ASSESSMENT OF VEGETABLE POSTHARVEST LOSSES AMONG SMALLHOLDER FARMERS IN UMBUMBULU AREA OF KWAZULU-NATAL PROVINCE, SOUTH AFRICA

Maremera Garikai

June 2014

Submitted in partial fulfilment of the degree of
Master of Agriculture (Food Security),
African Centre for Food Security,
School of Agricultural, Earth and Environmental Sciences,
College of Agriculture, Engineering & Science,
University of KwaZulu-Natal,
Pietermaritzburg

UNIVERSITY OF
KWAZULU-NATAL

ABSTRACT

Smallholder agriculture is identified as one of the probable and sustainable approaches to farming and offers insights towards a paradigm shift in food, nutritional and income security. Generally, smallholder fresh produce farmers in South Africa have performed poorly and have not delivered on their development objectives of increasing crop production and improving rural livelihoods. Where farmers have access to supply markets, post crop maturity quality deterioration and postharvest losses deprive farmers of profit. Lack of postharvest handling knowledge and effective cold storage facilities to mitigate postharvest losses threatens their profitability. In spite of the acute damage caused by fresh produce postharvest losses; these challenges have not received much attention, with the focus mainly on encouraging farmers to increase production. For perishable crops such as leafy and fruit vegetables, there is even fewer representative data available in African countries. Research on the contribution of postharvest losses on household food insecurity is limited, yet postharvest loss reduction may substantially contribute to food, nutritional and income security for many rural households. Postharvest handling practices of smallholder farmers who face several constraints related to production, postharvest handling and marketing are relatively unknown because they have not actively participated in formal value chains.

The study set out to investigate postharvest losses among smallholder farmers in Umbumbulu area of KwaZulu-Natal province, South Africa. Specifically, the study set out to describe the demographic and socio-economic characteristics of smallholder vegetable farmers in Umbumbulu; determine the main vegetables grown by smallholder farmers, their knowledge, training and the respective postharvest handling practices and to establish the determinants of vegetable postharvest losses among the smallholder farmers. Primary data was gathered by conducting a survey on 120 purposively selected smallholder vegetable farmers supplying and others who are intending to supply Umbumbulu Agri-Hub using a structured questionnaire, key informant interviews and observations. Socioeconomic data, household demographics, agronomic practices, knowledge, training and postharvest handling practices were captured during the survey. Descriptive statistics was used to provide summary and frequency of key variables. The ordered probit econometric model was used to establish leafy and fruit vegetable postharvest loss determinants with respect to cabbage and spinach as leafy vegetables since they were the most grown vegetables; grown by 90% and 85% of the farmers in the study area respectively and played a critical role as household food and income

source. Tomatoes were selected among the fruit vegetables since they were reported to have high postharvest losses and among the fruit vegetables, they were the ones grown by most of the farmers (76.7%).

Cabbage postharvest losses were significantly influenced by gender of household head, farming experience, literacy, type of packaging used, distance to the market and attendance of postharvest handling training. On the other hand, spinach postharvest losses were significantly influenced by gender of household head, farming experience, hand and equipment washing before harvesting, time of harvesting, storage duration before marketing and attendance of postharvest handling training. Variables that significantly influenced tomato postharvest losses were farming experience, farmers' group membership, farm size, hand and equipment washing, packaging used and distance to the market.

Findings from this study provide expedient tangible acumens for policy makers, agricultural extension officers, farm advisers and researchers in the design of effective and efficient policies, programmes and projects which can enrich the smallholder farmer postharvest handling practices, increase smallholder farmer's capacity to market their produce, drive progression in the fresh produce value chain and hence considerably contribute towards food, income and nutritional security.

DECLARATION

I, **Maremera Garikai** declare that:

- The research reported in this mini-dissertation, except where otherwise indicated, is my original research
- This mini-dissertation has not been submitted for any degree or examination at any other university
- This mini-dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from those persons
- This mini-dissertation does not contain other authors' writing, unless specifically acknowledged as being sourced from other authors. Where other written sources have been quoted then:
    - Their words have been re-written but the general information attributed to them has been referenced;
    - Where their exact words have been used, their writing has been placed inside quotation marks, and referenced.
- This mini-dissertation does not contain text, graphic or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the mini-dissertation and in the references section.

Signed:  01/09/2014

Maremera Garikai **Date**

As candidate's Research Supervisor, I agree to the submission of this mini-dissertation for examination.

Signed: ……

Professor A. Bogale **Date**

DEDICATION

To My Family

For all the sacrifices you made towards my academic journey to ensure I reach this far; without your hard work, encouragement and unending support this dream would never have become a reality. You are a perpetual source of inspiration, advocacy, assurance, and emotional refuelling that empowers me to endeavour with confidence into the greater world and to become all I am. You made me believe that for every steep uphill, there is always a gentle downhill.

In truth a family is what we make it. It is made strong by the rituals we help family members create, by the memories we share, by the commitment of time, care, and love we show to one another, and by the hopes for the future we have as individuals and as a family.

I love you all.

ACKNOWLEDGEMENTS

I am very grateful to my supervisor, Professor Ayalneh Bogale, who allowed me the latitude to follow my thoughts and develop my research skills, whilst being available to provide guidance when it was needed and providing financial assistance for my data collection exercise. Thank you for believing in my capabilities and contributing so much to help shape this work

I am also very grateful to smallholder farmers in Umbumbulu who willingly shared their knowledge and practices. Your participation was a vital component of this study. The community leadership deserves my heartfelt gratitude for allowing the study to be conducted in their community. I would not have done justice if I don't make a special mention to the Agri-Hub management, Paula Osborn for allowing me to conduct the study with Agri-Hub suppliers as research participants and Gabriel Mngoma for facilitating a smooth flow of the data collection exercise.

To my colleagues and staff at the African Centre for Food Security who gave critical input during the seminar presentation; after some introspection, I realised I needed to improve my research further, thank you for your valuable input. Many willingly contributed their invaluable guidance and strong support during the research, they considered the work important enough to give freely of their time. It has been a pleasure to add their views into my research work. Stanley Sharaunga, Kudakwashe Collin Chirigo and *ba*- Muchara, deserve to be mentioned for their assistance in econometric models and constructive criticism throughout the project.

Many thanks to Ntokozo Zondi, Khethiwe Mazibuko, Sabelo Xaba, Vuyo Mfingwana and Sthandiwe Luthuli for your support in data collection.

Special gratitude is given to the Kwazulu-Natal Treasury department for providing financial assistance to conduct this study.

I am indebted to my family and friends who always encouraged me and believed in my ability. Your love, emotional and spiritual support made this journey sailable. My best friend

Fadzai Garakara deserves special mention for always being there to reignite my faith when it flickered.

Above all, I would like to thank God almighty for blessing me with wisdom, good health and enabling resources for this study. It seemed as if there would never be a breakthrough or success in my postgraduate academic journey. It appeared as if there was never going to be light at the end of the tunnel. Through God's grace and unmerited favour, His faithfulness, authenticity, reliability, dependability and truthfulness; all made this journey possible. This journey taught me to put all my trust in God for He is ABLE!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AFRISCO	**:**	African Farms Certified Organic
CTA	**:**	Technical Centre for Agricultural and Rural Cooperation
DAFF	**:**	Department of Agriculture, Forestry and Fisheries
DOA	**:**	Department of Agriculture – South Africa
EFO	**:**	Ezemvelo Farmers' Organisation
EU	**:**	European Union
FAO	**:**	Food and Agriculture Organisation of the United Nations
FDA	**:**	Food and Drug Administration of the United States of America
HACCP	**:**	Hazard Analysis and Critical Control Points
HSRC	**:**	Human Science Research Council
LFS	**:**	Labour Force Survey
NDA	**:**	National Department of Agriculture – South Africa
OLS	**:**	Ordinary Least Squares Regression
PLAAS	**:**	Institute for Poverty, Land and Agrarian Studies
PPT	**:**	Project Preparation Trust
RPCs	**:**	Returnable Plastic Crates
SPSS	**:**	Statistical Package for Social Sciences
STATS SA	**:**	Statistics South Africa
UKZN	**:**	University of KwaZulu-Natal
VIF	**:**	Variance Inflation Factor
WHO	**:**	World Health Organisation of the United Nations

CHAPTER ONE
THE RESEARCH PROBLEM AND ITS SETTING

1.1 Introduction to the research problem

Agriculture has been earmarked as one of the sectors which have potential to transform the skewed economy of South Africa (DAFF, 2012) and there are high hopes for creating a significant reduction in income poverty and inequality through agriculture but the reality has rather been slow (Aliber and Hart, 2009). Thamaga-Chitja and Hendriks (2008) revealed that smallholder farmers often have limited access to important farming resources. Smallholder farming's contribution to agricultural output of less than five percent to South Africa's total output can be regarded as insignificant (Mdluli, 2013) but smallholder farming is however thought to have a good potential to contribute significantly to food security (Matshe, 2009; STATS SA, 2012). The role of crop production by smallholder farmers, though relatively minor, is still generally acknowledged (Machethe, 2004). However, farming and postharvest handling practices of smallholder farmers are relatively unknown because they have not actively participated in formal value chains (Louw *et al.,* 2007).

Increased production of local farm goods may offer solutions to food insecurity in rural areas through better income from farm and non-farm sources (Southgate *et al*., 2007) as agricultural growth benefits both rural and urban poor by providing more food, raw materials at lower prices, capital and labour for development, reducing poverty and increasing the participation of the poor in the growth process. Smallholder agricultural production is a common practice for many rural poor households of South Africa (Aliber *et al.,* 2006). There is potential to play a critical role in the fight against food insecurity and poverty in South Africa through smallholder farming (Thamaga-Chitja and Hendriks, 2008). However, smallholder farming is faced with a lot of challenges which need to be addressed for its real benefits to be realised.

Improving the income for smallholder farmers is a powerful tool in reducing poverty and food insecurity (Kirsten *et al.,* 2007). Income for smallholder farmers can be improved by a number of ways, one of them being reduction in postharvest losses. Reduction in postharvest losses increases food availability, hence alleviation of food problems. Postharvest losses lower the gains of the effort that was put into production and negatively affects marketing

efficiency (Babalola *et al.,* 2010). Results from a study by Babalola *et al.* (2010) showed that postharvest losses reduce the income of farmers. In the absence of advanced storage facilities, it is uncertain that smallholder farmers could warrant the supply of quality produce to meet market expectations. Smallholder farmers are faced with challenges of preserving produce quality and minimising postharvest losses of perishable horticultural products. While waiting for opportunities to supply, farmers risk produce losses due to quality deterioration (Kader, 2005).

Smallholder producers who generally lack appropriate technologies to maintain quality may not meet supermarket fresh produce quality expectations (Berdegué *et al.,* 2005). Where farmers have access to supply supermarkets, quality deterioration and postharvest losses may rob farmers of profit. Research related to indigenous knowledge and the use of locally available resources to reduce postharvest losses is urgently needed to assist smallholder producers (Katundu, 2008). There is need to involve farmers in the experiments and finding innovative ways of disseminating research findings to farming communities to facilitate understanding and application of recommended practices (Katundu, 2008). However, these needs cannot be addressed without understanding the handling practices being used at the farm level and having a clear understanding of the challenges they face.

Vegetables are considered as commercially important and nutritionally essential food commodities due to their provision of the major dietary source of vitamins, sugars, organic acids, and minerals, and also other phytochemicals including dietary fibre and antioxidants with health-beneficial effects (Chun-Ta, 2010). There is however an increasing demand for fresh produce at consumer level, because of the raising awareness among people about the superiority of fresh, natural foods than processed products resulting in the active encouragement by health agencies and public media as well as several medical researches demonstrating various health benefits of fresh produce consumption (Wills *et al.,* 2007). One of the major challenges in meeting this high demand for fresh vegetables is postharvest losses.

Harvested fresh vegetables are living, characterised by high moisture content, active metabolism, and tender texture; as a consequence, significant losses resulting in senescence, desiccation, physiological disorders, mechanical injuries, and microbial spoilage occur at any point from harvest through the food value chain (Chun-Ta, 2010). Due to this nature, fresh

vegetables are considered as highly perishable. Postharvest physiology of fruits and vegetables has in recent times become an important issue of discussion at national and international level. The increased attention afforded postharvest horticulture has mainly been due to the realisation that faulty handling practices after harvest can cause large losses of produce (Wills *et al.,* 2007). Minimising postharvest losses of produce that was produced through an investment of substantial labour, materials and capital to grow, is a very effective way to increase food availability without further boosting crop production (Wills *et al.,* 2007). Reduction of postharvest losses increases food availability to the growing human population, decreases the area needed for production, and conserves natural resources (Kader, 2003).

Postharvest losses can occur at any stage in the production and marketing chain. It is estimated that these losses due to inadequate postharvest handling, transportation and storage in fruits and vegetables is relatively higher, 20-50% in developing countries when compared to 5-25% in developed countries (Kader, 2005). In some African countries it has been estimated that about 30% of produce is lost, and this figure can rise to 50% for very perishable foods such as fruits and vegetables (Kader, 2003). These losses have several implications to the producers, retailers and consumers. However, little has been done to identify the main postharvest handling practices by smallholder farmers, documenting the quantities they lose and the associated income losses.

Most fresh produce handlers involved directly in harvesting, packaging, transporting and marketing in developing countries have limited or no appreciation for the need for, or how to maintain quality (Kader, 2005). Applying and adhering to grades and standards requires investments in training, equipment; infrastructure and monitoring systems, which is very expensive and this is a challenge in smallholder farming. Smallholder farmers lack an intimate knowledge of postharvest treatment such as cold chain management and traceability which is critical to prolong their short shelf life and reducing wastage (Louw *et al.,* 2008).

Thamaga-Chitja and Hendriks (2008) indicated that historically, smallholder farmers in South Africa have been given little attention with regards to appropriate extension and research, and the situation is still similar today. Extension of inappropriate services often results in the lost chance of essential capacity building opportunities. Research therefore, emphasises the

important role of capacity building (Martins *et al.,* 2012), where farmers are taught good farming and handling practices.

It is important to determine factors that influence farming practices (and postharvest handling) practices since this can act as a reference with regards to capacity building (Martins *et al.,* 2012). This facilitates the identification of groups which require most assistance and thus aligning interventions to particular target groups (Mdluli, 2013). For capacity building initiatives to be relevant in addressing smallholder farmer's needs, it is very crucial to determine what factors influence their practices (Agwu and Edun, 2007). According to Thamaga-Chitja and Hendriks (2008), farmers need to receive context specific information that is appropriate for their level of literacy and delivered through an appropriate channel. Age, gender, level of education, geographic location and training play a key role in the farming practices adopted by a farmer (Serin *et al.,* 2009) and these factors differ as different dynamics come into play (Mdluli, 2013).

This study therefore aims to investigate fresh vegetable postharvest losses among smallholder farmers in Umbumbulu area of KwaZulu-Natal province, South Africa.

1.2 Importance of the study

Smallholder crop production has the potential to contribute to the reduction of food insecurity and poverty in the form of household income generation and increasing food availability (Machethe, 2004). Reduction in postharvest losses as a food security intervention could make more food available for poor South Africans. In South Africa, research on the impact of postharvest losses on household food security is limited, yet postharvest loss reduction may substantially contribute to lives of many rural people.

Inadequate postharvest technologies jeopardize not only the amount of vegetables that the consumers can access, but also their quality and safety (CTA, 2012). In countries like South Africa, retail standards that go beyond straightforward food safety requirements lead to massive quantities of vegetables being removed from the supply chain, even though they are still fit for human consumption (Louw *et al.,* 2007). In spite of the acute damage caused by postharvest losses of fresh produce; these challenges have not received much attention, with the focus mainly on encouraging farmers to increase production. For perishable products

(root vegetables, tubers and fruits), there is even fewer representative data available in African countries. Understanding crops produced, handling practices, scale and the location of postharvest losses is crucial, especially in countries where scant information is available.

Despite adequate literature on postharvest handling practices, the information on harvesting practices and postharvest losses of vegetables is limited to smallholder farmers in South Africa. It is safe to say that postharvest losses occur in every country but the magnitude of losses and the effective remedial methods differ greatly. To solve specific problems in a given area effectively and economically, a comprehensive knowledge of the nature of postharvest losses should be considered (Kereth *et al.,* 2013).

Postharvest losses have been highlighted as one of the determinants of the food problem in most developing countries (Babalola *et al.,* 2010). Despite the remarkable progress made in increasing world food production at the global level, approximately half of the population in the third world does not have access to adequate food supplies; one reason being food loss occurring in the postharvest and marketing systems (Babalola *et al.,* 2010). Since many researches show that great effort is being made in the area of food production especially in the developing countries, the decline in food production therefore can be traced to food losses (Babalola *et al.,* 2010). However, due to poor postharvest management strategies in the sub-Saharan region, there has been a repeated cycle of food production and postharvest losses which have systematically depleted the mineral quality of the farms, leaving substantial food insecurity in the region (Kimatu *et al.,* 2012).

It is important to inform farmers of their role in minimising postharvest losses through various handling practices. This will help in minimising the rate of deterioration of their products, thus not compromising the product's shelflife. A series of postharvest handling practices determine the final quality of their products. Farmers need to meet a series of stringent quality requirements to access markets. The study investigates the different postharvest handling practices by smallholder farmers in Umbumbulu which inevitably determine the extent of potential postharvest losses and the shelflife quality of their fresh produce. The study also intends to raise smallholder farmers' awareness of vegetable postharvest losses thereby enabling them to take necessary precautions with regards to postharvest handling. This research could also be useful to policy makers who develop food security interventions.

1.3 The research problem

Aliber and Hart (2009) stated that South Africa has a dualistic agricultural system. According to STATS SA (2012), there is commercial and subsistence farming on opposite ends, with smallholder agriculture in between the two spectrums. Despite the fact that South Africa's land covers less than four per cent of the African continent, the country produces 17 percent of Africa's red meat, 20 percent of its potatoes, 27 percent of its wheat, 31 percent of its sugar, 45 percent of its corn, 54 percent of its wool, and 81 percent of its sunflower seed (DAFF, 2012). These impressive statistics on food self- sufficiency and South Africa being one of the six net food exporter nations in world masks the huge inequalities of this sector which is characterised by skewed distribution drawn over racial and ethnic lines (Chikazunga and Paradza, 2012).

The agricultural sector is mainly dominated by white commercial farmers who are the pillars in South African agricultural production, owning 87% of the country's agriculture land and they are responsible for 99% of the food production (Mdluli, 2013). Results from the 2007 commercial agricultural census (STATS SA, 2010) showed that there are 39 982 commercial farm units in the country. There is a decrease in the number of commercial farmers mainly due to consolidation and emigration (Aliber and Hart, 2009) and a recent research by DAFF (2011) has suggested that the number of commercial farmers is approximately 35 000. An increased consolidation in the commercial farming sector is characterised by land transfers among commercial farmers (Chikazunga and Paradza, 2012). A survey conducted by ESKOM in 1998 indicated that there were approximately 2.1 million small-scale and emerging farmers in South Africa (Aliber and Hart, 2009). According to the 2007 Labour Force Survey (Aliber and Hart, 2009), there are over 4.5-million households which can be described as smallholder farmers but DAFF (2011), however, put this number at 1.3 million.

Agriculture has been earmarked as one of the sectors which have potential to transform the skewed economy of South Africa (DAFF, 2012) and there are high hopes for creating a significant reduction in income poverty and inequality through agriculture but the reality has rather been slow (Mdluli, 2013). Despite the land reform initiatives since 1995, black subsistence and smallholder producers are predominantly settled in the former homelands and rural reserves, and produce on the remaining 13% of the agricultural land (Aliber and Hart,

2009). Smallholder farming is however thought to have a good potential to contribute significantly to food security (Matshe, 2009; STATS SA, 2012). The performance of smallholder farming has been dismal since the attainment of democracy (Altman *et al.,* 2009), and the blame is on what is termed as "double barrelled" exclusion (Chikazunga, 2012) in which smallholder farmers were marginalised by past political regimes and now by market forces of scale, consistency and compliance.

Limited knowledge about the fresh produce postharvest handling practices among farmers has been identified as one of the constraints to improved agricultural productivity, market access and high farm incomes. Previous research on vegetable production in smallholder farming has focused on produce yields, efficiency of the irrigation in terms of water use and other agronomic aspects, organic farming and risk perceptions. However, little attention has been given to the study of postharvest losses in smallholder vegetable production. This study set out to investigate vegetable postharvest losses among smallholder farmers in Umbumbulu area of Kwazulu-Natal province, South Africa

1.4 General research objective

Generally the research aimed to assess vegetable postharvest losses among smallholder farmers in area of KwaZulu-Natal province, South Africa. This study strived to contribute to the body of knowledge that will inform policy recommendations on improved postharvest handling practices by smallholder rural communities, which aids postharvest loss reduction and increase the market potential for smallholder farmers.

1.5 Specific research objectives

The study specifically seeks to address the following objectives:

- To describe the demographic and socio-economic characteristics of smallholder vegetable farmers in Umbumbulu.
- To determine the main vegetables grown by smallholder farmers, knowledge, training, postharvest handling practices and quantities lost in Umbumbulu.
- To investigate the determinants of leafy and fruit vegetable postharvest losses among smallholder farmers in Umbumbulu.

1.6 Specific research questions

The study specifically seeks to answer the following questions:

- What are the demographic and socioeconomic characteristics of vegetable farmers in Umbumbulu?
- What are the main vegetables grown by smallholder farmers, knowledge, training, postharvest handling practices and quantities lost in Umbumbulu?
- What are the determinants of leafy and fruit vegetable postharvest losses among smallholder farmers in Umbumbulu?

1.7 Study limits and assumptions

The study will be limited to smallholder farmers in Umbumbulu as a sample. This is not a true representative of smallholder farmer's population at large therefore, the results cannot be generalized. Apart from fresh produce that is actually lost or discarded, many products also suffer from a decline in quality, leading to a drop in economic and nutritional value (Wills *et al.,* 2007). The study does not take into account the quality and nutritional value losses associated with vegetable deterioration after harvest unless the product is inedible or unmarketable. Further studies can be done incorporating quality and nutritional losses in the product's marketable state. Vegetable postharvest losses vary with seasons. Due to the nature and objective of this study the researcher will not manage to investigate the seasonal variations in postharvest losses. The results of the study will therefore not be generalizable over all seasons.

It is assumed that all participants will be willing to participate and that participants will answer all questions honestly, information provided is reliable and true, and that members do not withhold any vital information that may affect the findings of the research.

1.8 Structure of the mini-dissertation

The mini-dissertation is organised into five chapters. Chapter one presents an introduction to the research problem, the importance of this study, the research problem, general research

objective, specific research objectives, the research questions, study limits and study assumptions. The second chapter presents a review of literature on smallholder farming, postharvest losses and their impact on the food security status of smallholder farmers. The descriptive characteristics of participating farmers are presented in chapter three. Chapter three also describes the methodology used to collect and analyse the collected data. The results and discussions are presented in chapter four. Lastly, a summary of research, conclusions and recommendations is presented in chapter five.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The literature review presents a body of information relating to issues of fresh produce postharvest losses in smallholder farming, which will aim to investigate postharvest loss determinants and what options are available for smallholders to improve postharvest handling. The chapter starts by defining smallholder farming in the South African context followed by the role of smallholder farming in food security. Postharvest loss determinants were also discussed in this chapter. Lastly, the chapter discusses some measurement and methodologies that were adopted in previous research related to postharvest losses.

