realising the highest production output, which subsequently impede higher returns. Farmers were asked to state the most common problems they experience in their day-to-day farming and state what they believe could be the ultimate solutions to overcome these challenges. The most common problems faced by farmers are illustrated in Table 12 and are discussed in details.

Table 12: Challenges faced by African indigenous vegetable farmers in Vhembe district

Constraints	Percentage	Possible solution	Percentage
Water irrigation shortage	79	Construction of boreholes	87
Lack of quality seeds	66	Seeds provision schemes	67
Poor access to high-value market	58	Market information and minimised transportation costs	41
Lower selling price	54	Group sales	40
Perishability of vegetables	45	Post-harvest training workshops	53
High competition	48	Group sales	35
Lack of farming materials	47	Input provision schemes	70
High production cost	42	Government intervention	85
Small farm size	39	Government intervention	43
Lack of market place	34	Government intervention	41
Diseases/pest outbreak	29	Pests control training workshops	33
High transportation cost	24	Group sales	32
Thief	19	Fence provision	17

Source: Author's analysis (2016)

4.10.1 Water shortage

A substantial number of farmers (79%) raised a concern of water shortage in the study area. Farmers indicated that although they are farming under irrigation scheme, water scarcity still remains a serious concern. This problem is worsened by the extreme hot condition experienced by the Limpopo province each year. Majority of the farmers believed that construction of borehole will be an ultimate solution to this problem, as it will guarantee them consistent supply of water at any production season.

4.10.2 Lack of quality seeds

Lack of quality seed was the second biggest challenge, earning it an aggregate of 66% that is experienced by indigenous farmers in Vhembe district. Farmers are still heavily dependent on seeds saved from previous season or recycled seeds as opposed to improved seed varieties. Due to low commercialisation of indigenous vegetables, some of the seeds of these vegetables are still unavailable in the local shops, and those that are available their supply is inconsistent. As a result of these challenge, smallholder vegetable farmers are still associated with low input – low output production systems. Seed provision schemes will be the definitive solution for this challenge to enhance farmer's vegetable production.

4.10.3 Poor access to high-value markets

Smallholder farmers find it challenging to participate and/or compete in high-value markets. They experience enormous challenges when it comes to physically accessing markets. This was the case with indigenous farmers in Vhembe district where 58% of the farmers expressed that they were unable to sell their produce to formal market outlets. This is a result of low quality produce, distance to the market, higher costs of transporting produce and poor access to market information among others. These obstacles make it difficult for smallholder to compete with commercial or large-scale farmers. Alleviating this constraint will require numerous solutions, such as government intervention educating farmers on how to efficiently market their produce and by making information available for access by farmers at any given time. Moreover, farmers themselves can minimize transaction cost through group sale and by targeting local retail supermarkets to sell their produce.

4.10.4 Lower selling price

The challenge of water shortage, lack of quality seeds, poor access to high-value markets and perishability of vegetable often leads to farmers selling their produce at lower price. This challenge is also a result of high completion of indigenous vegetables in Vhembe district. About 54% of the farmers testified to experiencing a challenge of lower selling price. This poses a serious challenge to farmers as it can hinder them from generating profit. Selling produce at lower price may result in farmer's inability to cover their production cost hence poor profit generation. Stoeve (2012) also found that vegetable production in Bulgaria is affected by such factors as low vegetable purchase price and poor quality among others. Farmers suggested group sale at the ultimate solution for these problem, wherein government take their produce in bulk and sell them on their behalf in areas where production is scares.

4.10.5 Perishability nature of vegetables

Indigenous vegetable are perishable in nature, as a results it is difficult to schedule their supply and meet the demand in the market. They are therefore subject to quantity and quality threats with fluctuating consumer demands and production conditions. There is no exception for farmers in Vhembe district, with 45% of the farmers indicating perishability of vegetable as a serious concern. Farmers in the study lack access to infrastructure on the farm like storage facilities to keep their produce in good state after harvest. As such in other instances it forces farmers to produce less or sell at the possible lowest price in order to avoid spoilage of the produce.

Currently, farmers rely heavily on the old post-harvest processing methods such as sun-drying and freezing which compromises the quality of the vegetables. Conduction post-harvest training workshop will be of utmost benefits for the farmers as it will teach them how to handle a produce from the time of harvest till the time of sale. Moreover, it will teach them other processing methods which they can adopt without a consequence of losing product quality and value. Alternatively, government can assist in building on-farm storage facilities which can be used by immense number of farmers under each irrigation and dry-land scheme.