2.2 Defining smallholder farming in the South African context

Smallholder farmer definition in South Africa is highly contested among researchers and academics (Louw *et al.,* 2007; Louw *et al.,* 2008; Altman *et al.,* 2009; Aliber *et al.,* 2009). The definition is derived from various ways depending on context, country and ecological zone which explains the interchangeable use of the term ‘smallholder’ with ‘small-scale’, ‘resource poor’ and ‘peasant farmer’. Such a farmer could either be involved in commercial production, semi-subsistence production or somewhere in between the two (Chikazunga and Paradza, 2012). DAFF (2011) categorises smallholder farmers into small-scale, communal and emerging farmers, where communal farmers tend to be a sub-group of smallholder farmers and generally farm on projects initiated or supported to varying degrees by the various provincial departments of agriculture’s extension services (Chikazunga and Paradza, 2012). Smallholder farmers include those who have access to very small pieces of land sometimes only a couple of hundred square metres, such as home gardens and food plots or possibly less than 3 to 5 hectares (Altman *et al.,* 2009). This is definition by Altman et al. (2009) was adopted for the purpose of this study.

2.3 The role of smallholder farming to food security

Machethe (2004) noted that crop production is one of the most important ventures in subsistence agriculture for many rural households in South Africa. Smallholder farmers play

a pivotal role in ensuring long-term household food sufficiency (NDA, 2002). From the available data, it is not always clear for what reasons black households and individuals engage in agricultural production. The engagement of individuals and households in agriculture fluctuates and is dependent on livelihood diversity. Harrison (1995) estimated that between 30 to 40 per cent of South African households did not have assured access to adequate diets, which has been related to a lack of physical availability of food in rural areas. Smallholder farmers engage in crop production as the main source of food, as an extra source of food, as a main source of income, as an extra source of income and as leisure (Aliber and Hart, 2009). Schmidt (2005) reported that only four per cent of South African households indicated agriculture as their primary income source in 1998.

The predominant reason for which people engage in agriculture is to procure an extra source of food, which is more evident in extreme poverty cases. Engaging in crop production may lead to a greater availability of food and increased economic growth in domestic and/or national markets (Devereux, 2001). Aliber and Hart (2009) concluded that despite the low-input nature of subsistence production it contributes directly to household food security as a supply of food, as well as enabling households to divert income to meet household's food and other requirements.

In developing countries, the most immediately apparent function of agriculture is to provide food for the 800 million children, women and men who are malnourished or starving (FAO, 2005). This however needs proper management to have a positive impact on poverty alleviation, food security, rural/ urban population distribution, and the environment (Fraser *et al.,* 2003). For the vast majority of poor people in developing countries, agriculture is a way of life, the basis of rural livelihoods in agrarian societies and a mix of economic, social and cultural dimensions of human existence (FAO, 2005). In KwaZulu-Natal province, five per cent of the households used farming as the main source of food, and 15% of the households used farming for supplementary food (Watkinson and Makgetla, 2002). If managed properly, Ravallion and Datt (1996) reported that agricultural growth is more effective than other sectors' growth in reducing overall poverty and food insecurity.

Crop production may lead to a greater availability of food and increased economic growth in domestic and/or national markets (NDA, 2002). Generating income for poor households through crop production may provide access to more and varied foods, and could provide

cash for use in other areas of the economy, such as small enterprise development and manufacturing, which in turn could further reduce poverty and food insecurity (Smith, 1999). Poor households rely more on subsistence agriculture for cash or food, as opposed to wealthier households. In 2000, STATS SA (2002) found that the percentage of households involved in farming for cash or food was highest in the lowest income category and then decreased steeply, from 39 per cent of ultra-poor households, to 22 per cent of the poor, to three per cent of the wealthiest income group.

Farming is the most important source of income for "poor" rural households in South Africa (Kirsten *et al.,* 2007). Machethe (2004) reported that agriculture is not only a major contributor to total household income, but the proportion of income from agriculture seems to increase as households become richer. Machethe (2004) noted that the level of farm income increases relative to total household income, suggesting that agriculture remains an important source of income, even though households derive a significant proportion of their income from non-farm sources. Hendriks and Lyne (2003), conducted studies in KwaZulu-Natal and concluded that households engaging in agricultural activities tend to be less poor than those not participating in agricultural production. Aliber (2005) reported that from gathered household survey data, black households with access to agricultural land reported that agriculture contributes 15% of the total household income, but for the poorest quintile the contribution stands at 35% (Aliber, 2005).

There are approximately 240 000 black farmers in South Africa who provide a livelihood for more than a million of their family members, and provide temporary employment for another 500 000 people according to the strategic plan for South African Agriculture (DOA, 2001). DOA further estimates that there are approximately 3 million small-scale farmers who produce food primarily to meet household consumption needs. In most developing countries, agriculture related activities provide most of the employment in rural areas and hence reduce food insecurity (Machethe, 2004).

While production for home consumption increases the availability of vegetables and increases micronutrient intake, the income 'savings' derived from home production seems to have more positive influences on the nutritional status of rural populations. Income replacement leads to increased purchases of energy-dense foods such as fats, oils and meat (Hendriks, 2003). Van Averbeke and Khosa (2007) noted that small-scale irrigated vegetable

production contributed significantly to household nutrition by substantially increasing the amount of Vitamins A and C available to such households. Kirsten *et al.* (1998) concluded that agricultural activities make a positive contribution to household nutrition, which suggests that designing effective programmes for improving agricultural productivity in the less-developed areas of South Africa could have a potentially positive impact on household and child nutritional status.

Vitamin Information Centre (2001) reported that in 1999, one in four children under the age of six years was stunted, and one in ten was underweight due to chronic malnutrition. Micronutrients, vitamins and essential minerals deficiency have been shown to have a negative impact on people's health, social and economic standing, both in South Africa and other countries (Labadarios, 2000; May, 2000). Nell *et al.* (2000) reported that root vegetables, such as beetroot and carrots, are mostly grown throughout the year to provide vegetables in community and home gardens of South Africa. Crop production can contribute a major part to food and nutrition security by ensuring adequate access to supplies of vegetables at all times (Hendriks, 2003).

The contribution of crop production may include: reducing food prices, employment creation, increasing real wages and improving farm income (Kirsten *et al.,* 2007). This is however met with a number of challenges, one of these challenges being postharvest losses.

2.4 Postharvest loss determinants

Despite the fact that minimizing postharvest losses of already produced food is more sustainable than increasing production to compensate for these losses, less than five percent of the funding for agricultural research is allocated to postharvest research areas (Kader, 2003). Minimizing postharvest losses of fresh produce is a very effective way of reducing the area needed for production and/or increasing food availability (Kader, 2005).

2.4.1 Socio-economic determinants

The principal causes of postharvest losses in Africa are mentioned to be poverty, inadequate postharvest handling, lack of appropriate processing technology and storage facilities, poor infrastructure as well as poor marketing systems (Buyukbay *et al.,* 2011). It has been reported

that the magnitude of postharvest losses depend on the nature of the commodities, the condition of the produce at the time of collection, distance travelled and the nature of the road network (Kereth *et al.,* 2013). It was observed that poor infrastructure from farm to the market account for great losses in the market including rough roads and means of transport (Kereth *et al.,* 2013). Improper harvesting and postharvest practices result in losses due to spoiling of the product before reaching the market, as well as quality losses such as deterioration in appearance, taste and nutritional value (Buyukbay *et al.,* 2011).

In developing countries, storage, packaging, transport and handling techniques are practically non-existent with perishable crops and so, this allows for considerable losses of produce (Babalola *et al.,* 2010). Due to poor storage conditions resistance of fruit and vegetables to natural disease usually declines, leading to infection by pathogens (Tefera *et al.,* 2007). Absence of proper storage and marketing facilities, farmers are forced to sell their products at throw away prices and sometimes farmers do not even get the two ways transportation costs back, so they would rather dump their produce near the market area than taking them back to home (Awan *et al.,* 2012).

Kereth *et al.* (2013) argued that picking or harvesting time and stages, selling time, loading and unloading, distance from the market were found to be a problem due to educational level and inadequate information amongst farmers which could be overwhelmed by different forms of training and information availability. The time of picking is considered most important factor in postharvest losses (Awan *et al.,* 2012). A study by Awan *et al.* (2012) reviewed that harvesting time is determined by the commitments of farmers with the transporters for short and long distance transportation. In their study, they observed that farmers who transported their produce to local and nearby markets generally pick tomato early in the morning (28%) while farmers who transport their produce to distant markets pick their tomato in the afternoon (38%) and evening time (34%) in order to make the produce ready for transportation and available for sale in the wholesale markets.

Mbuk *et al.* (2011) suggests that losses of fruits and vegetables occur in transit due to long distance to markets, poor and inadequate infrastructures, and the method of transportation. According to Kader (2005), in developing countries postharvest losses of fruits and vegetables are more serious than those in developed countries. In most developing countries, the number of scientists concerned with postharvest handling research is significantly lower

than those involved in production research (Mbuk *et al.,* 2011). In developing countries, for perishable crops like fruits and vegetables, storage, packaging, transporting and handling technologies are practically non-existent, hence considerable amount of produce are lost (FAO, 2004).

2.4.1.1 Marketing system and market information

Growers can produce large quantities of good-quality fruits and vegetables but if they do not have a dependable, fast, and equitable means of getting such commodities to the consumer, losses will be extensive (Kader, 2005). This is mainly caused by lack of communication between producers and receivers, and lack of market information. Smallholder farmers face competition from experienced, well informed and established commercial farmers when attempting to supply retailers and agro-processors with stringent quality and safety standards (Wegner and Zwart, 2011).

Smallholder farmers find themselves at a major disadvantage because many do not understand the market well, how it works and why prices fluctuate, they have little or no information about market conditions and prices, they are not organised collectively, and they have no experience of market negotiation (Magingxa *et al.,* 2009). There is therefore need for these farmers to be made aware of various products they can grow in relation to their climatic conditions and market demand (Thamaga-Chitja and Hendriks, 2008). However smallholder farmers tend to cultivate mostly traditional crops without conducting a demand assessment to see which products have ready markets. High perishability of fresh produce coupled with random production of products which do not have ready markets, smallholder farmers often lose huge sums of money due to product deterioration before the products are purchased. Differentiated markets (niches) were seen to be a promising means of market entry for small-scale farmers as this is where they benefit from comparative advantages such as local expertise or environmentally friendly ways of producing (Louw *et al.,* 2008). However smallholder farmers are often unaware of these niche markets (Mdluli, 2013).

2.4.1.2 Farmer organisations and producer groups

Institutional arrangements, such as vertical coordination through contract farming and horizontal coordination through producer groups such as cooperatives, may help to reduce the

relatively high transaction costs smallholders face and may help them to overcome access barriers to production resources, information, services and markets for high value products (Holloway *et al.,* 2000). Long-term contractual arrangements and technical support that are part of many retailers' preferential procurement systems could, at least in some cases, support farmers with the specific knowledge and asset investment (Biénabe *et al.,* 2011) required to meet stringent quality and food safety standards as well as postharvest loss reduction. Technical and organisational changes required in the supply chain to deal with the increased requirements of the new quality trends will further support development of, and be facilitated by, specific arrangements between retailers and farmers (Biénabe *et al.,* 2011).

Hendriks and Lyne (2009) point out that small-scale producers often need to market their produce collectively in order to reduce unit compliance and transaction costs to viable levels. Hendriks and Lyne (2009), however, state that these groups have their own costs and institutional difficulties which hamper smallholder farmer participation. There is need for the formation and strengthening of producers' associations that jointly market and process outputs and hence reduce transaction costs and increase negotiating power. Collective action enables individual poor farmers to attain economies of scale in terms of size of supply and scope of produce, which will allow them to engage on a level negotiation platform (Louw *et al.,* 2008).

Other reasons for the formation of farming cooperatives and collective action groups include: market failure (due to costly information and transaction costs), promotion of self-help, a desire to enhance bargaining strength with input suppliers and buyers of farm products, operation at cost (including normal return for capital invested), income enhancement, reduction of transaction costs with trading partners, provision of missing services (e.g. input and/or product marketing), assurance of input supplies and/or product markets (particularly for perishable crops like vegetables and fruit), coordination of the flow of input supplies and farm products to markets, reduce opportunistic behaviour by potential competitors, gain economies of size advantages (e.g. in providing inputs and/or marketing services to members, or with a plant), public policy (e.g. support of government), and promoting community development in general (Ortmann and King, 2007).

Farmer group organisations can ease the burden of inadequate marketing systems by providing central accumulation points for the harvested fresh produce, purchasing harvesting

and packing supplies and materials in quantity, providing for proper preparation for market and storage when needed, facilitating transportation to the markets, and acting as a common selling unit for the members, coordinating the marketing program, and distributing profits equitable (Kader, 2005). In rural areas, alternative distribution systems, such as direct selling to the consumers on roadside stands also help to ease the burden on smallholder farmers. Mrema and Rolle (2002) indicated an evolution of priorities within the postharvest sector of developing countries from a primarily technical focus geared towards the reduction of losses, to a more holistic approach designed to link on-farm activities to processing, marketing, and distribution.

2.4.1.3 Formal education and literacy

Studies conducted by Matungul *et al.* (2001) in two rural areas of the KwaZulu-Natal midlands showed that education levels of respondents in both study areas were generally low (mean of 5.2 years), and only 36% of all respondents speak English and 32.5% speak and write English (Ortmann and King, 2010). Low education levels are strongly related with the age of the farmers (Mdluli, 2013). Due to language barriers, costly arrangements when marketing products outside their areas increase the transaction costs. Education is the key in understanding consumer quality expectations in niche markets which is necessary also because consumers may have different expectations and acceptance of the same food product produced using different technologies (Miraux *et al.,* 2007). A clear understanding of consumer quality expectations is essential for the farmers to ensure that the produce they supply convinces competitive supermarkets to keep them as suppliers of organic produce. Berdegué *et al.* (2005) reported that a step towards continued access to markets is a demonstration of consistent production of quality and safe produce.

Studies carried out in Turkey, Portugal, United Kingdom and Slovenia (Bas *et al.,* 2006; Jevsnik *et al.,* 2008; Santos *et al.,* 2008) present results which showed that food handlers might not have their perception of the role of temperature in maintaining food safety as clear as could be expected. A similar lack of knowledge about critical temperatures was reported in Italy (Buccheri *et al.,* 2010) among food service staff in nursing homes. The results of several studies are consistent in demonstrating the lack of knowledge of food handlers as regards temperature control and its importance in food handling.

2.4.1.4 Agricultural extension services

Thamaga-Chitja and Hendriks (2008) stated that historically, smallholder farmers in South Africa have been given little attention with regards to appropriate extension and research, and the situation is still similar today. Extension services available are inadequate and the number of extension officers is far much below the required to meet the needs of farmers. Extension of inappropriate services often results in the lost chance of essential capacity building opportunities (Thamaga-Chitja and Hendriks, 2008). Studies by Matungul *et al.* (2001) in Impendle and Swayimani reviewed that extension officers visited households roughly once a year (Ortmann and King, 2010). Most fresh produce handlers involved directly in harvesting, packaging, transporting, and marketing in developing countries have limited or no appreciation for the need for, or how, to maintain quality (Kader, 2005). There is lack of an effective and far-reaching educational (extension) program on these aspects and has negative impact on smallholder farmers. There is a sizable volume of printed agricultural information for farmers in South Africa but only a small percentage have access to such information because many producers of agricultural information fail to meet the smallholder farmers' real needs in South Africa (Stefano, 2004). According to Thamaga-Chitja and Hendriks (2008), farmers need to receive context specific information that is appropriate for their level of literacy and delivered through an appropriate channel.

2.4.1.5 Training

Farmers require postharvest handling and storage training to improve their knowledge and capacity to observe, experiment and implement certain handling and storage practices since training is an extremely important element in technology adoption. Naidoo (2009) stated that it is important to build local systems of knowledge, relating to specific locations, based on experience and understanding of local conditions of production.

A model such as decision making tool for determining suitable handling and storage practices for specific crops, based on production area specific conditions; such as climate, organic and synthetic fertiliser usage and pest management practices; nature of the crop and the intended market for the crop should be made available to farmers through training workshops to demonstrate how the tool works. Sometimes agricultural innovations fail to generate expected benefits due to poor implementation, especially if farmers do not understand how the

technology works (Naidoo, 2009). It is important that policies and technical support services by extension personnel encourage the use of available knowledge, techniques and equipment for better postharvest management. The availability of personnel suitably trained in the appropriate techniques is essential for sustainable agricultural development and research to ensure long term postharvest management for food security.

Less postharvest handling and storage training research have been conducted at the smallholder farm level. Training is crucial to any fresh produce handling operation. Education is the key element in development of a society and it is one of the most important strategies to ensure successful programs (Egan *et al.,* 2007; Seaman, 2010). Soon and Baines (2012) reported that poor staff training in food hygiene is a real threat to the food safety; hence effective training is an important prerequisite to successful implementation of a food safety management system. While food hygiene training can be a main necessity in food industry and should be placed as a part of an effective food safety management strategy (Farzianpour *et al.,* 2012), postharvest handling and storage training should not be left out if the effects of losses are to be minimal.

Teaching food handlers can be the most important indices of development in food establishments and effective education can improve the knowledge, attitude and skills (Farzianpour *et al.,* 2012). The need for training of food handlers is an essential part of HACCP concept and is thus recognized by European Union legislation (EU Regulation 852/2004) and by international organizations such as the WHO. Nevertheless, recent studies have suggested that the level of knowledge, attitudes and practices of food handlers needs to be improved (Bas *et al.,* 2006; Bolton *et al.,* 2008; Gomes-Neves *et al.,* 2007; Marais *et al.,* 2007; Martins *et al.,* 2012).

Training and education are essential to ensure that workers have the awareness and knowledge necessary to comply with food hygiene demands (Seaman and Eves, 2008) as well as postharvest handling and storage practices, although these do not always result in a positive change in food handling behaviour. While most food hygiene training courses and postharvest handling and storage practices rely heavily on the provision of information, Soon and Baines argue that to be effective, food safety training needs to target changing the behaviour most likely to result in foodborne illnesses (Soon and Baines, 2012). Postharvest

handling and storage training must as well target on changing the behaviour most likely to result in triggering postharvest losses.

Since some studies have shown that increasing knowledge does not necessarily lead to changes in behaviours (Clayton *et al.,* 2002), Griffith (2000) argued that behavioural change (i.e. the implementation of required hygiene, handling and storage practices) is not easily achieved and that consideration must be given to motivation, constraints, barriers and facilities as well as to cultural aspects. Clayton and Griffith (2008) argued that food safety practices will only be implemented given adequate resources and appropriate management culture. The same does apply to postharvest handling and storage practices.

Ko (2010) argued that sustainability of safe food handling practices depends on the ability to link positive behaviour, attitudes and continued education of food handlers. An understanding of the food handlers' behaviour and how this behaviour interacts with their beliefs and levels of knowledge was suggested to increase training programme effectiveness (Egan *et al.,* 2007). Education and training will lead to an improvement in food safety if the knowledge imparted leads to suitable changes in behaviour at the workplace (Kassa *et al.,* 2010). Findings from a study by Soon and Baines (2012) reviewed that only perceived behavioural control was the significant predictor in employee handling practice. However, perceived control can be improved by supplying adequate resources and reminding employees to perform the behaviours (Pilling *et al.,* 2008).

Motivation from supervisors and management, the support and facilities given to staff are critical to the success of food handling training as these will contribute to changing attitudes and company culture, and have an impact on behaviour and therefore on foodborne outbreaks caused by food workers (Todd *et al.,* 2007). Results of a study by Ko (2010) suggested that attitudes affect practices, and practices function as a mediator for the attitudes in terms of satisfaction with work performance. A positive motivational atmosphere in working environment significantly contributes to higher productivity, employee loyalty and a generally positive attitude in the workplace. In terms of work efficiency and job satisfaction, superiors must devise strategies to assess employee comments and incentive systems (Ko, 2010). Employer behaviour is correlated with the organizational climate in their companies, job satisfaction level and labour conditions, as well as with employee–supervisor relationships (Jevsnik *et al.,* 2009). Ko (2010) concluded that more positive perception and

practice is associated with a higher satisfaction with work performance; perceptions are positively related to practices, which serve a mediating role between attitudes and satisfaction with work performance.

The development of evaluation criteria for the effectiveness of training is very important to protect public health (Park *et al.,* 2010; Gomes *et al.,* 2011). However, quite often training of food handlers is based on theoretical knowledge which is not accompanied by evaluation of the training effectiveness. Seaman (2010) suggested two evaluation stages for the effectiveness of the training interventions; the first one, measure the knowledge retained or the practical capabilities developed by the food handler; the second one, provides information about food handlers' evaluation of the training programme. Martins *et al.* (2012) suggested training and supervision of food handlers on an on-going basis; implementation of standard procedures and their regular verification. The most effective means of adjusting attitudes with respect to food handling and, ultimately, the frequency of practice is participation in continuing education activities (Ko, 2010).

Education and training programmes which are more closely associated with the work site are potentially more effective especially if supported by practical reinforcement of the message (Soon and Baines, 2012). Successful training also requires careful planning by the trainer and needs to be designed in a way to meet the needs of the trainees. Acikel *et al.* (2008) argued that the most efficient method to stop food related epidemics problem or at the very least to decrease it is by to training those working in the food industry and repeating this training periodically.

Seaman (2010), proposed a training model in which the starting point is the identification and analysis of the training needs to assess food handlers' current knowledge, skills and attitudes towards safe food handling behaviour. In addition to relevance of the information, the choice of a training programme should considered location, duration of training and the use of a language that allows food handlers to understand information (Seaman, 2010). Some studies have demonstrated that retention of knowledge is more effective if active learning is incorporated, like hands-on approach or role-playing activities (Clayton *et al.,* 2002; Niode *et al.,* 2011). Martins *et al.* (2012) argued that based on their findings they suggested that the added value of performing different training courses to groups with different backgrounds, experience, duties in the company or pedagogical needs, each one giving emphasis to specific

issues, with different depth of coverage, or using alternative educational strategies, should be assessed as well as the effectiveness of the training courses.

Smallholder farmers require training in several aspects of the farming process (Digbo and Momoh, 2007), including postharvest handling practices, storage and cold chain maintenance systems. Studies by Magingxa *et al.* (2009) concluded that there is a need for investment in the acquisition of skills for smallholder producers to improve their competitiveness through the design of focused training programmes that will enable them to study market trends and plan accordingly and enable them to identify niche markets instead of targeting markets that are already congested.

2.4.1.6 Farm size

Average farm size varies tremendously across countries. In developing countries particularly, Asia and Africa, the average land holding has been declining over the years and the majority of the farm sizes are estimated at less than one hectare (Huang, 1973). These small farms constitute the backbone of traditional agriculture throughout the developing countries (Devendra, 1983). The impact of farm size on the agricultural decisions is one of the key issues in most developing countries. Much empirical adoption literature focuses on farm size as the first and probably the most important determinant and is frequently analysed in many adoption studies (Nkonya *et al*., 1997; Adesina and Baidu-Forson, 1995; Green and Ng'ong'ola, 1993; Shakaya and Flinn, 1985 as cited by Kisaka-Lwayo, 2012). This is perhaps because farm size can affect and in turn be affected by the other factors influencing adoption.

Higher land holdings serve as an incentive to produce surplus for markets (Martey *et al.,* 2012). Farm size has a direct impact on the farm income; with the larger farm expected to generate more income and reduce the cost of production. However, most smallholder farmers are still having small land sizes hence low income from farming activities. Farm size is directly related with employment of labour. If the farm size is big and the household labour is not able to handle the farming activities, the employment of labour is necessary for income generation. However, in cases where the size of the farm is small coupled with costly labour, this will reduce the farm income. Large farm sizes can mean the need to rely on hired labour which has negative effects on postharvest losses. Hired labour may not carefully handle produce whilst harvesting resulting in high postharvest losses from mechanical damages

induced by poor handling. With respect to postharvest losses, large land holdings implies large volumes being produced and the higher the production volumes, the higher the losses since farmers face the constraints of poor handling practices and limited storage facilities (Babalola *et al.,* 2010; Kereth *et al.,* 2013).

2.4.1.7 Farming experience and age

Farming experience is an important characteristic in postharvest handling and management. Farming experience is thought to positively influence technology adoption (Adesina and Baidu-Forson, 1995; Kisaka-Lwayo, 2012; Babalola *et al.,* 2010). The effect is thought to stem from accumulated knowledge and experience of farming systems obtained from years of observation and experimenting with various technologies. Since adoption pay-offs occur over a long period of time, while costs occur in the earlier phases, experience of the farmer can have a profound effect on technology adoption and postharvest handling practices.

Conversely age and farming experience have also been found to be either negatively correlated with adoption, or not significant in farmers‘ adoption decisions. Hassan *et al.* (1998) for Kenya and Kimseyinga and Kyotsi (1998) for Malawi, Adesina and Baidu-Forson (1995) for Ethiopia, Celis, Milimo and Wanmali (1991) for Zambia, Polson and Spencer (1991) for Nigeria (as cited by Kisaka-Lwayo, 2012), reported that the farmer‘s age is negatively related to adoption of agricultural technology, implying that older farmers are less likely to be adopters. This may be due to the fact that older farmers are more likely to be conservative to the introduction of new innovations and reluctant to change. Older and experienced farmers, perhaps because of investing several years in a particular practice, may not want to jeopardize it by trying out a completely new method. In addition, farmers‘ perception that technology development and the subsequent benefits, require a lot of time to realize, can reduce their interest in the new technology because of farmers‘ advanced age, and the possibility of not living long enough to enjoy it (Caswell *et al.,* 2001; Khanna, 2001).

2.4.1.8 Distance to the market and road condition

In most developing countries, roads are not adequate for proper transport of fresh produce (Kader, 2005). The majority of producers have small holdings and cannot afford to own their own refrigerated trucks to transport fresh produce to markets. Public transport in the form of

taxis is usually available (Ortmann and King, 2010). This is not always adequate for transporting crops to markets or inputs back to the household. Homesteads are also geographically dispersed and some residents have to walk long distances to the nearest road served by public transport vehicles and this will result in quick deterioration of the produce which has been exposed to the scotching sun for long periods. In a few cases, marketing organizations and cooperatives have been able to acquire transport vehicles, but they cannot do much about poor road conditions (Kader, 2005).

2.4.1.9 Market access

Killick *et al.* (2000) stated that market access is determined by information about product availability, attributes and prices, including the frequency, quality and cost of this information; information about counter-parties to transactions, as trustworthiness is critical if payment is not instantaneous or checking of quality is costly; the extent of confidence in market conduct for example, how well markets are regulated; and the physical costs of accessing the market, which are a function of the quality of infrastructure and the organisation of the transport sector, and the actual prices found in the markets in which people transact. Lack of access to profitable markets is a major reason why even those farmers who can produce a surplus remain trapped in the poverty cycle since they are often forced to sell to the buyer of convenience at whatever price that buyer dictates (Magingxa *et al.,* 2009).

Smallholder farmers are often inexperienced; they are unaware of strict market requirements and are unaware of niche markets (Mdluli, 2013). A number of detailed studies have been undertaken to understand opportunities and challenges facing smallholder farmers in accessing markets (Louw *et al.,* 2007; Vermuelen *et al.,* 2008; Chikazunga and Paradza, 2012; Altman *et al.,* 2009). These studies have shown that mainstream markets have limited opportunities for smallholder farmers and this can be attributed to low productivity among smallholder farmers as well as the stringent procurement practises of the agribusiness (Chikazunga and Paradza, 2012).

There are typically three most common marketing destinations for smallholder farmers, namely fresh produce markets, informal markets and supermarket chains (PLAAS, 2009). The procurement decisions and practices of supermarkets are complex in nature and may be

influenced by many factors both economic and non-economic, such as reducing transaction costs, determining the appropriate payment period and increasing efficiency in the supply chain and factors such as forming long term trust based relationships with suppliers and ethical trade requirements (Louw *et al.,* 2006).

Most supermarket chains operate a centralised procurement and distribution system which is designed to reduce transaction costs. Within such a system, separate and once-off transactions with scattered smallholder farmers increase transaction costs and lower efficiency (Louw *et al.,* 2007). Retail chains have developed procurement arrangements in which they by-pass wholesalers and procure directly from farmers (Louw *et al.,* 2007). Supermarket procurement specialists are increasingly procuring directly from farmers using growing programs (Louw *et al.,* 2006). Lack of growing programmes and failure to adhere to specified growing programmes is a big challenge hindering market access. Supermarkets and agro-processors prefer sourcing their fresh produce from few selected preferred suppliers who can meet the procurement requirements (Chikazunga and Paradza, 2012). These preferred suppliers are mainly commercial farmers who have the production capacity and resources to meet the stringent demands on food safety and quality set by supermarkets and agro-processors (Vermuelen *et al.,* 2008). Smallholder farmers are marginalised because of their limited production capacity, limited access to financial capital, limited access to production equipment and post-harvest infrastructure (Louw *et al.,* 2008).

The use of contracts has changed the governance of agricultural supply chains in South Africa from spot transactions to hierarchies which have brought challenges including the withholding of supplies by farmers and late payments by supermarkets and processors (Louw *et al.,* 2008). The distribution companies sourcing for the supermarkets and processors establish agreements with producers detailing on volumes, varieties and quality standards that producers are required to deliver. This becomes a big challenge for smallholders and they will back paddle to sign agreements which they will not manage to fulfil whilst legally bound to them. Centralised and direct procurement has also brought the introduction of preferential procurement procedures and stringent private standards (Chikazunga and Paradza, 2012).

The institutionalisation of quality and food safety is often associated with the development and implementation of new standard and certification frameworks. There is a fundamental shift occurring in the role of standards, from reducing transaction costs in commodity markets

to serving as strategic tools for market penetration, system coordination, quality and safety assurance, brand complimenting and product niche definition (Biénabe *et al.,* 2011). These practices define mechanisms of market entry and often create strong barriers to entry, constituting a source of power for those controlling them (Renard, 2005; Ponte and Gibbon, 2005).

Retailer's strict requirements relating to volumes, quality, food safety systems, consistency and year round supply make it difficult for just any producer and especially small-scale producers to supply them (Louw *et al.,* 2008). To qualify as a supplier to large high-value supermarkets, smallholders need to comply with a host of standards, such as organic farming certificates, food quality and safety regulations and packaging criteria (Baiphethi and Jacobs, 2009). The volume and quality as well as infrastructure requirements necessary to qualify as a supermarket fresh produce supplier effectively excludes many of the smaller producers (Louw *et al.,* 2006). Smallholder farmers are not as efficient in their production systems, thus their average cost of production due to product rejections are a main barrier to competitive entry into the formal markets. Placing poor quality produce on sale tends to have an adverse impact on consumer acceptability and damage the prospects for future sales, however good the actual or apparent cooking quality. Smallholder farmers therefore need to ensure that their produce meets the quality standards necessary to convince buyers to pay premium prices for their products.

Part of food handling facility audits carried out by retailers in South Africa includes the following components:

- Policy and procedures manual
- Personal hygiene policies, procedures and training records
- Protective clothing suitability
- Facility and local environment
- Pest control by a reputable pest control company
- Equipment, maintenance and waste management
- Facility layout and production control
- Receiving, storage and stock rotation
- Housekeeping, cleaning and sanitation
- Process control, including product segregation and temperature records

- Laboratory and product analysis, 12 months history
- Dispatch/ transport records including transport temperature records

Louw *et al.* (2008) argue that the increasing importance and changing nature of food grades and standards is a reason for the rise of cooperatives and contract farming in developing countries, particularly for perishables such as fruits and vegetables. Applying and adhering to grades and standards requires investments in training, equipment, infrastructure and monitoring systems, which is very expensive and this is a challenge in smallholder farming. Page and Slater (2003) reported that knowledge of and the capacity to meet externally imposed production, health and safety standards as a barrier for small scale farmers to access markets. As pointed out by Biénabe *et al.* (2011) in a dualistic agricultural context, smallholder farmers are largely excluded from large retailer procurement schemes that demand a high level of technology in terms of farming and post-harvest handling practices which includes a need for storage facilities (often cold-storage) and transport, factors which have large cost implications.

2.4.2 Postharvest handling practices

It has been reported that, the magnitude of postharvest losses depend on the nature of the commodities (Kereth *et al.,* 2013). Intrinsic or biological (internal) causes of fruit and vegetable quality deterioration include respiration rate, ethylene production and action, rates of compositional changes (associated with colour, texture, flavour, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological breakdown (Kader, 2005). These intrinsic characteristics depend with the product. Within a commodity grouping, there is a genotypic variation in composition, quality, and postharvest life potential (Getinet *et al.,* 2008). The shelf life of harvested fresh fruits and vegetables depends on the interaction between genetic and physiological status on the one hand and the postharvest physicochemical activities and spoilage organisms on the other hand (Garcia and Barrett, 2006).

Vegetables are usually harvested when the plant is fresh and high in moisture and are thus distinguished from field crops (Babalola *et al.,* 2010). This high moisture content of vegetable makes their handling, transportation and marketing a special problem. Since fresh

fruits and vegetables are living, metabolism continues after harvest. When designing postharvest handling technology, these intrinsic factors are very critical. Kinyuru *et al.* (2011) reported that smallholder farmers have been practicing different handling techniques with a view to prolonging the shelf-life of the snap beans with little regard to the inherent quality characteristics.

Exposure to stressful conditions such as high temperature, air, bruising among others creates a suitable environment for the produce to deteriorate. Mechanical injuries (such as bruising, surface abrasions and cuts) can accelerate loss of water and vitamin C resulting in increased susceptibility to decay-causing pathogens (Kader and Rolle, 2004). It is very important to note that management of harvesting operations, whether manual or mechanical, can have a major impact on the quality of harvested fruits and vegetables.

Usually, losses occur from poor handling at the farm and markets, poor storage conditions at the farm and the markets and poor packaging during transportation. Huge postharvest losses are incurred in fresh produce due to the physiological form of fruits and vegetables; they deteriorate easily in transit and storage, especially under conditions of high temperature and humidity (Mbuk *et al.,* 2011). Their physiological form encourages increased rate of metabolic activities, which is accelerated by higher temperatures prevalent when the produce is harvested when it's hot and lack of pre-cooling of harvested fresh produce (Kader, 2005). Since fresh produce is living, cells continue to respire. As respiration continues, a considerable quantity of the main nutritional ingredient- ascorbic acid in vegetables is lost (Wills *et al.,* 2007).

Microbiological contamination is often related to food safety issues. Fresh produce is frequently identified as being a culprit in many food borne disease outbreaks (Mdluli, 2013), thus becoming a major food safety concern. However microbiological contamination can also be a major cause of postharvest losses. Expedited and careful handling, immediate cooling after harvest, maintenance of optimum temperatures during transit and storage, and effective decay-control procedures are important factors in the successful postharvest handling of fruits and vegetables (Kader and Rolle, 2004).

Fresh fruits and vegetables are susceptible to microbial contamination at any stage. They may be contaminated at any point along the farm-to-table continuum (FDA, 2008), including

postharvest handling and processing (Rico *et al.,* 2007). Kereth *et al.* (2013) reported both quantitative and qualitative losses of extremely variable magnitudes occurring at all stages in the post-harvest system from harvesting, through handling, storage, processing and marketing to final delivery to the consumer. Studies have shown that microorganisms are natural contaminants of fresh products and minimally processed fresh products (Kereth *et al.,* 2013). Contamination can be through contact with possible sources of contamination such as soil, faeces, water, ice, animals, handling of the products, harvesting and processing equipment and transport (Lehto *et al.,* 2011).

Potential on-farm contamination sources include contact with untreated manure used as a soil amendment, contaminated water, infected workers, or conditions in the field or packing facility such as unclean containers and tools used in harvesting and packing, and the presence of animals (Lehto *et al.,* 2011). Contamination can also occur during transportation as a result of transport conditions such as unclean floors and walls of the transport vehicle and unclean containers (FDA, 2008). Contamination can also occur when marketing the product due to improper handling and poor storage conditions. It is however very important that fresh produce handlers be aware of the conditions under which their fresh produce is grown, harvested, packed and transported (Lehto *et al.,* 2011).

Poor postharvest handling practices induce damages to fresh produce which include splitting, tearing, internal bruising, superficial wounds and crushing of soft produce. Poor handling can thus result in development of entry points for mould and bacteria, increased water loss and an increased respiration rate (Kereth *et al.,* 2013). Mechanical injuries are major causes of losses in the quality and quantity of fresh horticultural commodities in all handling systems. The incidence and severity of mechanical injury can be greatly minimized by reducing the number of steps involved in harvesting and handling and by educating all personnel involved, about the need for careful handling (Kader and Rolle, 2004).

A study by Kereth *et al.* (2013) reviewed that most of the respondents place their produce on top of each other and make a huge heap on the table which leads to spoilage of produce at the bottom due to high heat generated and condensation which encourage mould to grow on the surface of fruits. Kader (2005) argued that the level of contamination could be greater due to the use of contaminated field package, dirt water for washing produce before packing,

decaying, rejected produce lying around packing area and unhealthy produce contaminating healthy ones in the same package.

The need to control high perishability and safe handling involves specialised production, packing techniques and refrigerated transport, all of which require large capital investments and also investment in research, development and marketing (Kirsten and Sartorius, 2002) which smallholder farmers cannot easily afford. Smallholder farmers lack an intimate knowledge of postharvest treatment such as cold chain management and traceability which is critical to lengthen their short shelf life and reducing wastage (Louw *et al.,* 2008). With the emergence of the consumer protection act, retailers have tightened their requirements, giving priority to consumer safety to avoid legal battles with consumers. This is a major challenge even to smallholders who had gained market entry since retailers are even stricter than before. Postharvest handling and storage of fresh produce needs to ensure that the produce maintain appearance, sensory and keeping qualities to penetrate and secure access to niche markets. Some special tools and/or equipment in harvesting and postharvest handling such as containers, equipment for cleaning, waxing, and packing, and cooling facilities may not be available in domestic markets or available but at exorbitant prices, thus becoming unaffordable to most smallholder farmers (Kader, 2005). Many facilities and equipment ends up not functioning properly because of lack of maintenance and unavailability of spare parts.

The rate of biological deterioration depends on several external (environmental) factors, including temperature, relative humidity, air velocity, and atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene), and sanitation procedures. Temperature is the most important environmental factor that influences the deterioration of harvested commodities. Temperature has a significant effect on how other internal and external factors influence the commodity, and dramatically affects spore germination and the growth of pathogens (Kader and Rolle, 2004). Relative humidity can influence water loss, decay development, the incidence of some physiological disorders, and uniformity of fruit ripening. Condensation of moisture on the commodity (sweating) over long periods of time is probably more important in enhancing decay than is the relative humidity of ambient air (Kader and Rolle, 2004).

Naturally, fresh produce needs low temperature and high relative humidity during storage and transportation. Low temperature decreases physiological, biochemical and microbiological

activities, which are the causes of quality deterioration (Getinet *et al.,* 2008). On the other hand, higher relative humidity increases the vapour pressure of the air and decreases physiological weight loss of commodities. Mbuk *et al.* (2011) stated that the most important goals of postharvest handling are to keep the product cool, thereby avoiding moisture loss and slowing down undesirable chemical changes and to avoid physical damage such as bruising to delay spoilage.

Temperature control is one of key tools in controlling microbial growth in foods and, where inadequately performed, is a major cause of the proliferation or permanence of microbial hazards and, thus, subsequent food borne disease (WHO, 2006). Temperature control is also critical in maintaining the shelflife of the product thus playing a critical role in postharvest losses (Kader, 2005).

With the high perishability of fresh produce, cold storage and transport is a major challenge for smallholder farmers. Proper maintenance of the cold chain in fresh produce is of key importance. Farmers in several instances have been reported using non-refrigerated transport for the delivery of fresh produce which contributes greatly to a number of rejections by retailers and dumping in fresh produce markets since the produce quickly deteriorates as a result of the break in cold chain. Smallholder farmers who generally lack appropriate technologies to maintain quality may not meet supermarket produce quality expectations for suppliers (Berdegué *et al.,* 2005; Biénabe and Sautier, 2005). Where farmers have access to supply supermarkets, quality deterioration post crop maturity and postharvest may rob farmers of profit and consequently, farmers need appropriate storage technologies, especially for perishable produce to mitigate these losses (Eltawil *et al.,* 2006).

The human element in postharvest handling of vegetables is extremely important as reported by Kader (2005). Therefore, management of harvesting operations, whether manual or mechanical, can have a major impact on the quality of harvested fruits and vegetables (Kader and Rolle, 2004). Proper management procedures that include the selection of optimum time to harvest in relation to product maturity and climatic conditions, training and supervision of workers, and proper implementation of effective quality control (Kader and Rolle, 2004) becomes very critical. Attention must be paid to the careful handling, immediate cooling after harvest, optimum temperature maintenance during transit and storage, and effective decay-control procedures since the factors are very critical in the successful postharvest handling.

Vegetables have high moisture content and are rich in nutrients and thus naturally contaminated with microbes; therefore, keeping the number of microorganisms as low as possible by keeping a clean environment is very critical (Lehto *et al.,* 2011). Hygienic conditions of harvesting and postharvest handling equipment need to be effectively improved to prevent any source of cross contamination. Improper harvest and postharvest practices result in losses due to spoiling of the product before reaching the market, as well as quality losses such as deterioration in appearance, taste and nutritional value (Babalola *et al.,* 2010). However, most handlers involved directly in harvesting, packaging, transporting, and marketing in developing countries have limited or no appreciation for the need for, or how, to maintain quality (Kader and Rolle, 2004). This therefore creates a need for postharvest handling training, especially in smallholder operations where technical expertise was reported to be lacking.

The time of picking or harvesting is considered as the most important factor in fresh produce postharvest losses. The vegetables are healthy, heavy, and turgid in the morning since there is high humidity in this time of the day. In the afternoon, high temperature and evaporation are the key issues that cause vegetable shrinkage and become unacceptable to consumers.

2.5 Overcoming market access challenges

Although small-scale farmers in the communal areas of South Africa have limited access to resources, including credit and information, and markets are often constrained by inadequate property rights and high transaction costs (Lyne, 1996), some smallholder farmers have managed to produce food for own consumption and for the market. Differentiated markets (niches) were seen to be a promising means of market entry for small-scale farmers as this is where they benefit from comparative advantages such as local expertise or environmentally friendly ways of producing (Louw *et al.,* 2008).

Although agribusiness dominates food markets in South Africa, other studies concerning smallholder farmers highlight the importance of alternative systems such as informal markets and related and intermediaries (Chikazunga and Paradza, 2012). The ease of entry associated with traditional markets explains why small-scale farmers are often restricted only to these market options. Although Spar has centralised distribution centres across South Africa, all

SPAR stores are allowed to procure fresh produce locally through alternative channels other than through the distribution centres. Local procurement with small farmers triggers benefits in terms of freshness of vegetable produce with an acceptable quality level and low transportation cost. Research related to indigenous knowledge and the use of locally available resources to reduce postharvest losses is urgently needed to assist small scale producers.

There is need to further explore local quality trends in South Africa and their impact throughout the supply chain in order to gain a deeper understanding of the implications of alternative quality food dynamics on small-scale farmers' market access in the South African context (Biénabe *et al.,* 2011). Smallholder farmers may have difficulties in making the transition to a more commercialised food system because they often struggle to meet the private quality and safety standards set by large retailers, wholesale buyers and exporters and at the same time they are constrained by limited support services provided by governments due to policy reforms, market liberalisation and fiscal and governance problems (Vermeulen *et al.,* 2008).

The Institute of Natural Resources (2009), suggested that possible public policy interventions that include the provision of less sophisticated public standards aimed at the domestic market would ease market access for small-scale farmers especially during the learning phase. Because of the changes in agricultural and food systems and the dominant role played by large agribusiness firms in agricultural and food systems, it is important to find ways and means to effectively engage them in the important task of promoting market access for smallholder farmers (Vermeulen *et al.,* 2008). There is need to build relationships between smallholder farmers and commercial farmers which would give commercial farmers an opportunity to assist smallholder farmers to meet their demands (Wegner and Zwart, 2011). Agribusiness firms should be considered partners in the challenge of establishing ways and means of strengthening their linkages with smallholder farmers.

2.6 Measurement and methodologies

In their study, determinants of postharvest losses in tomato production, Babalola *et al.* (2010) used the linear regression form as the lead equation on the basis of coefficient of determination, F-ratio, number of significant variables, sign of the coefficients and economic expectation. Mbuk *et al.* (2011) used the Tobit regression model; a hybrid of the discrete and

continuous models, to determine the impact of explanatory variables on the probability of spoilage of tomatoes. Though the Tobit model can determine the intensity of the losses as it relates to each independent variable, it wasn't used in this study due to the nature of the dependent variable. The dependent variable was captured as ordinal data hence the choice of the ordered probit model.

Multiple response models are used when the number of alternatives that can be chosen is more than two (Kisaka-Lwayo, 2012). In this study the alternatives were four. They are used to describe the probability of each of the possible outcomes as a function of alternative specific characteristics (Verbeek, 2008). The ordered probit model was used to establish the determinants of postharvest losses among smallholder farmers in the study area. The ordered response model was applied since an ordered or logical ordering of the alternatives exists, implying that the results in this case will be sensitive to the way in which the alternatives are numbered.

The ordered probit is suitable for modelling with an ordered categorical dependent variable; the category based on percentage postharvest losses in this study. The model is useful in determining a combination of the multiple factors contributing to the resultant percentage postharvest loss categories on a given crop. The ordered probit model is appropriate in this study because, like the Ordinary Least Square (OLS), it identifies the statistical significant relationships between the explanatory variables and the dependent variable (Kisaka-Lwayo, 2012). The ordered probit model recognizes unequal differences between ordinal categories in the dependent variable unlike the OLS regression (Greene, 2003).

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

Background information regarding the location and agro-ecological situation of the study area, the land tenure system, agricultural potential, crops grown in the area and the main farming systems of the participants are described in this section. A brief description of the participants' livelihoods is also given as well as a description of Umbumbulu Agri-hub activities. The chapter also concisely outlines the research design, the data, sampling techniques and the sample size. Data collection procedures adopted in the study were also presented in this chapter as well as the methods used to analyse the data.

3.2 Characteristics of the study area

3.2.1 Location of Umbumbulu

The study was conducted in Umbumbulu area within KwaZulu-Natal Province. This area is situated south-east of Durban. Umbumbulu, just forty kilometres away from Durban, is one of the many rural areas that form part of the eThekwini Metro jurisdiction. Comprised of 25 smaller districts, Umbumbulu and its surrounding areas is home to more than a quarter of a million people.

3.2.2 Land tenure system in Umbumbulu

Umbumbulu forms part of the former KwaZulu homeland characterised by traditional forms of land tenure and subsistence agriculture (Ortmann and Machete, 2003), typically symbolised by widespread poverty (Agergaard and Birch-Thomsen, 2006). The study area is controlled by a traditional authority, which is headed by *Inkosi* (Chief), who has influence over local institutions and affairs such as tribal courts, land tenure and allocation of land rights as well as a local government representative council. An *Induna* (headman), appointed by the chief, also performs specific tasks as agreed to by the chief.