4.10.6 Small farm size

Indigenous vegetable farmers under irrigation schemes in Vhembe district are associated with smaller farm sizes ranging between 1 to 2 hectares. Besides, they are engaging in diverse farming system, whereby the produce variety of agricultural crops, leaving very little land allocated for indigenous vegetables. About 0.25ha to 0.80 ha is allocated for indigenous vegetable production. Smaller farm size has recently become a challenge in the study as farmers are beginning to enjoy the benefits of participating in the formal markets. Mokgalabone (2015) found a positive relationship between farm size and production efficiency, emphasising that increasing farm size is highly likely to increase production efficiency. The results concur with the study of Baloyi *et al.*, (2010) and Dorward (1999). The farmers are calling for government intervention to expand their land area to enable them to expand the production and enjoy the benefit of greater returns.

4.10.7 Other challenges

Additional challenges that indigenous vegetable farmers in Vhembe district are currently facing include high competition (48%), lack of farming material (47%) and high production (42%). High competition is due to massive number of farmers producing indigenous vegetable in the study area. Farmers have to compete for the market in order to sell all of their produce. This requires a strategic selling where a farmer is able to secure his or her regular customers. Farmers highlighted that they lack crucial farming materials and inputs such as tractor, irrigation equipment, boreholes and storage facilities, to mention just these. Additionally, farmers lamented that their inability to acquire these inputs is due to the high capital required and their inability to secure formal credit. As a result, they are calling upon government intervention to invest in them by assisting in acquisition of these inputs as this will significantly influence their productivity and income. Biermacher *et al.*, 2007 suggest that farmers could reduce costs of production by using family labour instead of hired labours.

Small farm size and lack of market place were among other challenges affecting the farmers with 39% and 34% respectively. The results showed that farmers in government schemes had an average of 1.2ha, which clearly indicates that small size is a constraint to farmers. Farmers also lack market place where they can sell their produce. As such, majority of the farmers are forced to sell their produce at the farm-gate. Farmers believe that having a fresh produce market station where they can sell their vegetable around the district can go a long way in ensuring high production and improved marketing.

Lastly, farmers indicated diseases/pest outbreak, high transportation cost and theft as the least of the problems they are facing when producing and marketing their produce; the fractions for the trio are 29%, 24% and 19% respectively. Many farmers have no means of transportation to move their produce to the markets. Transportation constraint leads to inconsistent delivery of quality produce, which points towards lower selling price (Louw *et al.*, 2004). Farmers who attempt to transport their produce to market places find it difficult to cover the transportation cost; this is a common problem not only in Vhembe district but in other developing countries as well. Farmers believe that attending workshops where expected will educate them on how to deal with diseases and pest outbreak; this, they believe will help them overcome these problems.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Introduction

This chapter summaries the study, draws conclusion and make recommendations based on the outcomes of the study. It further highlights the extent to which the objectives of the study were addressed by the analysis.

5.1 Summary

The study was aimed at evaluating productivity and technical efficiency of African indigenous vegetable farmers in Vhembe district, Limpopo province. The marginal effects of production were also estimated in cover returns of scale of the famers. Moreover, the constraints faced by farmers in Vhembe district were explored and their possible solutions were clearly elaborated and discussed in details. Socio-demographic factors influencing productivity and technical efficiency of AIV farmers were investigated. These factors were analysed using econometric models on the the Statistical Package for Social Sciences (SPSS), Frontier and Statistical (STATA) software. Cobb-Douglas stochastic production function was adopted to evaluate productivity of indigenous vegetables and the interaction effect model in order to achieve the second objective. Stochastic frontier analysis in terms of translog production function was adopted to evaluate technical efficiency level of indigenous vegetable farmers in the study area. It was also used to examine socio-demographic factors influencing technical efficiency level.

Result from the analysis showed that the average age of the farmers was 59.6 years. The farmers (43.9%) had a maximum of 13 years of schooling while the number of years of farming experience was relatively high with mean of 30.9 years. Results of gender indicated that 36% of the respondents were male while, woman comprised 64% of the respondents. The average of household size was revealed to be 4.96 people. A substantial number of farmers were farming on full-time basis, which suggest that majority of them lack formal employment. As a result, 54% of the farmers' finance needed to operate the farm was obtained from farm savings. A fairly large proportion of farmers (87%) indicated that their primary purpose of farming was to generate income other than household consumption. Farmers(84%) lacked access to formal credit while a portion of 92% had access to extension services. Majority (88%) of the farmers lacked the ability to enter formal retail outlets. About 71% of the smallholder farmers had access to irrigation system in the study area.