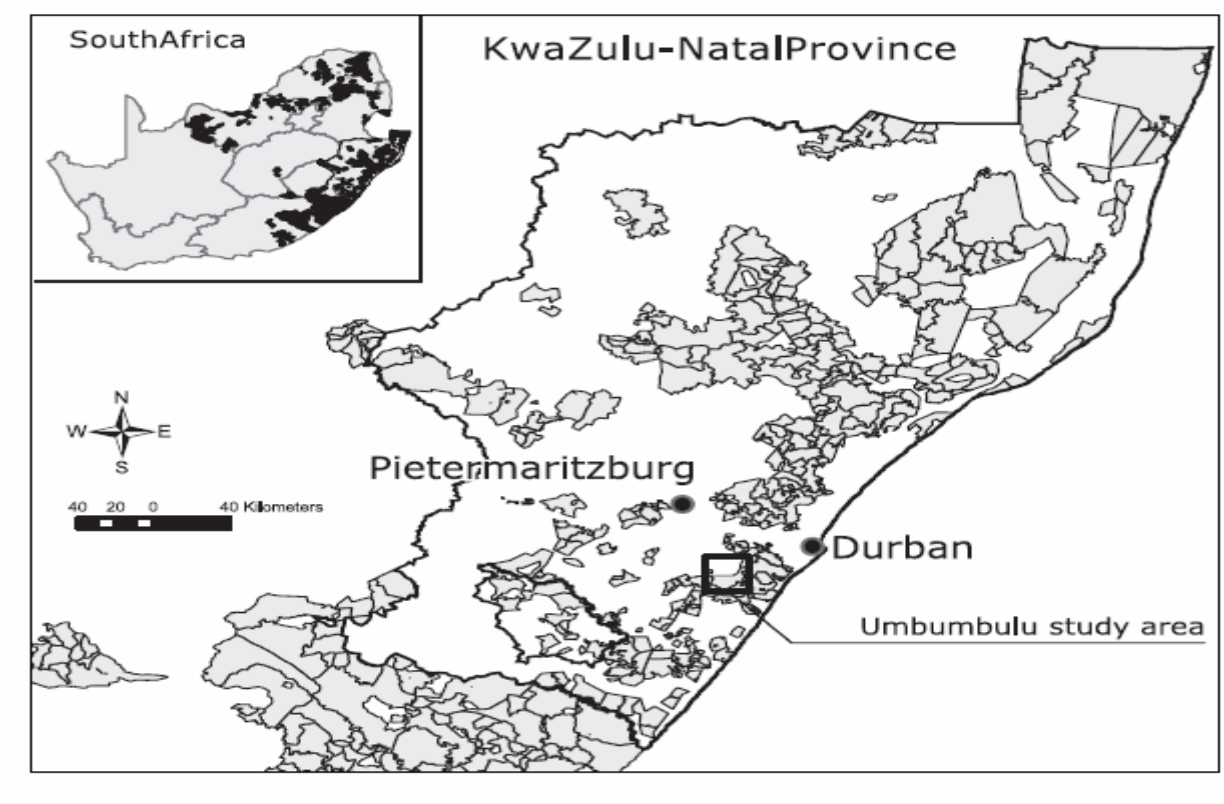

Figure 3.1: Map of KwaZulu-Natal indicating the study area of Umbumbulu (Agergaard and Birch-Thomsen, 2006).

Due to communal tenure and weak traditional institutions, there is no land rental market. Unlike commercial farmers, who traditionally farm privately-owned land, smallholder farmers in these areas cannot use their land to secure finance/loans (Thamaga-Chitja, 2008). This implies that for these farmers, land can be taken away at any time due to lack of tenure security (Naidoo, 2009). Most smallholder farmers in South Africa are found in rural areas of less favourable agricultural potential (Hendriks and Lyne, 2003), which makes it difficult for them to succeed. Smallholder farms in Umbumbulu are often found on steep slopes making farming difficult and farmers are often only able to cultivate manually due to the steep slopes. These areas are associated by a general degradation of the land due to overgrazing and incorrect grassland burning for grazing purposes (Kisaka-Lwayo, 2012).

3.2.3 Agricultural potential of Umbumbulu

Umbumbulu is a humid area, with an average rainfall of 956mm per annum (Katundu, 2008) and has an abundance of arable fertile land which makes it highly productive. Although there

is rainfall throughout the year, the main rainfall is between November and March. The mean, minimum and maximum temperatures for the place are 18.6 ^{0}C, 13.4 ^{0}C and 24.0 ^{0}C respectively (Kisaka-Lwayo, 2012). The duration for the rainy season is 241 days in a year.

Figure 3.2: Typical topography of Umbumbulu, October 2013

Only 15 per cent of the total Umbumbulu area has high potential for annual cropping. Another nine percent is arable, but less favourable for annual cropping. The climate is favourable for a wide range of adapted crops and the area has a year-round growing season. Agriculture in this communal area is predominantly rain-fed.

Figure 3.3: Water harvesting and irrigation, October 2013

Smallholder farmers often lack supplementary irrigation unless they are beneficiaries of smallholder irrigation schemes of the former homelands (Aliber *et al.,* 2006), and as a result some farming activities are not very active during the dry season but only gain momentum during the rainy season. Farming under such conditions makes it difficult for them to succeed (Thamaga-Chitja and Hendriks, 2008). Subsistence farming activities mostly begin in September/October, depending upon the onset of rains (Modi *et al.,* 2006).

3.2.4 Crops grown in Umbumbulu

The land use pattern in Umbumbulu, KwaZulu-Natal is predominantly agricultural in nature and is characterised by small-scale subsistence farming (Kisaka-Lwayo, 2012). Most of the farmers in the area are smallholder and have knowledge of and practice organic farming (Modi, 2003). In general, every household has a garden where traditional crops are grown (Ndokweni, 2002) and income from such gardens can benefit these households.

The vegetables that are produced in the study area include carrots, green beans, potatoes, spinach, tomatoes, taro (*amadumbe*), sweet potatoes, green pepper, cabbage, beetroot, onions, lettuce, and butternut. These crops are produced in household gardens as well as by farmer groups. There is no major variation between crops grown in home gardens and in farmer's groups except the quantities which are higher when produced by a farmer's group. A few farmers also produce other crops such as brinjals, though produced in very small quantities.

3.2.5 The farming system in Umbumbulu

Delgado (1999) reiterated that farming forms an important part of livelihood strategies for most rural communities in South Africa. Smallholder crop production in KwaZulu-Natal is promoted widely as a strategy to overcoming poverty and food insecurity (Hendriks, 2005). Vezi (2005) as cited by Naidoo (2009) reported that the majority of rural smallholder farmers rely on organic production which is promoted as a means of income generation among smallholders in the province. The most common farming practice is based on traditional farming methods similar to organic production methods. However, only some farmers use conventional farming methods on a very small scale with the aid of conventional pesticides and fertilisers.

Figure 3.4: Some of the vegetables that are produced in Umbumbulu, October 2013

Farming in the study area is characterised by smallholder activities that are traditionally dominated by women, the main reasons for farming being the need to improve household food security. Selling the surplus is only done when the first need has been satisfied. Farmers in the study area farm individually and some are organised in farmer groups with varying membership. Individual farming at homestead units is mainly for household consumption

with little surplus to sell. Collective farming in farmer groups is at a larger-scale as compared to individual farming at homesteads and this is mainly done for selling purposes. Some farmer groups have big pieces of land that they group own but farm individually on that group owned land. Others produce as groups on the group owned land.

Hendriks and Msaki (2009) conducted a study using Ezemvelo Farmers Organisation (EFO) and non-EFO members. They reported that farm size varied from 0.01 to 8.90 hectares, with a mean of 0.48 hectares (non-Ezemvelo Farmers Organisation members), 0.77 hectares (partially organic certified EFO members) and 0.75 hectares (fully organic certified EFO members).

3.2.6 Smallholder farmer's livelihoods in Umbumbulu

Farming provides the potential for providing cash income at a time when the population pressure is increasing and urban incomes are diminishing (Agergaard and Birch-Thomsen, 2006). Smallholder agriculture is an important livelihood option for many rural families contributing a significant portion of their household income (Kisaka-Lwayo, 2012). Farming is a dominant livelihood strategy in Umbumbulu (Agergaard and Birch-Thomsen, 2006) even though Msaki *et al*. (2005) reported that the main sources of income were remittances and grants. Favourable agricultural productivity of the area necessitates the increase in income from farming.

Agergaard and Birch-Thomsen (2006) stated that previous and current urban employment of family members provides essential capital through pensions, salaries and remittances for the advancement of agriculture in Umbumbulu. Hendriks and Lyne (2003) reported that non-farm incomes averaged R2310 per month, and was sourced from employment wages, remittances, hiring out of accommodation, catering services, and building of houses, shop keeping, furniture making, sewing, hair braiding, hawking and taxi operating.

Hendriks and Lyne (2003) reported household numbers ranging from one to 25, with an average of eight members. Ndokweni (2002) reported that Umbumbulu had a large rural population with no public services such as post offices and police stations, or infrastructure such as piped water, sanitation, refuse removal, electricity and tarred roads. Minibus taxis were reported as the most common mode of public transport in the area (Ndokweni, 2002).

3.2.7 Umbumbulu Agri-Hub

Umbumbulu Agri-Hub is a project that originated from Newlands Mashu Community Development Centre, a non-profit organisation which has previously worked with Project Preparation Trust (PPT) of KwaZulu-Natal and supported by the eThekwini municipality on a number of fruit tree establishment and food garden projects. The project was launched in 2009. The Agri-Hub focuses on all aspects of organic farming value chain.

The main aim of the project is to improve food security for all participants (Mdluli, 2013). The project aims to improve the profitability of smallholder farmers and community growers with limited access to capital, land and skills in the Umbumbulu sub-node of eThekwini Municipality by means of piloting an intervention that will capacitate and add value to loosely-arranged small farmers' groups in the area. The project also aims to facilitate improved access to markets, improved technical and business skills and a co-ordinated support service to farmers as well as providing infrastructure such as a storage facility, sorting facility, cold room and office facilities which will provide input functions, light processing and output functions of vegetable and niche crops.

This project creates opportunities for long term local food sovereignty, which is the right of all people to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. An integrated approach adopted at the Umbumbulu Agri-Hub is a bottom up development process. This mechanism is viewed as a vital preliminary step in identifying viable and productive growers in an area for further investment – in either economic or land reform terms.

The Agri-Hub has a membership of more than 100 farmers, with new members joining the project regularly. Community members approach the Agri-Hub if they are interested in being part of the programme and being farmers. They are trained through practical workshops and the training covers enterprise development, organic gardening, and fencing among others and before being granted the membership.

Figure 3.5: Hands on training of farmers supplying the Agri-hub, October 2013

Members spread across Umgababa, Adams Mission, uMbumbulu, Folweni and Mphusheni. Most of the members are in wards 13, 96, 97, 98, 99 and 100. Some of the farmers have grouped themselves into cooperatives that operate under the Agri-Hub. Formation of cooperatives helps in the supervision since members monitor each other to ensure that proper organic practices are practiced.

Farmers are given support by routing farm visits and finding out what challenges and problems they are facing. Member farmers are trained in sustainable agriculture; soil management; water management; garden management; pest management; composting and postharvest protocols. Organic practices are implemented by farmers to produce their products which are sold under the "organically produced" label. This is because the organisation's produce is not yet organic certified. Farmers purchase seedlings and farming equipment at discount prices from the Agri-Hub. Water for irrigation is sourced from the taps, dams, river and springs. Most farmers use tap water; however, some irrigate using water from natural sources (Mdluli, 2013).

The produce by member farmers is for self-consumption, surplus is sold to the Agri-Hub and other players at market prices. The "box" scheme is used for products to be sold. The produce from farmers is weighed and separated into different grading packaged in a veggie box where the consumer receives different vegetables. The farmers produce different types of vegetables which range from spinach, beetroot, red onion, potatoes, and carrots among others. This is sold to the local shops in the area, food markets, and restaurants in Durban and to the community under the Fair Foods brand. Money received from shops is distributed accordingly to farmers based on how much they supplied to the Agri-Hub.

3.3 The research design

Brink and Wood (1998) stated that the purpose of a research design is to provide a plan for answering the research question and "is a blueprint for action". It is the overall plan that spells out the strategies that the researcher uses to develop accurate, objective and interpretative information. A quantitative, descriptive research design was chosen for this study in order to give a detailed description of the vegetable postharvest losses. Quantitative research is a formal, objective and systematic process for generating information about the world.

According to Brink and Wood (1998), a descriptive survey design may be utilised "to study characteristics in a population for the purpose of investigating probable solutions of a research problem". A survey was chosen for this study for the following reasons:

- It is appropriate for the research objectives of this study as the aim of the study is not to infer cause and effect but to describe the nature of the research topic (Brink and Wood, 1998).
- There is no active intervention on the part of the investigator that may produce researcher bias (Cohen *et al.,* 2000).
- According to Brink and Wood (1998), a survey design may be utilised to study characteristics in a population to investigate probable solutions of a research problem. It is impartial; there is no prejudice in the selection of units participating in the research. The research data can be collected in the natural setting and in a short time, using an interview or observation (Brink and Wood, 1998).

The survey, however, has its own limitations. According to Burns and Grove (1997) and Cohen *et al.* (2000), the following are some of the limitations:

- The person who responds to a survey is aware of being studied and can be responsible for biased data. Sometimes the information collected tends to be relatively superficial because survey questionnaires rarely probe deeply into complexities such as contradictions of human behaviour and feelings. The design also requires the cooperation of the respondents, which might not be forthcoming.
- Surveys can be costly, time consuming and tedious because they are very demanding of personnel.
- Sometimes the data collected is too much, making data coding and analysis difficult in the absence of a computer.

Despite the limitations, in the researcher's view, the strengths outweighed the weaknesses and the survey was the appropriate design to adopt.

3.4 The data sources

Due to the lack of secondary data on postharvest handling practices in the study area, primary data was collected. Primary data was gathered through surveys, key informant interviews and field observations. Some of the advantages of collecting primary data are that it can be collected from a number of ways like interviews, telephone surveys, focus groups etc.; it can be also collected across the national borders through emails and posts. It can include a large population and wide geographical coverage; primary data is current and it can better give a realistic view to the researcher about the topic under consideration and reliability of primary data is very high because it is collected by the concerned and reliable party. However, gathering primary data generally takes time and is costly in terms of the resources that are required.

3.5 Sampling technique and sample size

A purposive sampling technique was used for the study. Maxwell (1997) defined purposive sampling as a type of sampling in which, ‘‘particular settings, persons, or events are

deliberately selected for the important information they can provide that cannot be acquired as well from other choices'' (Teddlie and Yu, 2007). Participants are selected based on specific purposes associated with answering a research study's questions. Purposive sampling enables an initial understanding of the situation, and to identify and differentiate the needs of the survey participants. It produces a sample where the included groups are selected according to specific characteristics that are considered to be important as related to the specific study objectives (Teddlie and Yu, 2007). The characteristic which was of importance was smallholder production of vegetables in Umbumbulu and having supplied or intending to supply the Agri-hub with vegetables. With such a sample, group differences can be compared and contrasted and a range of experiences can be summarized.

A sample of 120 smallholder farmers was purposively selected for the study. A list of farmers who were registered by the Agri-hub was supplied by the senior Agri-hub manager. A total of 128 smallholder farmers were identified but out of these, eight farmers refused to participate in the study.

3.6 Data collection procedures

3.6.1 The research instruments

Primary data were collected using structured questionnaires and key informant interviews (See Appendix A for the questionnaire). The approach enabled the collection of both qualitative and quantitative information on various aspects from respondents. The structured questionnaire provided a systematic, ordered way of gathering information from respondents and allowed the collection of precise data which was statistically analysable. The structured questionnaire gathered information on age of respondents, gender, level of education, farming status, number of years in farming, farm ownership, the farming practice, main sources of income, membership of any farming group, crops grown, distance from markets, transport system (owned, rented or agent), refrigerated or non-refrigerated transport, time of harvesting, frequency of harvesting, quantity lost, causes of the losses, storage systems, any postharvest handling training, access to agricultural extension and challenges faced by the farmers, among others.

Four key informants were interviewed, one of which was a field officer from the Agri-hub, one was consultant from the area who is assisting and encouraging formation of farmer groups in the area while two involved farmers who were knowledgeable with issues pertaining to the farming activities in the area.

3.6.2 Validity and reliability

Validity is defined by Polit and Hungler (1995) as "the degree to which the instrument measures what it is supposed to be measuring". The researcher mostly focussed on content validity, which refers to the accuracy with which an instrument measures the factors under study. Therefore content validity was concerned with how accurately the questions to be asked tend to elicit the information sought. The research instrument was tested for content validity by giving the questionnaire to the supervisor and conducting a pilot study. Reference was also made to previous studies related to the research topic. Reliability relates to the precision and accuracy of the instrument. Cohen *et al.* (2000) argued that if used on a similar group of respondents in a similar context, the instrument should yield similar results. Accurate and careful phrasing of each question to avoid ambiguity and leading respondents to a particular answer ensured reliability of the tool.

For any research instrument to qualify the test of validity and reliability, it needs to be administered and approved before it is used. This is meant to ensure the usefulness and worthy of the instrument. The instrument should accurately and consistently measure what it is intended to measure; therefore, a pilot study was conducted before the detailed data collection.

3.6.3 The pilot study

A pilot study was conducted before the detailed data collection exercise. The questionnaires were pre-tested before being administered using a sample of five households. The pilot study was conducted by interviewing some smallholder farmers in different wards in the study area. The purpose of the pilot study was to check the time taken to complete the questionnaire, whether it is too long or too short, too easy or too difficult and to check the clarity of the questionnaire items, and to eliminate ambiguities or difficulties in wording (Cohen *et al.,* 2000). This was part of the test for validity and reliability. Some questions that were not clear

during questionnaire pre-testing were modified to make them clearer and some were removed from the questionnaire. The pilot study was also used to ensure that there was consistency of measurement and ensuring that the instrument measured what it is intended to measure, thus improving the reliability and validity of the questionnaire. One other importance of the pilot study was in improving translation of the questionnaire to isiZulu, the local language clearly understood by the research participants.

3.6.4 The data collection exercise

Research data was collected in October 2013 by seven enumerators who are very fluent in isiZulu, the local language in the study area. The enumerators were trained in respect to the contents of the questionnaire and data collection methods before going for the survey. The enumerator training was necessary in making sure that the enumerators were at the same of level of understanding the contents of the questionnaire and what was expected of them during the survey.

Figure 3.6: Data collection exercise, October 2013

3.7 Data processing and analysis

The data was coded and captured in SPPS Version 21. Data cleaning was conducted before analysing the data to check for any errors and missing variables. Different data analytical methods were used to achieve the specific objectives of this study. Table 3.1 gives the specific objectives and the corresponding analytical methods that were used. As shown in Table 3.1, descriptive statistical analysis was used to describe the socio-economic and demographic characteristics of the sample households. Descriptive statistical analysis (frequency, means, cross tabulations and Chi Square tests) were used in determining the main vegetables grown by smallholder farmers, knowledge, training and the respective postharvest handling practices. The Ordered Probit Regression model was used to establish the determinants of leafy and fruit vegetable postharvest losses. The regressions were done using STATA Version 13. Table 3.2 and Table 3.3 present the variables that were used in the econometric model. The variables and the codes as they were used in STATA analyses are presented in Appendix B.

Table 3.1: Study objectives, data collection tools and analysis methods

No.	Objective	Data to be collected	Data collection tool	Method of data analysis
1	To describe the demographic and socio-economic characteristics of smallholder vegetable farmers	Demographic and socioeconomic characteristics	Structured questionnaire, key informant interviews and field observations	Descriptive statistics
2	To determine the main vegetables grown by smallholder farmers, knowledge, training, postharvest handling practices and quantities lost.	Vegetables grown, training, extension and handling practices		Descriptive statistics
3	To investigate the determinants of leafy and fruit vegetable postharvest losses among smallholder farmers	Demographic, socio-economic, training, extension and handling practices		Ordered Probit Regression Model

3.7.1 Descriptive statistical analysis

Descriptive statistical analysis for all the variables was carried out as a first step in data analysis. Descriptive analysis is important since it can inform decisions on which variables to include in the regression analysis and highlights data management issues, such as coding of variables and missing values (Vyass and Kumaranayake, 2006). Descriptive analysis involved looking at means, frequencies and standard deviations of the variables. Cross tabulation and chi square tests were also done on some variables to check for any significant relationships. Descriptive statistical analysis was used to categorise survey participants under different socio-economic characteristics, showing the main vegetables grown by smallholder farmers in Umbumbulu, describing the various postharvest handling and storage practices employed and categorising the postharvest losses.

3.7.2 The Ordered Probit Regression model

The Ordered Probit Model was used to establish the determinants of vegetable postharvest losses. The dependent variables in this study were the proportion of cabbage lost in per cent, proportion of spinach and proportion of tomato lost, grouped into four ordered categories. The categories are Q1 (1 – 25%), Q2 (26 – 50%), Q3 (51 – 75%) and Q4 (76 – 100%). In this study, the ordered probit model was used to establish the factors that influence postharvest losses in smallholder farming. Based on the review of literature, the model is estimated as follows:

A. Quantity of cabbage lost = *f* (*gender, marital status, farming experience, literacy, farmer group membership, farm size, hand and equipment washing, time of harvesting, packaging used, storage duration, distance to the market and postharvest handling training*)…….....[1]

B. Quantity of spinach lost = *f (gender, marital status, farming experience, literacy, farmer group membership, farm size, hand and equipment washing, time of harvesting, packaging used, storage duration, distance to the market and postharvest handling training)*……..….....[2]

C. Quantity of tomatoes lost = *f (gender, marital status, farming experience, literacy, farmer group membership, farm size, hand and equipment washing, time of harvesting, packaging used, storage duration, distance to the market and postharvest handling training)*……..…..[3]

The respective category for quantity lost is unobserved and is denoted by the latent variable q_i*. The latent equation below models how q_i* varies with personal characteristics and is represented as:

$$q_i^* = X_i \beta + \boldsymbol{\varepsilon_i} \quad \text{[4]}$$

Where:

- the latent variable $\mathbf{q_i}$*measures the difference in utility derived by individual *i* from either losing between 1 – 25% or 26 – 50% or 51 – 75% or 76 – 100%.
- ($\boldsymbol{i}$ = 1, 2, 3…….n) n represents the total number of respondents. Each individual i belongs to one of the four groups.
- $\boldsymbol{X_i}$ is a vector of exogenous variables,
- β is a conformable parameter vector, and
- the error term $\boldsymbol{\varepsilon_i}$ is independent and identically distributed as standard normal, that is $\boldsymbol{\varepsilon_i} \sim NID\ (0, 1)$.

Taking the value of 4 if the individual was losing between 76 – 100% and 1 if the individual was losing between 1 – 25%, the implied probabilities are obtained as:

$$\begin{aligned}
&\Pr\{Q_i = 1 | X_i\} = \Phi(- \ _i\beta),\\
&\Pr\{Q_i = 2 | X_i\} = \Phi(\mu_2 - \ _i\beta) - \Phi(\mu_1 - \ _i\beta),\\
&\Pr\{Q_i = 3 | X_i\} = \Phi(\mu_3 - \ _i\beta) - \Phi(\mu_2 - \ _i\beta),\\
&\Pr\{Q_i = 4 | X_i\} = 1 - \Phi(\mu_3 - \ _i\beta). \quad \text{[5]}
\end{aligned}$$

Where μ is the unknown parameter that is estimated jointly with β. Estimation is based upon the maximum likelihood where the above probabilities enter the likelihood function. The interpretation of the β coefficients is in terms of the underlying latent variable model in equation [4].

The probability of the farmer's postharvest losses lying between 1 – 25% can be written as:

$$\Pr(Q_i = 1) = \Phi(\ \ _i\beta_1), \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad [6]$$

Where Φ (·) is the cumulative distribution function (cdf) of the standard normal (Verbeek, 2008).

A measure of goodness of fit can be obtained by calculating:

$$\rho^2 = 1 - [\ln L_b / \ln L_o] \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad [7]$$

Where ln L_b is the log likelihood at convergence and ln L_o is the log likelihood computed at zero. This measure is bounded by zero and one. If all model coefficients are zero, then the measure is zero. Although ρ^2 cannot equal one, a value close to one indicates a very good fit. As the model fit improves, ρ^2 increases. However the ρ^2 values between zero and one do not have a natural interpretation (Greene, 2003). Another similar informal goodness of fit measure that corrects for the number of parameters estimated is:

$$\rho^2 \text{ bar} = 1 - [\ln L_b\, K / \ln L_o] \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [8]$$

Where K is the number of parameter estimates in the model (degrees of freedom).

3.7.3 Regression model diagnostics

Testing for the overall significance of the regression models was done using F-tests and utilizing the R-squared measures of fit. In addition, the regression model was tested for multicollinearity. The degree of multicollinearity was checked using STATA version 13 software package. The Ordinary Least Squares regression (OLS) was initially used to test for multicollinearity by examining variance inflation factors (VIFs) from a correlation matrix (Gujarati and Porter, 2009). Robust standard errors were used to remedy for heteroscedasticity in the regression model.

3.7.4 Variables used in the regression model

Different socio-economic variables, knowledge indicators, training and postharvest handling variables presented in Table 3.2 were used as independent variables in the econometric model that was estimated. The specifications of the econometric models estimated in this study are presented in the following sections.

Gender of household head is expected to capture the differences in postharvest handling orientation between males and females with either males or females expected to have a higher propensity to careful handling of produce and therefore minimum postharvest losses.

Characteristics of the household head such as age and farming experience imply farming knowledge gained over time (Martey *et al.,* 2012) and are important in postharvest handling. Age is a proxy measure of experience and availability of resources. Babalola *et al.* (2010) argued that age is a very important demographic characteristic because it determines the size and quality of the labour force. Martey *et al.* (2012) argued that older farmers are expected to use their farming experience to decide to adopt new technology. In regard to this research, older farmers are expected to use their farming experience to decide on appropriate postharvest handling practices and hence an overall reduction in postharvest losses. More experienced farmers are expected to have minimal postharvest losses as compared to the inexperienced ones since they can utilise the gained experience to make important handling decisions as well as having market contacts to ensure that harvested produce is sold quickly. Farming experience was captured in this model, hence the exclusion of age which captures almost a similar measure with experience.

Education level is expected to exert a negative effect on the quantity that is lost. Martey *et al.* (2012) argued that education enables an individual to make independent choices and to act on the basis of the decision, as well as increase the tendency to co-operate with other people and participate in group activities. Enete and Igbokwe (2009) argued that education endows the household with better production and managerial skills. It is also possible that education could increase the chances of the household head earning non-farm income and invest in better postharvest handling technologies. Babalola *et al.* (2010) argued that only farmers with post-primary education can appreciate and use most postharvest technology available hence the overall effect on quantity lost is negative.

Membership of an association or a farmers group has a negative effect on postharvest losses. Household membership of association/group increases access to information important to production, postharvest handling and marketing decisions. Most farmer groups engage in group marketing as well as credit provision for their members. It is therefore expected that household membership of association/group will positively impact on marketing and postharvest handling knowledge, hence a reduction in postharvest losses.

The larger the area put into cultivation the higher the quantity harvested and chances of higher losses due to poor handling and lack of proper storage. Good hygiene practices such as hand washing and postharvest handling equipment washing minimises chances of produce contamination, hence a reduction in postharvest losses (Kader, 2005). Time of harvesting has an impact on postharvest losses. Harvesting in the morning tends to result in low postharvest losses while harvesting in the afternoon increases postharvest losses. In the morning there is high humidity and therefore produce is healthy, heavy, and turgid whilst in the afternoon, high temperature and evaporation are the key issues that cause produce shrinkage and it becomes unacceptable to consumers (Kereth *et al.,* 2013), hence there are high postharvest losses if harvesting is done in the afternoon. The use of plastic crates for harvest, packing, transport and storage of fresh produce has been shown to reduce damage and postharvest losses (Kitinoja, 2013).

Longer periods of storage result in quality deterioration and hence an increase in postharvest losses. Harvested produce is living hence respiration carries on which results in a build-up of heat and withering/ shrivelling due to water losses. The longer the distance of the farm to the market, the longer the time it will take for the produce to get to the market and so, postharvest losses will increase because of congestion of the produce and build-up of heat. Training and access to agricultural extension have a significant impact on postharvest handling practices. Gained postharvest handling knowledge entails good handling practices and hence a reduction in postharvest losses.

Table 3.2: Explanatory variables used in the regression model

Variable	Description	Measurement	Expected sign
GND	Gender of the household head	D = 1 if Male; 0 = otherwise	+/-
Mar_Stat	Marital status of household head	D = 1 if Married; 0 = otherwise	+/-
Fam_Xp	Farming experience of household head	Number of years	-
Edu_Lvl	Attendance of post-primary education by household head	D = 1 if Yes; 0 = otherwise	-
Fam_Grp	Membership of a farming group	D = 1 if Yes; 0 = otherwise	-
Fam_Sz	Farm size	Hectares	+
Hnd_Eqp_Was	Washing of hands & postharvest handling equipment	D = 1 if Yes; 0 = otherwise	-
Tm_Hvst	Time of harvesting	D = 1 if morning; 0 = otherwise	-
Pck_Usd	Use of crates as packaging	D = 1 if Yes; 0 = otherwise	-
Tm_Sto	Time taken keeping harvested produce before transporting to the market	Hours	+
Dst_Mkt	Distance from the farm to the market	Kilometres	+
Trn_PHH	Postharvest handling training attendance	D = 1 if Yes; 0 = otherwise	-

The quantity of cabbage lost, quantity of spinach lost and quantity of tomato lost were used as the dependent variables in the econometric models. Table 3.2 gives a description of the dependent variables as used in the regression models.

Table 3.3: Dependent variables used in the regression models

Variable	Description	Measurement
Qnty_Cab	Quantity of cabbage lost	1 = 1 – 25 % 2 = 26 – 50 % 3 = 51 – 75 % 4 = 76 – 100 %
Qnty_Spin	Quantity of spinach lost	
Qnty_Tom	Quantity of tomato lost	

3.8 Summary

This chapter presented the research methodology adopted in the mini dissertation. The chapter provided background information on the study area, the research design; the data sources and elaborates how the sample selection was done. The chapter goes on to describe the data collection procedures (the research instrument, validity and reliability, pilot study and the data collection exercise). The chapter also elaborated the descriptive statistical analysis and the econometric analysis that was adopted. A mathematical presentation of the econometric model used in the study was also given in this chapter. The variables that were used in the regression models were also discussed and the regression diagnostics.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

The chapter presents the main findings of the study. It reports on descriptive statistical analysis of household demographic and socio-economic characteristics of smallholder farmers in Umbumbulu which addresses the first objective of the study. This is followed by a descriptive statistical analysis of the farming system and crop choices to address the second objective. Knowledge, postharvest handling training and practices regarding the study area are also described in this chapter as part of the second objective of the study. The chapter lastly gives the ordered probit regression results which were utilised to determine factors affecting leafy and fruit vegetable postharvest losses among smallholder farmers in Umbumbulu.

4.2 Household demographic and socio-economic characteristics

Descriptive statistical analysis of both continuous and categorical variables for the smallholder farmers was done in terms of their demographics and socio-economic characteristics. The results of descriptive analysis are presented in Table 4.1 and Table 4.2. Results in Table 4.1 present the descriptive analysis of categorical variables while Table 4.2 presents the results from descriptive analysis of the continuous variables.

4.2.1 Gender of household head

The results in Table 4.1 revealed that the majority of the households were female-headed which supports the widely encountered phenomenon in Africa. This indicated that women played significant role in vegetable production and postharvest processes, especially in the study area. Statistics South Africa's Labour Force Survey (LFS) of March 2007 revealed that women make up 60% of all those involved in farming (Aliber and Hart, 2009). Insofar as women outnumber men as subsistence producers, this is consistent with the prevalent stereotype of homeland agriculture. This shows that when postharvest losses occur, the livelihood of women is mostly affected (Mbuk *et al.,* 2011).

Table 4.1: Descriptive categorical demographic and socio-economic variables

Variable description	Categories	Frequency	Percent
Gender of respondent	0 = Female	76	63.3
	1 = Male	44	36.7
Marital status of respondent	0 = Single	49	40.8
	1 = Married	71	59.2
Formal education level of household head	1 = None	17	14.2
	2 = Primary education	48	40.0
	3 = Secondary education	48	40.0
	4 = Tertiary education	7	5.8
Literacy of household head	0 = Illiterate	65	54.2
	1 = Literate	55	45.8
Main occupation of household head	0 = Otherwise	21	17.5
	1 = Farming	99	82.5
Main source of household income	0 = Otherwise	83	69.2
	1 = Farming	37	30.8
Membership of a farmer's group	0 = Otherwise	26	21.7
	1 = Yes	94	78.3
Land ownership	0 = Group owned	43	35.8
	1 = Own	77	64.2

Postharvest literacy defined as attendance of post primary education i.e. secondary and tertiary education level (Babalola *et al.,* 2010; Mbuk *et al.,* 2011).

Source: Survey data (2013)

Farming is mainly undertaken by female members of the household in the study area since most of the men are engaged in wage employment at neighbouring sugarcane farms as well as employed as migrant workers in other cities. These findings affirm that women make up 61% of all those involved in farming as reported by Altman *et al.* (2009). These findings show that an investment in women would have a greater impact in postharvest loss reduction since they are actively involved in agriculture.

4.2.2 Marital status of household head

Table 4.1 shows that 59.2% of the household heads are married while 40.8% are single headed households. This result is a clear indication of a relatively large proportion of married households in the study area. Married household heads are thought to have an advantage with regards to labour availability for their production and postharvest handling activities, which in turn could minimise postharvest losses. Takane (2008) contented that usually single headed households are female–headed households, and because of the absence of husbands, female-headed households have fewer economically-active household members and are in a disadvantageous position relative to their male-headed counterparts in deploying family labour for farm activities.

Table 4.2: Descriptive continuous demographic and socio-economic variables

Variable description	Minimum	Maximum	Mean	Std. Deviation
Age of household head in years	25	78	53.98	11.623
Farming experience in years	1	46	9.07	8.726
Household size in numbers	2	17	7.01	2.980
Farm size in hectares	0.20	5.00	1.812	1.165

Source: Survey data (2013)

4.2.3 Age of household head

Table 4.2 indicates a minimum age of 25 years and a maximum of 78 years reported in this study. Table 4.2 also indicates a mean age of 53.98 years which suggests an ageing farmer population. This can be attributed to a number of factors; chief among others being that Umbumbulu is entirely a farming community with very few other professions available to absorb this generation therefore leaving them with no option except farming. This age might not be appropriate for strenuous farm activities like land preparation, weeding, planting, heaping and harvesting and as a result may negatively affect production by leading to technical inefficiency (Obasi *et al.,* 2013).

The youngest farmer was 25 years old in the study area. The age statistics suggest an ageing farmer population in the study area, with the much younger generation moving to more

lucrative and higher paying ventures in the non-farm sectors. Discussions with the farmers indicated that the youths were shunning the agricultural sector because it is less paying compared to other sectors. The results show that very few young farmers are engaged in farming, confirming the preceding findings by Mìne (2006) and Kisaka-Lwayo (2012) who found that in many African rural settings, the younger generation migrates to urban areas and farming is undertaken by the older generation.

Overall, these findings are consistent with previous studies in the province that estimated the average household head to be roughly 60 years of age (Matungul *et al.,* 2001) and an average age of around 50 years reported by Gadzikwa *et al.* (2006) in Umbumbulu. The study results also affirm the findings by Chikazunga and Paradza (2012) which reported a majority of the farmers in Limpopo with an average age of 55 years.

4.2.4 Farming experience of household head

The results in Table 4.2 show a farming community which is largely composed of a moderately experienced population. These years of experience in vegetable production suggest better knowledge and adoption of postharvest handling technology and practices among the farmers. Such a population with moderate farming experience requires more frequent fruit and vegetable training and agricultural extension services for the farmers to be better equipped in meeting the challenges that come with smallholder vegetable farming. However, an inexperienced farming community coupled with low formal education levels might be contributory to high postharvest losses (Babalola *et al.,* 2010).

4.2.5 Household size

The results in Table 4.2 show that smallholder farmers in Umbumbulu have large families indicating a high supply of labour for the farming and postharvest practices. This statistical result is very close to the findings from a study by Hendriks and Msaki (2009) in Umbumbulu which indicated that household size ranged from one to 25, with a mean of eight members. These findings affirm the findings by Matungul *et al.* (2001) who reported mean household sizes of 6.7 in Impendle and Swayimani (two rural areas of KwaZulu-Natal). Large households as denoted by the study findings however, also highlights the likelihood of

high poverty level among the farming households (Akinbile and Ndaghu, 2005; Babalola *et al.,* 2008).

Large household sizes ensure adequate supply of family labour for vegetable production activities and also enable household members to earn additional income from non-farm activities (Martey *et al.,* 2012). Large family sizes are also an indication of availability of labour and provide the opportunity for the farm to develop the technical know-how required in farming (Kisaka-Lwayo, 2007). Moloi (2008) however argued that generally large household sizes have more people to feed and, as a result, they may commit less money to purchase inputs, which, in turn negatively affects farm income.

4.2.6 Formal educational level and literacy of household head

Data with respect to the education levels of sampled farmers were collected on the basis of the formal level of education attended. Education levels were grouped into four groups i.e. (i) – no formal education attended; (ii) – primary education; (iii) – secondary education and (iv) – tertiary education. Descriptive analyses, presented in Table 4.1 indicated that a small proportion of the farmers 14.2% had never attended school, 40.0% attended up to primary school, 40.0% up to secondary level and only 5.8% attended up to tertiary level. Generally, the level of literacy is low considering the technical knowhow required for proper farm management, pest and disease control and postharvest handling practices in vegetable production. This could be a contributory factor to high postharvest losses in smallholder vegetable production because only farmers with post primary education can appreciate and use most postharvest technologies.

In most instances, farmers with secondary education can easily understand the dynamics of farming for business purposes and can be easily trained, unlike the ones with primary education only (Moloi, 2008). Only farmers with post primary education can appreciate and use most postharvest technologies available (Babalola *et al.,* 2010). Basing on these assumptions, this study therefore related education level to literacy which enables a farmer to understand postharvest handling practices. In this regard, literacy was categorised into two categories, literate (attended post primary education) and illiterate (no formal education and attendance of only primary education). Basing on literacy levels, only 45.8% of the farmers are literate and 54.2% are illiterate. This result is consistent with the findings by Fawole and

Fasina (2005) and Babalola *et al.* (2010). This result also supports the one reported by Dearlove (2007) and Mnkeni *et al.* (2010) where they concluded that there were high levels of illiteracy in smallholder irrigation schemes in KwaZulu-Natal.

Low levels of education, more especially amongst vegetable farmers, is a hindrance to respond to new business opportunities or improved methods of doing farm business and production and, as a result, this negatively affects the farm income. Furthermore, this may render them less competitive in the current market system wherein they have to compete with their established counterparts. Unless the imbalances of education or training are addressed, the farm income of most smallholder farmers is likely not going to change for an extended period regardless of the number of efforts that the government is investing in emerging farmers.

4.2.7 Main occupation and source of income

Table 4.1 shows that 82.5% of the farmers practice farming as their main occupation, while only 21 (17.5%) of the farmers have other occupations (such as regular salaried jobs, temporary jobs, trading, retired etc.) as their main occupation. This suggests that most of the farmers combined occupations to complement their earnings. Such households also diversify their sources of livelihoods and income in order to manage their risk (Baiphethi and Jacobs, 2009).

The results in Table 4.1 also show that only 30.8% took farming as their main source of income while 69.2% rely on other sources of income such as social grants, pension, remittances, salaries and wages. This shows that most smallholder farmers in South Africa tend to diversify their income and livelihood sources where possible, which is a strategy to spread and manage risk and is a buffer against poverty. This result affirms what was argued by Aliber and Hart (2009) who contended that while some livelihood and income might arise from agricultural production and the exchange of produce for other products or services, a greater percentage of income is earned from other sources such as remittances (including social grants and migrant labour contributions), purchase and sale of goods – especially consumables such as food, beverages and paraffin, the renting of animals for traction, sale of labour and off-farm full-time and seasonal employment in rural towns or on commercial farms.

Although the majority of the households 82.5% practiced farming as their main occupation, agriculture was not the main source of cash income. This suggests that those who cultivated crops did so to provide an extra source of food for the household. Matungul *et al.* (2001) reported that household income was mainly from off-farm sources such as welfare payments and wage remittances.

Studies by Ellis and Mdoe (2003) from a sample of rural villages in Tanzania revealed that, on average, half of household income came from crops and livestock and the other half from non-farm wage employment, self-employment and remittances. The poorest households were more reliant on agriculture; a reliance which decreased as non-farm activities increased. However, surpluses from off-farm income may provide farmers with the financial security that would enable greater on-farm innovation. Smallholder agriculture should therefore be understood in this context of diversified income sources. Despite the challenges faced by smallholder farmers, African rural-dwellers value the pursuit of farming activities (Bryceson, 2000) thus subsistence production of food is still a major component of livelihoods in sub-Saharan Africa.

Since most people consider farming as an alternative job when they are retiring, this may mean that they do not invest considerably in this business due to the fact that they are not driven far by business passion to generate more income. Likewise, the old farmers, especially those with low levels of education cannot easily respond to opportunities and improved productivity as the young people would do. As a result, agricultural productivity would be low due to the fact that old farmers may not easily adopt new ways of production that would enhance productivity and minimise postharvest losses. Farm income will remain low as a result of these factors.

4.2.8 Farmers' group membership

The results in Table 4.1 show that there is a high percentage of participation in farming groups. Key informant interviews disclosed that most of the members were involved in farmers' groups mostly for social activities, improving access to land, government support and buying inputs at a cheaper cost from the Agri-hub. Although there are huge benefits in farming as a farmer cooperative or farmer groups, close corporation and partnership, low

levels of education, different objectives and goals of vegetable producing farmers may have contributed to some of them not to consider operating in partnership, close corporation and farmer cooperatives or groups.

Household membership of association/group increases access to information important to production and marketing decisions. The results show that the majority of the farmers belong to a farmer association and have access to market information through friends, relatives and sometimes the media (Martey *et al.,* 2012). Most farmer groups engage in group marketing as well as credit provision for their members, therefore it is expected that household membership of association/group will positively impact on market participation (Martey *et al.,* 2012). Farmers that are involved in cooperatives and partnerships are expected to generate more income as compared to the ones that farm on their own unless the individual farmers have enough capital, skills and labour that is necessary for their farming activity (Moloi, 2008).

4.2.9 Farm size and ownership

The results in Table 4.2 supports that land holdings in the former homelands are generally very small as reported by Aliber and Hart (2009) and are mainly used for subsistence purposes. Matungul *et al.* (2001) reported average farm sizes of 1.1 hectares in Impendle and 1.8 hectares in Swayimani. Hendriks and Msaki (2009) also reported small farm sizes that varied from 0.01 to 8.90 hectares with a mean of 0.6969 hectares from their study conducted among Ezemvelo Farmers Organisation in Umbumbulu.

Higher land holdings serve as an incentive to produce surplus for markets (Martey *et al.,* 2012). Farm size has a direct impact on the farm income; with the larger farm expected to generate more income and reduce the cost of production. However, most smallholder farmers are still having small land sizes hence low income from farming activities. Farm size is directly related with employment of labour. If the farm size is big and the household labour is not able to handle the farming activities, the employment of labour is necessary for income generation. However, in cases where the size of the farm is small coupled with costly labour, this will reduce the farm income. Large farm sizes can mean the need to rely on hired labour which has negative effects on postharvest losses. Hired labour may not carefully handle

produce whilst harvesting resulting in high postharvest losses from mechanical damages induced by poor handling.

It was however observed that even though the majority of the farmers in the study area own the land, the size of the land owned was very small thus such land size is not adequate to use as collateral for credit access. As stated by Ortmann and Machethe (2003), smallholder agriculture is characterised by insufficient security of land tenure and free rider problems associated with communal land ownership which are considerable obstacles to agricultural development.

4.3 Crop choices, knowledge, training, practices and quantities lost

4.3.1 Farming methods

Key informant interviews revealed that the choice for organic production was driven by the perception that organic produce is safe and nutritious. Key informant interviews also revealed that organic production was a cheap means of production using indigenous knowledge systems and producing vegetables in an environmentally friendly way. This affirms the findings from a similar study area by Modi (2003) in study conducted in Embo, Umbumbulu, which established that farmer's decision to produce organic vegetables was influenced by perceptions that organic produce was more nutritious and safe.

Environmental sustainability, cultural factors and profitability are the major drivers of organic farming as an opportunity for small-scale farmers in Africa (Thamaga-Chitja and Hendriks, 2008). Organic products often fetch premium market prices hence their production and marketing could alleviate food insecurity for smallholder farmers.

It is believed that organic production systems are similar to many traditional African production systems that have been practised for years by smallholder farmers (Thamaga-Chitja and Hendriks, 2008). This could be one of the reasons why many rural smallholder farmers practice organic farming systems. Some farmers in the study area cited that their choice for organic farming was compelled by the fact that it is a cheap production system. This is supported by Hellin and Higman (2002) and Scialabba (2007) who revealed that organic farming uses readily available resources in nature to improve soil fertility and to

manage pests and diseases, and appears to offer an opportunity to smallholder farmers to realise commercial and food security goals that may not be possible through conventional agriculture. However, the organic production system among the studied farmers is not certified since the certification system is lengthy, technical and very costly. Government intervention in assisting smallholder farmers towards organic certification is critical in this area if the smallholder farmers are to enjoy premium prices paid for organically certified products.

4.3.2 Crop choices

The vegetables grown in the study area include beetroot, butternut, cabbage, carrots, green beans, green mealies, lettuce, onions, green pepper, potatoes, spinach, sweet potatoes, tomatoes and *madumbe* (yams) as shown in Figure 4.1

The findings from this study were close to the findings by Mdluli *et al.* (2013) in the same study area. They reported that 87.7% of all farmers who participated in the study cultivated beetroot and 84.9% produced cabbage and carrots. Findings from this study are however contradictory to the findings by Mdluli *et al.* (2013) about the least grown vegetables were they reported turnip and onions (4.1%) being the least grown vegetables. The high percentage for onions in this study could be as a result of more farmers being ready to produce them since they experienced little problems in their production and the percentage postharvest losses are considerably low on onions. Key informants revealed that onions are less prone to pests and diseases which result their production being easy and less costly.

Key informants pointed out that personal preferences, health, nutrition, customer demand (mainly the Agri-hub) and affordability were the main driving forces behind the choice of vegetables grown. Table 4.3 shows that a small proportion of the farmers grew their vegetables mainly for consumption while the majority produced mainly for sell. However, selling vegetable surplus for economic gain was done only once self-consumption needs have been fulfilled (Mdluli *et al.,* 2013). Other respondents cited that self-consumption reasons were behind vegetable selection which led other farmers to prefer growing crops that they consume over those that were grown for sale. This was confirmed by respondents who all admitted to consume the vegetables produced at a household level.