Empirical results from Cobb-Douglas production function found area cultivated, fertiliser, seeds and labour to be positive and significantly related to productivity of indigenous vegetables farmers. The estimated elasticity of production with respect to area cultivated, fertiliser, labour and seed inputs were 0.22, 0.07, 0.09 and 0.002 respectively. The implication was that 10% increase in area cultivated with indigenous vegetables, production yield will rise by 2.2%. Furthermore, a 10% growth in the amount of fertiliser and seeds used for vegetables production will slightly increase output by 0.7%, and 0.02% respectively, while similarly an increase in the number of hired labour will accelerate vegetable output by 0.9%.Land was found to be the most vital factor of production influencing productivity with a higher elasticity compared to other factors of production.

Interaction effect model revealed that some of the combinations of inputs were better than the others in terms of increasing yield. Doubling factors of production (land, fertiliser and labour) was found to have a positive influence on productivity while doubling of pesticides and seeds was found to have an inverse effect on vegetable production. These outcomes can be attributed to the law of diminishing marginal return (Brue, 1993). In addition, combinations of land and pesticides, fertiliser and seed, labour and pesticides were found to be positively significant in relation to productivity whereas, combinations of land and labour; labour and fertiliser; land, fertiliser and seed were significant and negatively influencing vegetable production in Vhembe district.

Empirical results from stochastic translog production function revealed that indigenous vegetable farmers in Vhembe district are technically efficient with a mean of 93%. It further showed that there is 7% opportunity to increase efficiency in order to achieve the highest production yield. The analysis of factors determining technical efficiency of the respondentswas identified on inefficiency effect model. It was revealed that variable gender and access to irrigation system were negatively associated to technical inefficiency, implying that they increase technical efficiency. The outcome further demarcated that years of schooling and access extension services were negatively related to technical inefficiency implying that increasing years of schooling and access to effective extension services will increase technical efficiency level of indigenous vegetable farmers in Vhembe district.

Marginal effects were computed through comparison of value of marginal product and marginal factor cost in order to detect if farmers were underutilising or over utilising the available resources. The results reveals that land, fertilisers and hired labour input were underutilised as marginal product is greater than marginal factor cost ($MP_i > Px_i$). The farmer should therefore increase the use of fertiliser and hired labour and area under vegetable cultivation in order to attain high production yield. On the other hand, seeds and other farm material appeared to be over-utilised, hence the farmers should reduce their use in order to maximise production.

Farmers in Vhembe district were found to be facing numerous challenges while producing and marketing indigenous vegetables, of which the most common ones were shortage of water (79%), lack of improved seeds (66%), perishability of vegetables (58), poor access to high-value market (54%) and low selling price (54%).Farmers also suggested possible solution to these challenges such as; construction of borehole, formation of seed provision scheme, post-harvest training, access to market information, group sales and government intervention were some of the possible solutions suggested by indigenous vegetable farmers in Vhembe district.

5.2 Conclusion

The outcomes of the study showed that production of indigenous vegetables (African nightshade, pumpkin leaves and Chinese cabbage) is greatly concentrated in the study area. Mean Log of total yield was 6.72kg, implying that farmers were producing enough for household consumption and to distribute to the market. Among the three selected crops, results indicated that the most common indigenous vegetable that majority of farmers were producing was found to be African nightshade due to its increasing demand.

The results revealed that the sum of elasticity of production was equivalent to 0.407, suggesting that yield increases by less than one per cent provided all units were increased by 10%simultaneously. This indicated decreasing return to scale. If there is a 10% increase in land under vegetable production, it will increase yield by 2.2%. It further suggested that an increase in the amount of fertiliser and seeds used for vegetables will slightly increase vegetable output by 0.7%, and 0.02% respectively, while a rise in the number of labour will accelerate vegetable output by 0.9%.It can be concluded that not all combination of inputs yield the best outcome. Farmers should therefore select input combination or double input that guarantees them an increase in productivity.