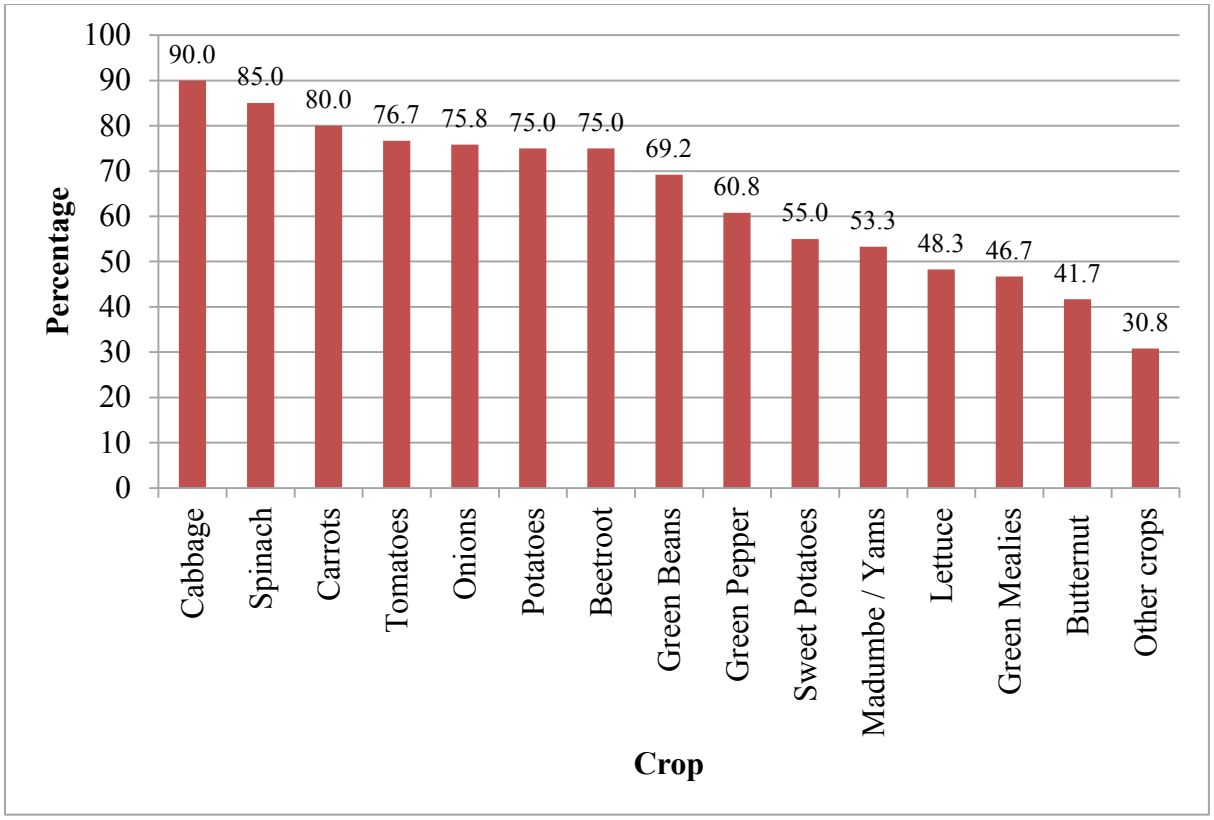

Fig 4.1: Crops grown by the farmers in Umbumbulu: Survey data (2013)

Key informants cited that seedling availability, affordability and the farmer's understanding of the production system of certain vegetables resulted in their preference over others. Some of the crops such as lettuce were preferred by other farmers (though it was being produced by only 48.3% of the farmers) because of the high returns and availability of a ready market. Production of lettuce was however hindered by lack of lettuce agronomic skills, pests and diseases. Leafy vegetables such as cabbage and spinach were grown by the majority of the farmers regardless of high postharvest losses because these vegetable are regarded by the community as 'traditional' vegetables which every farmer had to consume. Traditional vegetables such as sweet potatoes and *madumbe* were grown by approximately 50% of the farmers for self-consumption and the market did not prefer these types of vegetables.

The results in Table 4.3 shows that crop choices were partly driven by extension advocacy and farmer preferences. The results also show that the majority of the farmers have a surplus to sell which supports the finding that selling was the main reason for growing the crops.

Table 4.3: Key drivers of crop choices

Variable description	Categories	Frequency	Percentage
Main reason for growing the vegetables	Sell	80	66.7
	Consumption	40	33.3
Surplus available always	No	25	20.8
	Yes	95	79.2
Crops grown advocated by extension officers	No	64	53.3
	Yes	56	46.7

Source: Survey data (2013)

Table 4.4 presents a cross tabulation of surplus availability and the reason for growing the vegetables. Chi square results show that there is a significant difference (**p = 0.001**) between surplus availability and the reason for growing the vegetables. This shows that smallholder farmers who grow vegetables mainly for sell always had surplus which they could sell to ensure that the main reason for growing them has been satisfied.

Table 4.4: Cross tabulation - surplus availability and reason for growing the crops

Description	Category	Surplus availability always		Total
		Yes	No	
Main reason for growing the vegetables	Sell	9 (36.0%)	71 (74.7%)	80 (66.7%)
	Consumption	16 (64.0%)	24 (25.3%)	40 (33.3%)
	Total	25	95	N = 120
Chi square		**Value** 13.364	***P* value .001**	

Source: Survey data (2013)

A chi square test of gender and the reasons for growing the vegetables show that there is no significant difference (p = 0.789) between the reason for vegetable growing by men and women. This is an indication that men and women in the study area grew almost similar crops. This result can be attributed to the fact that both men and women grew the vegetables mainly for sell hence no significant difference across gender.

Table 4.5: Cross tabulation - gender and the reason for growing vegetables

Description	**Category**	**Gender of household head**		**Total**
		Female	**Male**	
Main reason for growing the vegetables	Sell Consumption	50 (65.8%) 26 (34.2%)	30 (68.2%) 14 (31.8%)	80 (66.7%) 40 (33.3%)
	Total	76	44	N = 120
Chi square		**Value** 0.72	**P value** 0.789	

Source: Survey data (2013)

Results in Table 4.6 supports the point that was raised by key informant interviews that the majority of part time famers grow vegetables for consumption or other reasons whilst the majority of full time farmers grow vegetables for sell. The main reason for selling the vegetables that they produce is mainly to supplement household income. Chi square test shows that there is a significant difference (**p = 0.027**) between full time and part time farmers with respect to the main reason for growing vegetables.

Table 4.6: Cross tabulation - full time farming and reasons for growing vegetables

Description	**Category**	**Full time farming**		**Total**
		Otherwise	**Yes**	
Main reason for growing the vegetables	Sell Consumption	3 (33.3%) 6 (66.7%)	77 (69.4%) 34 (30.6%)	80 (66.7%) 40 (33.3%)
	Total	9	111	N = 120
Chi square		**Value** 4.865	***P* value** **0.027**	

Source: Survey data (2013)

The results in Table 4.7 differ from the expected outcome where a higher percentage is expected to grow vegetables mainly for sell as compared to non-farmer group members. The reason for a variation in this study could be due to the observed trend that even though most of the farmers are in farmer groups; they produce individually but use the bargaining power of farmer groups to access inputs at a lower cost form the Agri-hub. Some of the farmer groups exist just for the sake of accessing land without the intention to produce as a group. Chi square results however shows no significant difference (p = 0.210) between the reasons for growing crops by farmer group members and non-farmer group members.

Table 4.7: Cross tabulation - farmers' group membership and reasons for growing vegetables

Description	**Category**	**Farmers' group membership**		**Total**
		Otherwise	**Yes**	
Main reason for growing the vegetables	Sell Consumption	20 (76.9%) 6 (23.1%)	60 (63.8%) 34 (36.2%)	80 (66.7%) 40 (33.3%)
	Total	26	94	N = 120
Chi square		**Value** 1.571	***P* value** 0.210	

Source: Survey data (2013)

Even though it is suggested that smallholder farmers often need to produce and market their produce collectively in order to reduce unit compliance and transactional costs to viable levels, Hendriks and Lyne (2009), however, contented that farmer groups have their own costs and institutional difficulties, which hamper smallholder farmer participation. Collective action enables individual poor farmers to attain economies of scale in terms of size of supply and scope of produce, which will allow them to engage on a level negotiation platform (Louw *et al.,* 2008). One of the main reasons behind the failure to achieve fruitful outcomes in farmer groups as reported by key informants is the free rider problem and lack of a common vision among members.

Table 4.8: Cross tabulation - main occupation and reasons for growing vegetables

Description	**Category**	**Main occupation**		**Total**
		Otherwise	**Farming**	
Main reason for growing the vegetables	Sell Consumption	9 (42.9%) 12 (57.1%)	71 (71.7%) 28 (28.3%)	80 (66.7%) 40 (33.3%)
	Total	21	99	N = 120
Chi square		**Value** 6.494	***P* value** **0.011**	

Source: Survey data (2013)

Chi square test results in Table 4.8 shows that there is a significant difference (**p = 0.011**) between main occupation and the reason for growing the vegetables. Those participants whose main occupation was farming produced mainly for sell while those whose occupations were other than farming produced mainly for consumption. Investment in people whose main

occupation is farming will help to produce a variety of vegetables for sell in local and national fresh produce markets since selling is their main reason for agricultural production.

4.3.3 Labour availability

The results in Table 4.9 show that the majority of the households do not have sufficient family labour for their production and postharvest operations. Household sizes were found to be big as in Table 4.2 with an average of seven persons, which suggests availability of family labour for the farming operations. The contradiction could be as a result of youth shunning agricultural activities as was pointed out by key informants in the study area. Another contributory factor could be as a result of the aging population. The aging population is not able to supply the labour required for strenuous farming activities such as land preparation, planting, weeding and harvesting operations.

Even though farming still remains important for rural households, people are looking for diverse opportunities to increase and stabilise their incomes and therefore rural livelihoods are based not solely on agriculture but on a diverse array of activities and enterprises (Aliber and Hart, 2009). Shortage of family labour implies the need to use labour from other sources such as hiring or use of cooperative / farmers' group members. Hired labour requires training prior to harvesting so as to ensure that careful handling is practiced to minimise mechanical damages on produce.

Table 4.9: Labour availability

Description	Category	Frequency	Percentage
Availability of enough family labour	No	82	68.3
	Yes	38	31.7
Shortage of harvesting labour	No	68	56.7
	Yes	52	43.3
Training of hired labour before harvesting	No	15	28.8
	Yes	37	71.2

Source: Survey data (2013)

Table 4.9 shows that the majority of the vegetable farmers had enough family labour for vegetable harvesting activities. Farmers who did not have enough family labour relied on hired labour for these operations or made other arrangements such as agreeing with other families in the community to help each other when the need arises. Lack of training of the hired labour for harvesting operations is thought to have a negative effect on postharvest quality. This could have contributed to high postharvest losses reported by some of the vegetable farmers.

4.3.4 Knowledge, training and postharvest handling practices

4.3.4.1 Knowledge and training

Fruit and vegetable training included land preparation, soil management, planting, pest and disease control, organic farming principles, irrigation practices, postharvest handling and marketing.

These results in Table 4.10 show a general lack in sufficient postharvest handling practices to have a significant impact on postharvest loss reduction. Acikel *et al.* (2008) however represented that the most efficient method to stop food related epidemics problem or at the very least to decrease it is by training those working in the food industry and repeating this training periodically. If ever training is to have an impact on postharvest handling practices, there is however a need for this training to be repeated more often. Key informant interviews revealed that some of the farmers had received fruit and vegetable training more than a year before the survey was conducted.

Formal educational level is suggested to have an influence on knowledge of postharvest handlers. A study to assess knowledge of food hygiene of professional food handlers from an institutional catering company which manufactures and distributes meals to the canteens of schools, kindergartens and nursing homes by Martins *et al.* (2012) revealed that the level of knowledge among handlers was influenced by their level of formal education. If formal education is taken into consideration, these observations affirm the findings by Kereth *et al.* (2013) that indicated both formal educational and postharvest knowledge gaps which in turn affect agricultural activities within the entire food chain, especially postharvest handling.

Table 4.10: Fruit and vegetable training

Variable description	Response	Frequency	Percentage
Fruit and vegetable training attendance	No	26	21.7
	Yes	94	78.3
Land preparation training	No	33	27.5
	Yes	87	72.5
Soil management training	No	30	25.0
	Yes	90	75.0
Planting training	No	27	22.5
	Yes	93	77.5
Pest and disease control training	No	36	30.0
	Yes	84	70.0
Organic farming training	No	35	29.2
	Yes	85	70.8
Irrigation training	No	49	40.8
	Yes	71	59.2
Personal hygiene training	No	50	41.7
	Yes	70	58.3
Postharvest handling training	No	50	41.7
	Yes	70	58.3
Marketing training	No	80	66.7
	Yes	40	33.3
When was training last attended?	>Month ago	78	83.0
	<Month ago	16	17.0

Source: Survey data (2013)

4.3.4.2 Access to agricultural extension services

The provision of extension services remains one of the major interventions that are crucial in the agricultural sector for rural development, food security, poverty alleviation and income generation of the emerging farmers. Table 4.11 shows that the majority of the farmers had access to agricultural extension. Some of the members had last met extension officers more

than a year ago. If vegetable production is to succeed, key informants suggested that extension visits be done regularly.

Table 4.11: Access to agricultural extension services

Variable description	Response	Frequency	Percentage
Access to agricultural extension	No	23	19.2
	Yes	97	80.8
Frequency of agricultural extension	Rarely	39	32.5
	Sometimes	27	22.5
	Often	31	25.8

Note: *rarely (once or twice); sometimes (3 to 6 times); often (> 6 times) per year*

Source: Survey data (2013)

The role of the extension and advisory services can never be undermined, more especially their contribution to the emerging agricultural sector, given the challenges in the industry, low education levels and the inexperienced smallholder farmer population. The provision of agricultural extension services remains one of the major interventions that are crucial in the agricultural sector, especially in smallholder farming for rural development, food security, poverty alleviation, postharvest loss reduction and income generation of the smallholder farming community. In their study, Thamaga-Chitja and Hendriks (2008) however noted that there is insufficient appropriate information to smallholder farmers to make better decisions about agricultural production, marketing, pest and disease control and organic certification.

Chi square test in Tale 4.12.shows that there is no significant difference ($p = 0.451$) between men and female access to agricultural extension. This implies that men and women had more or less equal access to extension and the frequency with which they had contact with the extension service was not statistically different for both genders.

Table 4.12: Cross tabulation - access to agricultural extension services and gender

Description	Category	Access to agricultural extension		Total
		Female	Male	
Access to agricultural extension	No	13 (17.1%)	10 (22.7%)	23 (19.2%)
	Yes	63 (82.9%)	34 (77.3%)	97 (80.8%)
	Total	76	44	N = 120
Chi square		**Value**	***P* value**	
		0.569	0.451	

Source: Survey data (2013)

4.3.4.3 Washing of hands and postharvest handling equipment

The results in Table 4.13 show a general good practice hand washing and postharvest handling equipment before harvesting vegetables. These results show that there is a high understanding and practice of good personal hygiene in the study area. Good hygiene practices are vital in minimising cross contamination hence postharvest reduction in fresh produce handling (Kader and Rolle, 2004).

Table 4.13: Key postharvest handling practices

Description	Category	Frequency	Percentage
Hand and equipment washing	No	9	7.5
	Yes	111	92.5
Time of harvesting	Otherwise	26	21.7
	Morning	94	78.3
Packaging used	Crates	66	55.0
	Sacks	21	17.5
	Boxes	19	8.3
	Other	23	19.2

Source: Survey data (2013)

4.3.4.4 Time of harvesting

The results for harvesting time of the fruits presented in Table 4.13 shows that majority of the respondents harvest vegetables early in the morning. Farmers supplying the local community harvested anytime a customer comes to buy the vegetables. Farmers supplying the Agri-hub harvested either in the morning or in the afternoon depending with the time when the vegetables were collected by the Agri-hub vehicle. Arrangements for the collection are done in advance so that the farmer can harvest accordingly. Kereth *et al.* (2013) reviewed that 95% of farmers harvested fruits in the morning in a study conducted in Bagamoyo district of Tanzania.

Harvesting in the afternoon has been reported to be a cause of high postharvest losses because of high temperatures and evaporation which causes the vegetables to shrink, thus affecting the marketing quality. Similar results have been reported by Genova *et al.* (2006) and Kereth *et al.* (2013) that harvesting activities should be completed during the coolest time of the day, which is usually in the early morning and produce should be kept shaded in the field and handled gently. Muhammad *et al.* (2012) concluded that a complete lack of proper postharvest knowledge was evident among farmers, as only 10% of the respondents in their study were found to harvest at an appropriate time of harvesting i.e. morning and evening.

4.3.4.5 Packaging used for vegetable packing

The results presented in Table 4.13 show that the majority of the farmers pack the vegetables in crates while only a few farmers pack in sacks, boxes and other means of packaging such as plastic bags brought by the customer. While crates are expensive, they serve as a good form of packaging for vegetables. The rest of the packaging options are reported to be cheap and mostly available, however, they have several disadvantages because they bruise the produce and cause it to be jarred and or compressed. Kereth *et al.* (2013) argued that the use of sacks does not protect fresh produce from mechanical damage as they cause postharvest losses by crushing. Kader and Rolle (2004) argued that a congestion of fruits and vegetables creates high heat in the sacks due to physiological change by metabolic reaction which in turn accelerates mechanical damage and microbial attack.

Results from a study by Kereth *et al.* (2013) revealed that 40% of the respondents pack their fruits in plastic sacks, 20% in baskets, 25% in woven bamboo baskets "*tenga*" while 15% in wooden crates. These packaging materials were reported to be cheap and mostly available in their study area.

4.3.4.6 Storage prior transporting to the market

Table 4.14 shows that produce storage prior transporting to the market ranged from zero to a maximum of 18 hours. These results show that some farmers (zero storage time) harvested and delivered to the market at the same time without storing the produce at the farm. Considering that none of the farmers in the study area have cold storage facilities at their farms, storage of produce for long periods such as 18 hours as reported in Table 4.13 is a contributory factor to high postharvest losses. This will result in rapid quality loss of the vegetables especially in summer when temperatures are generally high. Minimising the time spent keeping harvested produce at the farm will help in reducing postharvest losses as suggested by Kader (2005) who argued that as the time the produce stays in the market increase from the time of purchase, its deterioration also increases.

Table 4.14: Storage duration and distance to the market

Variable description	Minimum	Maximum	Mean	Std. Deviation
Storage duration before transporting	0	18	2.74	4.934
Distance from farm to market	0	30	7.93	7.165

Source: Survey data (2013)

Key informant interviews reported that farmers who kept their produce for more than five hours were the ones who harvested in the afternoon and the produce was only transported the following day in the morning to the respective market/ customers. Key informants also reported that storage for long hours is more evident in farmers who reside further form the Agri-Hub and the customers being supplied.

4.3.4.7 Distance to the market

Table 4.14 shows that distance from the farm to the market ranged from zero to a maximum of 30km. Key informants reviewed that transportation of fresh produce was hampered by poor roads in the study area, which are mainly dust roads. Such roads also contribute to product deterioration since the produce is contaminated with dust particles on delivery. The situation was aggravated by uncovered vehicles being used to ferry fresh produce from the farmer. The type of infrastructure and distance to the final markets play a critical role in the distribution and marketing of fruits and vegetables (Lenné and Ward, 2010). The longer the distance, the longer the time it will take for the produce to get to the market and so, the losses will increase because of congestion of the product and build-up of heat (Babalola *et al.,* 2010).

4.3.4.8 Produce cooling

The study revealed that all farmers did not have facilities to cool the produce before transporting and all transport systems used in the study area are not refrigerated to cool down the produce being delivered to the respective customers. This negatively affects the quality of the produce and poses a risk of huge postharvest losses along the value chain as argued by Kader (2005) that overheating during storage and transportation of fruits and vegetables leads to decay and increases the rate of water loss. High temperature increases the biological reactions in fruits and vegetables such as metabolism and respiration (Mashau *et al.,* 2012), hence increasing the rate of deterioration. Kader (2003) argued that provision of optimum temperature and relative humidity is the most important tool for maintaining quality and safety of intact and fresh-cut fruit and vegetables. Kader (2003) also argued that there is no substitute for the maintenance of cold chain throughout the postharvest handling chain.

4.3.5 Quantity lost

The results in Table 4.15 show that for leafy vegetables, cabbage had higher postharvest losses as compared to other leafy vegetables. Data for fruit vegetables shows that tomatoes had high postharvest losses as compared to the other fruit vegetables in the study area. The results also show that root vegetables had relatively lower postharvest losses as compared to

leafy and fruit vegetables. Overall, cabbage had the highest losses followed by tomatoes and spinach as the third vegetable with highest postharvest losses.

Table 4.15: Quantities of vegetables with high postharvest losses

Vegetable type	Vegetable name	Category of losses	Frequency	Percentage
Leafy vegetables	Cabbage	1 – 25%	48	44.4
		26 – 50%	60	55.6
	Spinach	1 – 25%	78	76.5
		26 – 50%	24	23.5
	Lettuce	1 – 25%	46	79.3
		26 – 50%	12	20.7
Fruit vegetables	Tomatoes	1 – 25%	51	55.4
		26 – 50%	41	44.6
	Green beans	1 – 25%	75	90.4
		26 – 50%	8	9.6
Root vegetables	Carrots	1 – 25%	87	90.6
		26 – 50%	9	9.4
	Potatoes	1 – 25%	83	92.2
		26 – 50%	7	7.8

Source: Survey data (2013)

Discussions with key informants and field observations revealed a number of causes for postharvest losses in the different vegetable categories. The major causes for losses in leafy vegetables were reported to be pests and diseases, wilting of spinach and lettuce, mechanical damage. Wilting can be traced to harvesting in the afternoon when it's hot, lack of cold storage facilities and overheating during transportation as Kader (2005) explained that overheating during transportation of fruits and vegetables leads to decay and increases the rate of water loss. Mechanical damage originates from poor postharvest handling practices (Mbuk *et al.,* 2011). According to FAO (2004), mechanical damage also occurs as a result of careless handling of packed produce, with packages often squeezed into transporting vehicles in order to maximize revenue for transporters.

The major causes of tomatoes and green pepper losses were reported to be rotting, mechanical damage and diseases. The major cause for losses in green beans was reported to be pest and diseases and over maturity. Green maize losses were reported to be mainly attributed to under maturity at harvesting. Rotting can be linked to diseases which affect the crops during their growth stages. On the other hand rotting can also be emanating from poor handling practices which cause mechanical damage to the harvested produce. Poor harvesting practices leads to mechanical damage which include splitting of the fruit vegetables, internal bruising, superficial wounds and crushing of soft produce like tomatoes (Kereth *et al.,* 2013). Poor handling can thus result in development of entry points for mould and bacteria, increased water loss and an increased respiration rate (Dixie, 2005). The level of contamination could be greater due to poor hygiene practices and use of inappropriate packaging materials (Kader, 2005). Discussion with key informants and observations revealed that the major causes for losses in root vegetables were rodents, lack of markets and under maturity which resulted in small sizes which did not meet customer demands.

Key informants revealed that shortage of irrigation equipment was hampering their agronomic production. Most farmers did not have pumps which are a major requirement for irrigation and some of the pumps in place were broken. Water shortage to the crops implies that some of the crops have water and heat stress hence does not mature to the required levels. Shortage of water also leaves the crops prone to pest and diseases. This indirectly leads to high postharvest losses. Most farmers are confined to only producing principally during the rainy season even in the extremely wet parts of summer where losses due to pests and diseases are relatively high (Kisaka-Lwayo, 2012).

4.4 Determinants of leafy and fruit vegetable postharvest losses

From the leafy vegetables, cabbage and spinach were selected for the regression analysis. These crops were ranked first and second in the order of being produced by farmers in the study area (90% and 85% respectively), hence their selection. Key informants and descriptive statistical analysis also show that these vegetables are the ones which were reported to have high postharvest losses. Lettuce, though a leafy vegetable as well with relatively high postharvest losses, was not included in the regression analysis since the vegetable is only grown by 48.3% of the farmers, thus less than 50% of the study participants. Tomato was selected in the regression analysis since high losses were reported in the descriptive analysis

and it is grown by a large proportion of the farmers (grown by 76.7%) in the study area and was reported by key informants to have high postharvest losses, hence its selection for the regression model. Green beans though grown by 69.2% of the farmers were left out in the regression analysis because descriptive statistical analysis shows that 90.4% are losing less than 25% while only 9.6% are losing more than 25% which makes the second category relatively small to be analyzed in the regression model hence the crop was left out. The rest of the crops were not considered in the regression analysis since the quantities lost are only falling into category one (< 25%).

The degree of multicollinearity was assessed using STATA version 13 software package. The Ordinary Least Squares regression (OLS) was initially used to test for multicollinearity, heteroscedasticity and autocorrelation. Results in Table 4.16 show that there was no problem of multicollinearity among the explanatory variables used in all the regression models since the variance inflation factors were less than the critical value of 10, while all the tolerance factors were close to one (Gujarati and Porter, 2009) as indicated in Table 4.16. Mean VIFs of 1.30 for cabbage, 1.27 for spinach and 1.31 for tomatoes were reported. All of the proposed explanatory variables were thus used in the regression model. Robust standard errors were also used to remedy for heteroscedasticity.

The Ordered Probit Regression model was used to establish the determinants of leafy and fruit vegetable postharvest losses among smallholder farmers in Umbumbulu as mentioned earlier on in the previous chapter. The model fits data very well for cabbage, spinach and tomato as indicated by highly statistically significant F values. These findings coupled by the remedy on heteroscedasticity and the absence of multicollinearity, the ordered probit model's estimated coefficients are therefore considerably unbiased, consistent and efficient. The R^2 reported in study were 0.48 for cabbage, 0.63 for spinach and 0.44 for tomato. However, the R^2 value of 0.63 for spinach is relatively high for cross sectional data.

Table 4.16: Diagnostics to assess the degree of multicollinearity

Variable	Cabbage		Spinach		Tomato	
	VIF	**Tolerance (1/VIF)**	**VIF**	**Tolerance (1/VIF)**	**VIF**	**Tolerance (1/VIF)**
Sto_Drxn	1.56	0.641	1.50	0.665	1.58	0.633
Pck_Usd	1.53	0.653	1.48	0.675	1.60	0.627
Trn_PHH	1.52	0.660	1.47	0.680	1.45	0.688
Fam_Grp	1.42	0.706	1.32	0.759	1.41	0.708
Dst_Mkt	1.37	0.732	1.40	0.715	1.48	0.675
Hnd_Eqp_Was	1.25	0.799	1.21	0.829	1.22	0.817
Tm_Hvst	1.24	0.809	1.19	0.838	1.23	0.815
Fam_Xp	1.23	0.814	1.23	0.815	1.18	0.846
GND	1.21	0.828	1.16	0.861	1.17	0.853
Edu_Lvl	1.13	0.889	1.11	0.901	1.15	0.871
Mar_Stat	1.10	0.911	1.08	0.925	1.12	0.891
Fam_Sz	1.05	0.948	1.07	0.932	1.12	0.894
Mean VIF	**1.30**		**1.27**		**1.31**	

Source: Survey data (2013)

The regression results are in Table 4.17; Table 4.18 and Table 4.19. Among the hypothesized variables using ordered probit estimates, those that significantly influenced cabbage postharvest losses include gender of household head (GND), farming experience (Fam_Xp), literacy (Edu_Lvl), type of packaging used (Pck_Usd), distance to the market (Dst_Mkt) and postharvest handling training (Trn_PHH) as indicated in Table 4.17. Variables that significantly influenced spinach postharvest losses include gender of household head (GND), farming experience (Fam_Xp), hand and equipment washing (Hnd_Eqp_Was), time of harvesting (Tm_Hvst), storage duration (Sto_Drxn) and postharvest handling training (Trn_PHH) as indicated in Table 4.18. On the other hand, variables that significantly influenced tomato postharvest losses include farming experience (Fam_Xp), farmers' group membership (Fam_Grp), farm size (Fam_Sz), hand and equipment washing (Hnd_Eqp_Was), packaging used (Pck_Usd) and distance to the market (Dst_Mkt) as indicated in Table 4.19.

4.4.1 Gender of household head

Gender of household head regardless of age is an important variable influencing postharvest losses in smallholder farming. A positive and statistically significant relationship between gender of household head (GDN) and both cabbage and spinach postharvest losses was reported in the study (significant at 10% level and 1% level respectively). This implies that male headed households are likely to experience postharvest losses for these crops as compared to the female headed households.

Considering the fact that more time and careful handling is required to minimise mechanical damages in leafy and fruit vegetables, females are likely to encounter minimal losses since they are careful handlers and are considered to be more patient as compared to their male counterparts. Tomato, cabbage and spinach are produced for household consumption and as cash crops to generate household income. Due to low profit margins for these crops, male farmers tend to give less attention to them whilst giving more attention to those crops which are grown exclusively for cash income. Overall, an increase in male farmers has a significant impact in increasing postharvest losses for cabbage and spinach.

4.4.2 Farming experience of household head

Farming experience of the household head (Fam_Xp) had a strong negative and statistically significant relationship with cabbage, spinach and tomato postharvest losses (significant at 1% level, 5% level and 1% level respectively). These results imply that as the farmer population become more experienced, postharvest losses diminish. An experienced farmer population implies good knowledge and adoption of postharvest handling technology among the farmers (Babalola *et al.,* 2010). An accumulation of farming experience entails a knowledgeable farmer who is in a good position to utilise the acquired skills in postharvest loss reduction.

Table 4.17: Ordered probit regression results for cabbage

Variable	Ordered probit regression			Marginal effects outcome 1			Marginal effects outcome 2		
				Low losses (1 – 25%)			High losses (26 – 50%)		
	Coefficient	Robust Std. Err	Sig	Coefficient	Std. Err	Sig.	Coefficient	Std. Err.	Sig.
GND	**0.690***	0.365	0.059	**-0.250****	0.125	0.046	**0.250****	0.125	0.046
Mar_Stat	-0.336	0.345	0.331	0.126	0.128	0.324	-0.126	0.128	0.324
Fam_Xp	**-0.058*****	0.019	0.003	**0.022*****	0.007	0.003	**-0.022*****	0.007	0.003
Edu_Lvl	**-0.754****	0.354	0.033	**0.284****	0.129	0.028	**-0.284****	0.129	0.028
Fam_Grp	-0.832	0.519	0.109	**0.284****	0.139	0.041	**-0.284****	0.139	0.041
Fam_Sz	0.050	0.132	0.705	-0.019	0.050	0.703	0.019	0.050	0.703
Hnd_Eqp_Was	-0.284	0.541	0.599	0.103	0.189	0.584	-0.103	0.189	0.584
Tm_Hvst	-0.283	0.370	0.444	0.105	0.134	0.431	-0.105	0.134	0.431
Pck_Usd	**-1.036*****	0.370	0.005	**0.369*****	0.115	0.001	**-0.369*****	0.115	0.001
Sto_Drxn	-0.059	0.043	0.166	0.023	0.016	0.168	-0.023	0.016	0.168
Dst_Mkt	**0.056****	0.024	0.021	**-0.021****	0.009	0.020	**0.021****	0.009	0.020
Trn_PHH	**-1.187*****	0.407	0.004	**0.411*****	0.114	0.000	**-0.411*****	0.113	0.000
Wald Chi² (12)	**59.00*****								
Pseudo R ^{2}	0.4801								
Log-likelihood	-38.57								
N	108								

Note: *, **, * means the coefficient is statistically significant at 10%, 5% and 1% levels respectively: Survey data (2013)

Table 4.18: Ordered probit regression results for spinach

Variable	Ordered probit regression			Marginal effects outcome 1			Marginal effects outcome 2		
				Low losses (1 – 25%)			High losses (26 – 50%)		
	Coefficient	Robust Std. Err.	Sig.	Coefficient	Std. Err.	Sig.	Coefficient	Std. Err.	Sig.
GND	**1.570*** **	0.598	0.009	-0.156	0.099	0.114	0.156	0.099	0.114
Mar_Stat	-0.508	0.505	0.314	0.036	0.042	0.397	-0.036	0.042	0.397
Fam_Xp	**-0.133** **	0.062	0.031	**0.008***	0.005	0.072	**-0.008***	0.005	0.072
Edu_Lvl	-0.265	0.465	0.569	0.016	0.029	0.571	-0.016	0.029	0.571
Fam_Grp	-0.007	0.549	0.990	0.0004	0.034	0.990	-0.0004	0.034	0.990
Fam_Sz	0.003	0.164	0.987	-0.0002	0.010	0.987	0.0002	0.010	0.987
Hnd_Eqp_Was	**-2.247*** **	0.581	0.000	**0.539*** **	0.180	0.003	**-0.539*** **	0.180	0.003
Tm_Hvst	**-3.694*** **	0.723	0.000	**0.813*** **	0.116	0.000	**-0.813*** **	0.116	0.000
Pck_Usd	-0.045	0.505	0.929	0.003	0.032	0.930	-0.003	0.032	0.930
Sto_Drxn	**0.169*** **	0.050	0.001	-0.010	0.007	0.159	0.010	0.007	0.159
Dst_Mkt	0.038	0.032	0.230	-0.002	0.003	0.345	0.002	0.003	0.345
Trn_PHH	**-0.880***	0.519	0.090	0.066	0.059	0.260	-0.066	0.059	0.260
Wald Chi² (12)	**39.91*** **								
Pseudo R²	0.6262								
Log-likelihood	-20.86								
N	102								

Note: *, **, * ** means the coefficient is statistically significant at 10%, 5% and 1% levels respectively**:** Survey data (2013)

Table 4.19: Ordered probit regression results for tomatoes

Variable	Ordered probit regression			Marginal effects outcome 1			Marginal effects outcome 2		
				Low losses (1 – 25%)			High losses (26 – 50%)		
	Coefficient	Robust Std. Err	Sig	Coefficient	Std. Err	Sig.	Coefficient	Std. Err.	Sig.
GND	0.402	0.355	0.258	-0.156	0.136	0.252	0.156	0.136	0.252
Mar_Stat	-0.409	0.360	0.255	0.160	0.139	0.252	-0.160	0.139	0.252
Fam_Xp	**-0.113*****	0.031	0.000	**0.044*****	0.012	0.000	**-0.044*****	0.012	0.000
Edu_Lvl	-0.259	0.364	0.477	0.100	0.140	0.475	-0.100	0.140	0.475
Fam_Grp	**-0.837***	0.435	0.054	**0.325****	0.159	0.041	**-0.325****	0.159	0.041
Fam_Sz	**0.415****	0.172	0.016	**-0.161****	0.067	0.016	**0.161****	0.067	0.016
Hnd_Eqp_Was	**-1.530*****	0.474	0.001	**0.517*****	0.113	0.000	**-0.517*****	0.113	0.000
Tm_Hvst	-0.365	0.399	0.360	0.143	0.157	0.360	-0.143	0.157	0.360
Pck_Usd	**-0.832***	0.429	0.052	**0.317****	0.156	0.042	**-0.317****	0.156	0.042
Sto_Drxn	0.018	0.043	0.675	-0.007	0.017	0.675	0.007	0.017	0.675
Dst_Mkt	**0.082*****	0.028	0.004	**-0.032*****	0.011	0.004	**0.032*****	0.011	0.004
Trn_PHH	-0.308	0.401	0.442	0.120	0.156	0.443	-0.120	0.156	0.443
Wald Chi² (12)	**71.81*****								
Pseudo R ^{2}	0.4362								
Log-likelihood	-35.64								
N	92								

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels respectively**:** Survey data (2013)

Farming experience is related to age. Older farmers have a great store of farming knowledge and have much to offer. As revealed by Ahmad *et al.* (2002), Kibaara (2005) and Amos (2007), older household heads have farming experience and adopted new technologies than young farmers, therefore farming experience was expected to have a negative relationship with postharvest losses. Asayehegn *et al.* (2011) argued that age and experience are important variables farmer's decisions in irrigation. Mbuk *et al.* (2011) also reported that farming experience had a negative relationship with tomato postharvest losses, though the relationship was statistically insignificant.

Even though farming experience has an overall effect of reducing postharvest losses in the study area, a marginal increase in farming experience tends to have a significant effect of lowering postharvest losses to only those farmers who are experiencing high postharvest losses. This implies that a unit increase in farming experience increases the likelihood of postharvest loss reduction for tomato farmers in the higher postharvest loss categories as compared to the other crops. If farmers experiencing high postharvest losses gain more experience, their losses diminish.

4.4.3 Literacy of household head

In this study, literacy (Edu_Lvl) was found to have a negative and statistically significant relationship with cabbage postharvest losses (at 5% level), while the results for spinach and tomato indicate a negative though the relationship is statistically insignificant. This postulates that as farmers acquire more formal education, there is likelihood that postharvest losses are reduced. A unit increase in literacy increases the likelihood of reducing cabbage postharvest losses by 28% for those farmers who are experiencing high postharvest losses.

Babalola *et al.* (2010) reported high postharvest losses among farmers with low literacy levels. They argued that illiteracy could be a contributory factor to high postharvest losses in tomato production because only farmers with post primary education can appreciate and use most postharvest technology available. This result is consistent with the findings of Oduekun (1991) as cited by Babalola *et al.* (2010) and Fawole and Fasina (2005). According to Adams (1982), education has the potential to enhance understanding and communication in postharvest technology especially, for the fruit sellers (Mashau *et al.,* 2012). Poor postharvest

management and lack of knowledge of the required technologies, quality standards and food safety protocols severely limit many producers' access to markets (Lenné and Ward, 2010).

Formal education and training in agriculture improves farmers' ability to acquire accurate information, evaluate new production processes, use new agricultural practices and understand the benefits of appropriate farm practices (Kisaka-Lwayo, 2012). Education increases the probability of adoption as it enhances the ability to acquire, interpret and use information about such technology by farmers. However the level of education required is also dependent on the level and complexity of the given technology, hence in this study, farmers were described as literate when they acquired secondary or tertiary education and illiterate when they never attended any formal education or they attended only up to primary level. This is as a result of the complexity in understanding appropriate postharvest handling instructions for better handling practices.

4.4.4 Farmers' group membership

As was hypothesized, farmer group membership (Fam_Grp) had a negative though statistically insignificant relationship with postharvest losses for both cabbage and spinach. A negative and statistically significant relationship (at 10% level) was reported between farmer group membership and tomato postharvest losses. The reason for the variable being insignificant (for cabbage and spinach) and a low significance in tomato postharvest losses may perhaps be as a result of the fact that most farmers (78.7%) have easy access to production inputs through the subsidized government disbursement to the community and the Agri-hub input subsidies as well as free training services. Household membership of association or farmers group increases access to information important to production, postharvest handling and marketing decisions (Martey *et al.,* 2012) and hence minimising postharvest losses.

Ortmann and King (2007) contented that some of the reasons for the formation of farming cooperatives and farmer group organisations include: market failure due to costly information and transaction costs, promotion of self-help, a desire to enhance bargaining strength with input suppliers and buyers of farm products, operational costs, income enhancement, reduction of transaction costs with trading partners, provision of missing services such as inputs and/ or product marketing, assurance of input supplies and/ or product markets

particularly for perishable crops like fruits and vegetables, coordination of the flow of input supplies and farm products to markets, reduce opportunistic behaviour by potential competitors, gain economies of size advantages, public policy (e.g. support of government), and promoting community development in general.

Roothaert and Muhanji (2009) argued that participation in farmers' groups or associations helps to access markets for both inputs and outputs through economies of scale. Membership of farming groups / associations increase service and input accessibility for the members, including supply of agricultural inputs, credit financing, and provision of transport, storage facilities, advisory and training services. This is because farmer groups play a crucial role in ameliorating transaction costs and improving the farmers' competitiveness on input access.

4.4.5 Farm size

A positive though statistically insignificant relationship was observed between farm size (Fam_Sz) and postharvest losses for both spinach and cabbage. On the other hand, a positive and statistically significant relationship (at 5% level) with tomato postharvest losses was reported in the study. This implies that the larger the farm, the higher the likelihood for postharvest losses. Similar results were reported by Babalola *et al.* (2008). They reported that as production scale increases farmers will have to contend with the problem of storage and transportation; and where these facilities are not adequate, losses are imminent. The larger the area put into cultivation the higher the quantity harvested and chances of losses due to poor handling and lack of proper storage (Babalola *et al.,* 2010). Martey *et al.* (2012) however argued that farm size may have indirect positive impacts on market participation by enabling farmers to generate production surpluses and overcome credit market thus reducing postharvest losses.

Overall, an increase in farm size tends to have a significant increase in tomato postharvest losses. However, a unit increase in farm size lowers postharvest losses by 16% for those farmers already experiencing low tomato postharvest losses whilst at the same time increasing tomato postharvest losses for those farmers already experiencing high postharvest losses. This implies that instead of increasing farm size or land allocated to tomatoes, reducing the farm size or land allocated to tomatoes has an overall effect of tomato postharvest loss reduction.

4.4.6 Washing of hands and postharvest handling equipment

The coefficient of hand and equipment washing (Hnd_Eqp_Was) had a negative and statistically significant relationship (at 1% level of probability) with both spinach and tomato postharvest losses while the coefficient is negative though statistically insignificant with cabbage postharvest losses. Clean hands and equipment are less likely to be a contamination source during postharvest handling activities. The statistical significance for spinach and tomatoes could be due to the nature of spinach and tomatoes which have a shorter shelflife as compared to cabbage hence susceptible to higher losses than cabbage. Overall, hand and equipment washing have a significant postharvest loss reduction for spinach and tomatoes. However, a marginal increase in hand and equipment washing has a greater significance in postharvest loss reduction for those farmers who are already experiencing high spinach and tomato postharvest losses. This implies that practice of hand and equipment washing will significantly reduce postharvest losses for spinach and tomato farmers who are experiencing high losses.

Fruits and vegetables are rich in nutrients and thus naturally contaminated with microbes; therefore, keeping the number of microorganisms as low as possible by maintaining a clean environment is of importance (Lehto *et al.,* 2011). Microorganisms are natural contaminants of fresh produce and contamination arises from a number of sources, including postharvest handling and processing (Rico *et al.,* 2007). It is well-known that postharvest handling and processing of vegetables promotes a faster physiological deterioration, biochemical changes and microbial degradation of the product even when only slight processing operations can be used, which may result in degradation of the colour, texture and flavour (Rico *et al.,* 2007). Besides being a contributor to postharvest losses, microbiological contamination is also a food safety concern (Lehto *et al.,* 2011). Kader (2005) argued that the best approach to achieving and maintaining the safety of fresh fruits and vegetables is to focus on limiting potential contamination during their growth, harvesting, handling, treatment, packaging and storage. Good Hygienic Practices, i.e. conformance to sanitation and hygienic practices to the extent necessary to protect against contamination of food from direct or indirect sources, is strongly recommended to minimize microbial contamination (Kader and Rolle, 2004). One major source of contamination is humans handling the produce and equipment used for

handling purposes. Microbiological contamination is a postharvest concern since this can lead to rapid deterioration in quality and is a major food safety concern.

4.4.7 Time of harvesting

Time of harvesting (Tm_Hvst) had a negative though statistically insignificant relationship with cabbage and tomato postharvest losses. The relationship was insignificant probably due to the physiological nature of cabbage and tomatoes. Though cabbage is a leafy vegetable, a smaller surface area is exposed to the external environment which results in minimal water losses with respect to its size. Tomatoes have a thin gloss cuticle which minimizes water loss. However, a negative and statistically significant relationship (at 1% level) was reported for spinach. A relatively large surface area of spinach leaves is exposed to the environment due to the flat nature of the leaves, hence high water losses if exposed to high temperatures. The results imply that harvesting in the morning is associated with low postharvest losses as compared to afternoon harvesting. These results complement the findings by Kereth *et al.* (2013) and Genova *et al.* (2006) who reported that harvesting should preferably be done early in the morning.

The time of picking or harvesting is considered as one of the most important factors in determining postharvest losses (Awan *et al.,* 2012). Harvesting in the afternoon can be detrimental to vegetables due to high temperatures. High temperature increases the biological reactions in fruits and vegetables such as metabolism and respiration (Mashau *et al.,* 2012). Mashau *et al.* (2012) reported that fruit sellers in Tshakhuma fruit market (Limpopo Province) were using umbrellas to protect fruits from the heat but it does not work during summer season where the sun is too hot. Muhammad *et al.* (2012) argued that harvesting of fruits and vegetables should be done as carefully as possible to minimize mechanical damage such as bruises, scratches and punctures to the crops and should be carried out early morning or late evening.

Overall, harvesting in the morning has a significant spinach postharvest loss reduction. However, a unit increase in morning harvesting has a greater significance to only those spinach farmers who are experiencing high postharvest losses as compared to the ones with low losses. This implies that if farmers experiencing high spinach postharvest losses harvest in the morning instead of afternoon harvesting, their losses will diminish significantly.

4.4.8 Packaging used

Packaging used in postharvest handling plays a critical role towards postharvest loss reduction. During transportation the produce should be immobilized by proper packaging and stacking, to avoid excessive movement or vibration (Kitinoja, 2013). Vibration and impact during transportation may cause severe bruising or other types of mechanical injury to the food and hence leads to an increase in postharvest losses. This study revealed that packaging used (Pck_Usd) had a negative and statistically significant relationship (at 1% level and 10% respectively) with cabbage and tomato postharvest losses. A negative, though statistically insignificant relationship was reported for spinach. This implies a low likelihood of postharvest losses when crates are used in fresh produce handling as compared to other forms of packaging such as sacks and boxes. Use of crates has a significant impact of reducing postharvest losses for cabbage and tomatoes.

The use of plastic crates for harvest, packing, transport and storage of fresh produce has repeatedly been shown to reduce damage and postharvest losses (Kitinoja, 2013). In 2011, the Save Food Interpack 2011 congress produced a report on the use of appropriate packaging for developing countries, in which retainable plastic crates (RPCs) are included in the category of innovative packages, since they reduce damage and better allow produce to withstand transport over rough roads, and are reusable many times (FAO, 2011). Though farmers appreciate that plastic crates help in protecting produce against mechanical damage and maintaining the postharvest quality, the usage is not as expected because of cost constraints. As a result, farmers use the cheap and readily available forms of packaging such as sacks.

4.4.9 Storage duration

There was a strong positive and statistically significant relationship between storage duration (Sto_Drxn) and spinach postharvest losses (at 1% level). A positive though statistically insignificant relationship was reported for tomatoes. These results show that there is a high likelihood of postharvest losses if harvested produce is kept for longer duration before transporting to the market. Fruits and vegetables in their fresh forms contain high percentage of water; they are living and hence carry on their physiological function of respiration thereby absorbing and releasing gases and other materials from and to their environment (Idah *et al.,*

2007). As the produce respires and losses water, quality deteriorates as leaves become flaccid and shrivelled. These activities lead to their deterioration in transit and storage, which is more rapid under conditions of high temperature and humidity, hence the need for minimal storage times. Though storage duration has a significant overall effect of increasing spinach postharvest losses, a marginal increase in storage time does not have any significant effect.

There was however, a negative and statistically insignificant relationship between storage duration and cabbage postharvest losses. This suggests that there is a less likelihood of cabbage postharvest losses with an increase in storage time. Such results could be attributed to the longer shelflife of cabbage as compared to spinach. Cabbage retains its quality for a quite long duration before it starts to show signs of deterioration, hence, the deterioration may not be evident in the reported storage times of a maximum of 18 hours at the farm.

Yahia (2006) argued that the longer the time produce is stored, the higher the change in texture, aroma, flavour, spoilage and softening. Kader (2005) suggested that as the time the produce stay in the market increases from the time of purchase, the deterioration rate also increases. With longer storage times, quality can deteriorate and the produce becomes unmarketable hence adding to postharvest losses, especially in leaf vegetables like spinach. These results are consistent with the findings by Mbuk *et al.* (2011) who reported the coefficient of the number of days to finish selling tomatoes being positive, though not significant implying that the more the number of days to finish selling the more the spoilage, hence an increase in postharvest losses. Similar results were also reported by Kereth *et al.* (2013).

4.4.10 Distance to the market

The distance between the farm and the market (Dst_Mkt) had a positive and statistically significant relationship (at 5% level and 1% level) with cabbage and tomato postharvest losses. A positive though statistically insignificant relationship was also reported for spinach. Overall, the longer the distance to the market the higher the losses become. A marginal increase in the distance to the market has a significant impact of increasing postharvest losses to those cabbage and spinach farmers who are experiencing high losses.