Results revealed that pesticide is not a significant factor influencing productivity. This implies that increasing or decreasing pesticides application will not have a significant impact on vegetable productivity. It can be concluded that it is essential for farmers to increase their area under cultivation of indigenous vegetables in order to obtain higher returns from production. Seed appear to be the least important variable in increasing production yield. This might be due to farmer's lack of access to high quality seed varieties. Based on these outcomes of the first hypothesis; there are no significant factors influencing productivity of African indigenous vegetables in Vhembe district was therefore rejected.

The outcome of marginal effects of indigenous vegetable production revealed that land, fertilisers and hired labour inputs were underutilised as their marginal product is greater than the marginal factor price. It can be concluded that farmers should therefore increase the use of fertiliser and hired labour and expand area under vegetable cultivation in order to attain the highest returns in production and profit. On the other hand, seeds and other farm material (tractor, hoes etc.) appeared to be over-utilised. Is can therefore be concluded, farmers should reduce the use seeds and other farming material in order to maximise production.

Water shortage (79%), lack of quality seed (66%), poor access to high-value market (58%) perishability of vegetables (54%), low selling price (54%), high completion (48%), lack of inputs (46%), high production costs (42%), small farm size (39%), lack of market place (34%), diseases outbreak (29%), high transportation cost (24%) and theft (19%) were the challenges faced by African indigenous vegetable farmers in Vhembe district. It can be concluded that vegetable farmers in the study area are experiencing diverse constraints which are hindering them from reaching maximum production yield and operate above the frontier.

Possible solutions suggested by farmers in the study area were construction of boreholes (87%),seeds provision schemes (67%),market information and minimised transportation costs (41%),group sales (35%),post-harvest training workshops (63%), input provision schemes (70%),pests control training workshops (33%),fence provision (17%) and government intervention(85%).Implementation of these solutions will lead to improvement in farmers' production and marketing of vegetables thereby increasing their income and food security within the district.

5.3 Recommendations

In view of the conclusion of the study, the following recommendations are suggested for policy implication; Land was found to be the most vital factor of production to increase productivity with a higher elasticity compared to other factors of production. Farmers in Vhembe district are subjected to smaller land size which they utilise to grow different agricultural crops, African indigenous vegetables included. The results have demonstrated that indigenous vegetables have the potential of higher yield therefore, in order for the farmers to increase productivity, it is highly recommended that they expand the area under indigenous vegetable cultivation.

High technical efficiency level found in the study is an ample sign that indigenous vegetables have the potential to generate greater household income as a result their production should be enhanced. It was also found that other than land inputs fertilisers and hired labour were underutilised in the study area. As a result, it is recommended that farmers ought to increase utilisation of these inputs in order to maximise production and increase their marketable supply of indigenous vegetables.

About 92% of the farmers had access to extension services; however the examination of the sampled data showed that extension services increase technical inefficiency. It is evident that extension interaction was not effective and/or regular in the study area. Therefore, it is recommended that the approach of conducting training and practical workshops should be used as opposed to handing farmers inputs or technology without knowledge of how to efficiently use them. Government should also provide supportive information centres where farmers can visit at any given time to source for information rather than waiting for extension officers' visits.

Furthermore, results of empirical analysis found that years of schooling was positively associated to technical inefficiency, implying that it decreases technical efficiency of indigenous vegetable farmers. The study proposes strategies such as providing better extension services and farmers training programs as a way to enhance farmers' knowledge and skills of farming. It is further recommended that government should encourage youth participation in agriculture through emerging business funding opportunities. This will help close the educational gap which exists in the study area thereby, increasing technical efficiency.

Water shortage was viewed as the number one constraint facing indigenous vegetable farmers in Vhembe district. Farmers should be encouraged to play active role in saving water usage at the farm level in order to alleviate water scarcity problem. This will be possible through adoption of advanced irrigation systems as the results revealed that access to irrigation system positively influence technical efficiency. Moreover, government can intervene in assisting them acquire boreholes which will enable production to continue even during dry seasons. Government policies must be pointed towards improving access to formal credits by farmers as high level of financial support will advance the adoption and acquisition of advanced technologies needed to enhance farm operations.

It is obvious that change does not happen overnight, nevertheless, it is necessary for government to tackle one problem at a time in terms of finding alternative ways of dealing with production and marketing limitations facing farmers in the study area. It is also recommended that government officers and policy makers should use bottom-up approach in solving these problems. By so doing, they will have a clear picture of the problem, in terms of its severity, its consequences on the farmers and draw suggestion from the farmers themselves as the key actors in problem-solving. Lastly, it is strongly suggested that farmers ought to be motivated to be independent, such that they will not wait for government to bring change; instead they take initiative in ensuring success in their businesses.

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APPENDIX 1: Research questionnaire

ARC • LNR

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

FACULTY OF AGRICULTURE, SCIENCE AND TECHNOLOGY

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

Please note that the respondent will remain anonymous and information provided will be treated as confidential at all times. Respondents are not compelled into providing information that he/she perceive as sensitive or incriminating.

Questionnaire Number	
Date	
Name of Interviewer	

SECTION 1: SOCIO-ECONOMIC AND DEMOGRAPHIC INFORMATION				
1.1 Name of respondent				
1.2 Cell phone number				
1.3 District				
1.4 Local municipality				
1.5 Irrigation scheme/Village/Cooperative				
1.6 Age of the respondent				
1.7 Household size				
1.8 Years of Schooling				
1.9 Gender	Female		Male	
1.10 Main purpose of farming	Home		Business	
1.11 Primary source of income	Formal		Pensioner's	
	Farm savings		Other	
	Remunerations		Others	
1.12 Do you farm full/part-time?	Full-time		Part-time	
1.13 Do you have access to credit for farming purposes?				
1.13.1 If No, what is your reason for not having one?	I don't qualify		I don't know	
	I don't need it		Others (state)	
1.13.2 If Yes, where do you access the credit?	Bank loan		Other farmers	
	Family societies		Others	
1.14 Do you receive to extension services?	Yes		No	
1.4.1 If Yes, what type of services do you receive?				
1.4.2 If No, what is the reason for not receiving any?	I don't know		I don't need it	
	They are not		Others	

SECTION 2: PRODUCTION INFORMATION				
2.1 How long have you been farming? (Years)				
2.2 How long have you been growing Indigenous				
2.3 Total size of the farm (ha)				
2.4 Do you have access to irrigation?	Yes		No	
2.4 Sources of irrigation water	Borehole		Municipality	
	River		Tank	
	Dam		Others	
2.5 What irrigation system do you use?	Sprinkler		Hosepipe	
	Drip		Bucket	
	Furrow		Other	
2.6 How much do you pay for irrigation water?	R………			
2.7What Type of labours do you use?				

2.8Costs of production inputs/implements used for production in the previous season			
Inputs	**Quantity (how**	**Source (where were**	**Price per unit of**
Seeds/ seedlings			
Fertilisers			
Herbicides			
Tools- Hoes			
Forks			
Vehicle			
Spades			
Others (Please specify)			

2.9 Indigenous	**Area**	**Total yield**	**How many**	**Where were they**	**How much**
Vegetables e.g.					
Amaranth	0.35ha	30 bunches	22 bunches	Spar and local	R6/bunch
1.Nightshade					
2. Pumpkin leafs					
3. Chinese					
4.					
5.					

2.10 What challenges do you face when producing indigenous vegetables?		
	Lack of inputs	
	High production cost	
	Limited land size	
	Extreme temperatures	
	Shortage of irrigation water	
	Others (specify)	

2.11 What would you need to overcome these challenges?	Specify

SECTION 3: MARKETING INFORMATION				
3.1 Do you have contractual/guaranteed	Yes		No	
3.2 Do you have access to market information?	Yes		No	
3.3 Sources of information?	Extension officer		Radio	
	Other farmers		Television	
	Magazine		Others (state)	
3.4 What type of marketing information do you receive?	Demand		Prices	
	Date of sales		Others (state)	
3.5 Do you always find buyers for your produce?	Yes		No	
3.6 How accessible are the buyers in your market?	Easy			
	Fair			
	Difficult			
3.7 Do you compete for market with other indigenous vegetable farmers in your area?	Yes		No	
3.8 On which aspects do you compete with other farmers?	Quality of produce		Quantity of produce	
	Price of produce		Processing	
	Packaging		Others (state)	
3.9 What source of transport you use to move your produce?	Own transport			
	Hired transport			
	Buyers transport			
	Public transport			
	Head balance transport			
	Others (state)			
3.10 What challenges do you face when moving your produce?	Lack of transport			
	High transport cost			
	High competition			
	Poor Road infrastructure			

	Perishability of vegetables	
	Inability to enter formalmarket	
	Others (specify)	
3.12 What would you need to overcome these challenges?	Specify	

THANK YOU