Similar results were reported by Babalola *et al.* (2010) who found out that distance from the farm to the market was positively and significantly related to tomato postharvest losses. The further the market is from the farm, the longer it takes for the produce to reach the market and hence an increase in postharvest losses due to heat build-up and in transit mechanical injuries (Kader, 2005).

The results reported in this study show a maximum distance of 30km, which is relatively short. This distance is however characterised by bumpy dust roads which induce mechanical damage to the produce due to vibration. Coupled by lack of cooling facilities at the farms and the transport system in use, this suggests a contributory factor to postharvest losses. The accumulation of unarranged packed fresh produce in open trucks during transportation may lead to increased heat due to metabolic reaction of the cells and it may accelerate their mechanical damage. Postharvest losses in Kenya and Tanzania were both reported to be as high as 50% depending on the vegetable, weather conditions and distance from markets (Lenné and Ward, 2010).

4.4.11 Postharvest handling training

Postharvest handling training was considered as an important variable to capture the effects of expert advice, therefore expected to have an effect on postharvest losses. As was hypothesized, postharvest handling training (Trn_PHH) had a negative and statistically significant relationship with postharvest losses for both cabbage and spinach (1% level for cabbage and 10% level for spinach). On the other hand, a negative though statistically insignificant relationship was reported for tomato postharvest losses. This implies a less likelihood of postharvest losses among farmers who have attended postharvest handling training. Farmers who attend postharvest handling training are probable to handle produce carefully and hence minimal postharvest losses. Postharvest handling training has an overall effect of significantly reducing cabbage and spinach postharvest losses. However, attendance of postharvest handling training has a significant effect of reducing cabbage postharvest losses for those farmers experiencing high losses. The effect on spinach however doesn't have a significant effect.

Sinyolo *et al.* (2014) postulated that extension services imply access to new technologies, which help improve agricultural production, while agricultural training improves farmer's

skills. They also reported that farmers in the Tugela Ferry irrigation scheme use only trial and error, and those who have received some form of training are better-offs as they would put these skills to use. Akpalu (2013) argued that in South Africa, farmers consider the effectiveness of extension services in relation to receiving technological information and advice for purposes of crop and livestock production. Worth (2006) argued that the work of extension practitioners is that of facilitating the acquisition of skills by farmers to engage with scientific inquiry while simultaneously sharing their knowledge and information which enables farmers to make better informed agricultural decisions.

The Strategic Plan for South African Agriculture (NDA, 2001) clearly highlights the poverty, wealth and livelihoods agendas and identifies extension services, whether state, private, or NGO-based, as one of the key partners in the realisation of these objectives. However, this study did not capture access to agricultural extension services in the model as a measure for postharvest losses since key informants reviewed that not all farmers who have access to agricultural extension had attended postharvest handling training.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the main conclusions of the study and based on the empirical results, the chapter also draws several policy recommendations towards postharvest loss reduction. In addition, the last section of this chapter presents the suggestions for areas of further exploration in the future.

5.2 Recap of the research objectives and methodology

The general objective of the study was to assess vegetable postharvest losses among smallholder farmers in Umbumbulu. The first objective of the study was to describe the demographic and socio-economic characteristics of smallholder vegetable farmers in the study area. Secondly, the study intended to determine the main vegetables grown by smallholder farmers, their knowledge, training, postharvest handling practices and the percentage quantities lost. The study lastly targeted to establish the determinants of leafy and fruit vegetable postharvest losses among smallholder farmers in the study area.

Using a sample of 120 smallholder farmers who were purposively selected for this study, household data was gathered on socioeconomic characteristics, demography, agronomic practices, knowledge indicators, training and postharvest handling practices. Data analysis involved both descriptive and econometric techniques. Descriptive analysis made use of the frequency distributions, cross tabulations and $\chi 2$ tests, while econometric analysis involved the ordered probit regression model to establish leafy and fruit vegetable postharvest loss determinants. Qualitative data from key informant interviews and observations were used to contextually interpret the quantitative results from the econometric models.

5.3 Conclusions

Descriptive statistical analysis and an econometric model were used to analyse data in the study. The ordered probit model was used for the econometric analysis. The ordered probit model was applied due to the ordered nature of the dependent variable. The analysis was used

to empirically analyse the determinants of postharvest losses among smallholder farmers. The econometric model successfully estimated the significant variables associated with leafy and fruit vegetable postharvest losses. Cabbage postharvest losses were significantly influenced by gender of household head, farming experience, literacy, type of packaging used, distance to the market and attendance of postharvest handling training. On the other hand, spinach postharvest losses were significantly influenced by gender of household head, farming experience, hand and equipment washing before harvesting, time of harvesting, storage duration before marketing and attendance of postharvest handling training. Variables that significantly influenced tomato postharvest losses were farming experience, farmers' group membership, farm size, hand and equipment washing, packaging used and distance to the market.

Female headed households had lower postharvest losses in comparison to their male counterparts indicating that gender plays a critical role in postharvest loss reduction. However, if postharvest losses are high, the livelihood of women is mostly affected. This suggests that investment in women smallholder farmers will go a long way in reducing postharvest losses and hence improving household food, nutritional and income security. More experienced farmers had lower postharvest losses in comparison to the less experienced ones. Though descriptive analysis of age revealed that the study area is characterised by an aging population, farming experience was however relatively low in the study area, a phenomenon showing that the aging farmer population could be largely composed of farmers who are farming after retirement from other occupations. The average age of the farmers in the study area is over 50 years giving credence to the argument that young people tend to shun farming especially in rural areas.

Farmers with higher levels of formal education (secondary and tertiary) had lower cabbage postharvest losses than those with lower education levels. This suggests better postharvest handling practices by educated farmers and their ability to understand and adopt new technologies. Though the study revealed that participation in associations or farmers' groups played a significant role in tomato postharvest loss reduction only, the role was insignificant towards cabbage and spinach postharvest loss reduction. The key focus of farmer groups in the study area was only driven by the motive to access land and inputs and hence most of the farmers working as groups divided the land into individual blocks. This characterises failure of farmer groups in gaining economies of size, reducing transaction costs, provision of

missing services such as training, access to postharvest handling information and market information.

The study also concluded that the further the market is from the farm, the higher the postharvest losses. Though the reported distance is relatively short, the area is however characterised by bumpy dust roads which induce mechanical damage to the produce due to vibration. Despite the location of farms being close to the Agri-Hub, farmers to do not have cold storage facilities to precool their produce before transporting and the delivery transport is not refrigerated. Investing in road improvement, cold storage facilities or refrigerated delivery trucks will go a long way in minimising postharvest losses. The study also concluded that the bigger the farm size, the higher the losses, a finding supported by several studies revealed in previous sections.

Another conclusion of this study highlights the importance of access to support services such as agricultural extension and training in postharvest loss reduction efforts. These support services were found to have an influence of reducing postharvest losses. Despite their significant role in postharvest loss reduction, few farmers receive these government services and often the frequency is not ample for farmers to fully adopt the required knowledge and skills. There is a need for increased extension services among the smallholder farmers to enhance the postharvest loss reduction effects among smallholder farming. An example is the significant role played by postharvest handling training, hand and equipment washing before handling produce, time of harvesting, type of packaging used and storage duration in reducing postharvest losses. Training farmers in suitable postharvest handling practices and technologies would go a long way in improving postharvest handling efficiency in the farmer's individual plots, resulting in overall postharvest loss reduction. Farmers with formal postharvest handling training would experience lower postharvest losses compared to the untrained farmers. Though agricultural extension and training are common in the area, it is recommended that the frequency of visits be revised, training modules be strengthened and pay more attention to postharvest handling.

5.4 Policy recommendations for postharvest loss reduction

The identified determinants of postharvest losses in smallholder vegetable farming provide useful acumens for policy makers, advisers, developers and sellers of postharvest handling technologies. This information can yield extensive products in terms of the development of quality postharvest

management and education programs as well as the design of more effective government policies. Due to the variation in socioeconomic, demographic, knowledge, skills and risk aversion, new technologies and smallholder development programs need to be tailored to the requirements of a particular group of farmers if they are going to be effective. Programmes can only be tailor made if government and development agencies are knowledgeable of the production and postharvest handling challenges faced by the farmers, hence the need for continued research and development.

Continued research and development programmes which can be undertaken by Government, NGOs and research institutions to provide a strong basis for knowledge dissemination and documentation are recommended. Improved postharvest handling technology, its adoption, productivity and market access is a dynamic process that requires persistent research and development programmes. To maintain and further improve productivity, minimise postharvest losses and access to markets, continued investment in agricultural research aimed at generating new and improving old technologies that could shift the production and postharvest handling frontiers and improve their effectiveness is fundamental. Research findings must however be communicated to the farmers using appropriate means.

Information on production and postharvest handling of fresh produce that would enable the farmers to better understand good fresh produce handling practices is essential. It is important to note that while information on vegetable production and postharvest handling is readily available at the Department of Agriculture Forest and Fisheries and on the internet through various agencies, the challenge of accessibility, packaging and dissemination to smallholder farmers still remains. This could be addressed through the use of frequent extension services, farmer or producer groups, farmer field days and forums for information exchange.

It is recommended that government and other players in the agricultural sector plan initiatives to educate smallholder farmers on the benefits of proper postharvest handling practices as an effective means to curb the negative effects of fresh produce postharvest losses. Government policy aimed at training and developing farmer capacity in fresh produce production and postharvest handling is essential to ensure that farmers meet the demands of the growing fresh produce market. Appropriate training of extension officers to ensure that they are well equipped is vital in postharvest handling practices and technologies. Appropriate monitoring systems are also crucial in ensuring that frequent extension services are provided to the

smallholder farmers as this will facilitate better adoption of postharvest handling practices and technologies.

In the absence of appropriate cold storage facilities, it is mandatory for farmers to use appropriate postharvest handling practices to preserve desirable fresh produce quality characteristics and overall postharvest loss reduction. This is especially useful in the study area since farmers did not have cold storage facilities and the fresh produce being transported using unrefrigerated transport. Postharvest loss reduction could provide market access, additional income to the farmers and ensuring the availability of a healthy diet.

Smallholder farmers need assistance in accessing cold storage facilities and refrigerated transport for their fresh produce. To mitigate the effects of rapid deterioration as a result of continued respiration and delayed precooling, cold storage facilities in the vicinity of the farms are crucial. The challenge of losses as a consequence of harvesting when it is hot and longer storage durations will be counteracted by availing of cold storage facilities and refrigerated transport means. Road improvement projects can also play a crucial role towards postharvest loss reduction in the study area.

Smallholder farmers also need assistance in accessing irrigation resources to improve fresh produce production. Irrigation, especially in the drier months, would improve yields and increase the proportion of produce of sellable quality. It is recommended that government policy with regard to smallholder farmer support should focus on facilitating the farmers to access reliable water supply for production. Rainfed production confines farmers to only produce principally during the rainy season however, irrigation would provide farmers with options of when to produce, and consequently the ability to avoid production in the extremely wet part of summer where losses due to pests and diseases are relatively high. Provision of irrigation opportunities should be coupled with farmer education on the water demands to mitigate disease damage and critical water demand periods in the production of vegetables.

5.5 Recommendations for further study

Limited agricultural extension services and agricultural training in the study area was evident as the main source of information on smallholder farming, hence its role cannot be ignored. A comprehensive study on the state of agricultural extension and training and their efficiency as

well as comparative studies between regions, provinces or even similar communities could be important when advising policy-makers on the approach they can follow in developing rural agricultural livelihoods.

Further research should consider the impact of postharvest losses on rural livelihoods. A comparative analysis should be done to find if any differences exist in the food security, nutritional status and income gains from farmers with high postharvest losses in comparison to those with low postharvest losses. Seasonal variations in postharvest losses need to be given attention.

Comprehensive data on postharvest losses need to be gathered from different communities in different regions or provinces to have a postharvest loss map which can be applied towards targeted assistance to the farmers who are more vulnerable to postharvest losses. Such data is also crucial for tailor made training programmes since a ‘one size fits all’ programme does not apply. The importance of demarcating target domains for postharvest loss reduction as recommended in this study, need special attention to increase the incentives derived from postharvest loss reduction.

Research on the development of a training programme for smallholder farmers, which emphasizes the economic benefits and incentives of postharvest loss reduction, is of great importance. This action may contribute towards productivity, postharvest loss reduction, market access, profitability and poverty alleviation in rural areas in the face of climate change, growing demand for vegetables and high food wastes universally.

REFERENCES

ACIKEL, C.H., OGUR, R., YAREN, H., GOCGELDI, E. AND UCAR, M. (2008) The hygiene training of food handlers at a teaching hospital. *Food Control,* 19: 186-190.

ADESINA, A.A. AND BAIDU-FORSON, J. (1995) Farmers' perception and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *American Journal of Agricultural Economics*, 13: 1-9.

AGERGAARD, J. AND BIRCH-THOMSEN, T. (2006) Transitional rural landscapes: The role of small scale commercial farming in former homelands of post-apartheid KwaZulu-Natal. *Danish Journal of Geography,* 106: 87-102.

AGWU, A.E. AND EDUN, O.A. (2007) Influence of farmers' demographic characteristics on knowledge gap of recommended Fadana technologies in Ilaro agricultural zone of Ogun State. *Journal of Agriculture, Food, Environment and Extension*, 6(2): 52-60.

AHMAD, P.R., MUNIR, J., CHAUDHRY, M.N., GHULAM, M. AND IQBAL, M. (2002) Wheat productivity, efficiency, and sustainability: A stochastic production frontier analysis. *The Pakistan Development Review,* 41(4).

AKINBILE, L. A. AND NDAGHU, A.A.T. (2005) Poverty Levels and Poverty Alleviating Strategies of Farm Families in Michika LGA of Adamawa State Nigeria. *Journal of Rural Economics and Development,* 14(2): 101-108.

AKPALU, D.A. (2013) Agriculture extension service delivery in a semi-arid rural area in South Africa: the case study of Thorndale in the Limpopo province. *African Journal of Food, Agriculture, Nutrition and Development,* 13(4): 8034 – 8057.

ALIBER, M. AND HART, T.G.B. (2009) Should subsistence agriculture be supported as a strategy to address rural food insecurity? *Agrekon*, 48(4): 434-458.

ALIBER, M., HART, T. AND DONOVAN, M.O. (2009) *Review of rural development: 15 year review of economic and social sector programmes.* Cape Town: Human Sciences Research Council.

ALIBER, M., KIRSTEN M., MAHARAJ, R., NHLAPO-HLOPE, J. AND NKOANE, O. (2006) Overcoming underdevelopment in South Africa's second economy. *Development Southern Africa*, 23(1): 45-61.

ALIBER, M. (2005) Synthesis and conclusions. In: Aliber, M., De Swart, C., Du Toit, A., Mbhele, T. and Mthethwa, T. (eds). *Trends and policy challenges in the rural economy: Four provincial case studies.* Cape Town: Human Sciences Research Council.

ALTMAN, M., HART, T.G.B. AND JACOBS, P.T. (2009) Household food security status in South Africa. *Agrekon,* 48(4): 345-361.

AMOS, T.T. (2007) An analysis of productivity and technical efficiency of smallholder Cocoa farmers in Nigeria. *Journal of Social Science,* 15(2).

ASAYEHEGN, K., YIRGA, C. AND RAJAN, S. (2011) Effect of small-scale irrigation on the income of rural farm households: The case of Laelay Maichew district of Central Tigray, Ethiopia. *Journal of Stored Products and Postharvest Research,* 2(10).

AWAN, M.S., HUSSAIN, A., ABBAS, T. AND KARIM, R. (2012) Assessment of production practices of small scale farm holders of tomato in Bagrote valley, CKNP region of Gilgit-Baltistan, Pakistan. *Acta Agriculturae Slovenica,* 99(2): 191-199.

BABALOLA, D.A., MAKINDE, Y.O., OMONONA, B.T. AND OYEKANMI, M.O. (2010) Determinants of post- harvest losses in tomato production: a case study of Imeko – Afon local government area of Ogun state. *Journal of Life and Physical Sciences*, 3(2): 14-18.

BABALOLA, D.A., MEGBOPE, T.A. AND AGBOLA, P.O. (2008) Postharvest losses in Pineapple production: A case study of Ado-Odo Otta Local Government Area of Ogun State. *Bowen Journal of Agriculture* 5(2): 55-062.

BAIPHETHI, M.N. AND JACOBS, P.T. (2009) The contribution of subsistence farming to food security in South Africa. *Agrekon,* 48(4): 459-482.

BAS, M., ERSUN, A.S. AND KIVANC, G. (2006) The evaluation of food hygiene knowledge, attitudes, and practices of food handlers in food businesses in Turkey. *Food Control,* 17: 317-322.

BEMBRIDGE, T.J. (1991) Technology transfer in small-scale dry land crop production: Future challenges. *Development Southern Africa,* 8(4): 479 – 493.

BERDEGUÉ, J.A., BALSEVICH, F., FLORES, L. AND REARDON, T. (2005) Central American supermarkets' private standards of quality and safety in procurement of fresh fruits and vegetables. *Food Policy,* 30: 254–269.

BIÉNABE, E., VERMEULEN, H. AND BRAMLEY, C. (2011) The food quality turn in South Africa: An initial exploration of its implications for small-scale farmers' market access. *Agrekon,* 50(1): 36-52.

BIÉNABE, E. AND SAUTIER, D. (2005). The role of small scale producers, organizations to address market access. *Short Review.* Centre de Coopértion Internationale en Recherche Agronomique pour le Development: Breton.

BOLTON, D.J., MEALLY, A., BLAIR, I.S., MCDOWELL, C.A. AND COWAN, C. (2008) Food safety knowledge of head chefs and catering managers in Ireland. *Food Control,* 19: 291–300.

BRYCESON, D.F. (2000) *Rural Africa at the crossroads: livelihood practices and policies.* London: Overseas Development Institute.

BUCCHERI, C., MAMMINA, C., GIAMMANCO, S., GIAMMANCO, M., LA GUARDIA, M. AND CASUCCIO, A. (2010) Knowledge, attitudes and self-reported practices of food service staff in nursing homes and long-term care facilities. *Food Control,* 21: 1367 - 1373.

BUYUKBAY, E.O., UZUNOZ, M. AND SIBEL, G.B.H. (2011) Post-harvest losses in tomato and fresh bean production in Tokat province of Turkey. *Scientific Research and Essays,* 6 (7): 1656-1666.

CASWELL, M., FUGLIE, K.O., INGRAM, C., JANS, S. AND KASCAK, C. (2001) *Adoption of agricultural production practices: lessons learned from the US Department of Agriculture Area Studies Project.* E.R.S: USDA.

CELIS, R., MILIMO, J.Y. AND WANMALI, S. (1991) *Adoption of improved farm technology: A study of smallholder farmers in Eastern Province Zambia.* Washington DC: IFPRI.

CHIKAZUNGA, D. (2012) Determinants of smallholder farmer's participation in mainstream food markets. *Working paper produced under the pro-poor value chain governance project.* University of Western Cape: PLAAS.

CHIKAZUNGA, D. AND PARADZA, G. (2012) Smallholder farming: a panacea for employment creation and enterprise development in South Africa. *Working paper produced under the pro-poor value chain governance project.* Western Cape: PLAAS.

CHIPANDE, G.H.R. (2008) Innovation adoption among female-headed households: the case of Malawi. *Development and Change,* 18: 315-327.

CHUN-TA, W. (2010) An overview of postharvest biology and technology of fruits and vegetables. *Workshop on technology on reducing postharvest losses and maintaining quality of fruits and vegetables.* Taiwan: AARDO.

CLAYTON, D.A. AND GRIFFITH, C.J. (2008) Efficacy of an extended theory of planned behaviour model for predicting caterer's hand hygiene practices. *International Journal of Environmental Health Research,* 18(2): 83-98.

CLAYTON, D.A., GRIFFITH, C.J., PRICE, P. AND PETERS, A.C. (2002) Food handler's beliefs and self-reported practices. *International Journal of Environmental Health Research*, 12(1): 25-39.

CTA (2012) Going to waste – missed opportunities in the battle to improve food security. *Policy brief number 7.* Brussels: ACP-EU.

DEARLOVE, P.D. (2007) *Msinga Municipality Integrated Development Plan 2005 / 2006. KwaZulu-Natal Department of Local Governance and Traditional Affairs.* Available from: http://devplan.kzntl.gov.za/idp_reviewed_2007_8/IDPS/KZ244/Adopted/Msinga%20IDP.pdf [Accessed 20 November 2013].

DELGADO, C. (1999) Sources of growth in smallholder agriculture in Sub-Saharan Africa: The role of vertical integration of smallholders with processors and marketers of high value-added items. *Agrekon,* 38:165-189.

DEPARTMENT OF AGRICULTURE FORESTRY AND FISHERIES (DAFF) (2012) *A strategic plan for agriculture, 2012/13 – 2016/17.* Pretoria: DAFF Publishers.

DEPARTMENT OF AGRICULTURE FORESTRY AND FISHERIES (DAFF) (2011) *National policy on organic farming.* Pretoria: DAFF Publishers.

DEVEREUX, S. (2001) Livelihood insecurity and social protection: An emerging issue in rural development. *Development Policy Review,* 19(4): 507-519.

DIGBO, S.O.A. AND MOMOH, S. (2007) Sustainable agriculture in Nigeria: Contributions of soil fertility maintenance practices. *Journal of Sustainable Agriculture and Environment,* 9: 95–103.

EGAN, M.B., RAATS, M.M., GRUBB, S.M., EVES, A. AND LUMBERS, M.L. (2007) A review of food safety and food hygiene training studies in the commercial sector. *Food Control,* 18: 1180-1190.

ELLIS, F. AND MDOE, N. (2003) Livelihoods and rural poverty reduction in Tanzania. *World Development*, 31(8): 1367–1384.

ELTAWIL, M., SAMUEL, D., SINGHAL, O. (2006) Potato storage technology and store design aspects. *CIGR E-journal*, 11:1-18.

ENETE, A.A. AND IGBOKWE, E.M. (2009) Cassava market participation decision of household in Africa. *Tropicultura,* 27(3): 129-136.

FEDERAL DRUG ADMINISTRATION (FDA) (2008) *Guidance for industry: Guide to minimize microbial food safety hazards of fresh-cut fruits and vegetables*. Available from: http://www.fda.gov/food/guidancecomplianceregulatoryinformation/guidancedocuments/produceandplanproducts/ucm064458.htm [Accessed 10 May 2013].

FOOD AND AGRICULTURE ORGANISATION (FAO) (2011) Appropriate food packaging solutions for developing countries. *Save Food Interpack Congress held on 16 – 17 May 2011 in Dusseldorf, Germany*. Rome: FAO.

FOOD AND AGRICULTURE ORGANISATION (FAO) (2005) *FAO and the challenge of the Millennium Development Goals: The road ahead.* Rome: FAO.

FOOD AND AGRICULTURE ORGANISATION (FAO) (2004) *Socio-economic analysis and policy implications of the roles of agriculture in developing countries: Summary report for the Roles of Agriculture Project.* Rome: FAO.

FARZIANPOUR, F., KHANIKI, G.J., BATEBI, F. AND YUNESIAN, M. (2012) Compare the effects of two educational methods on the health principles knowledge of employees in food preparation. *American Journal of Applied Sciences,* 9 (10): 1678-1683.

FAWOLE, O.P. AND FASINA, O. (2005) Factors predisposing farmers to Organic Fertilizer Uses in Oyo state, Nigeria. *Journal of Rural Economics and Development,* 14(2): 81-90.

FRASER, G., MONDE, N. AND VAN AVERBEKE, W. (2003) Food security in South Africa: A case study of rural livelihood in the Eastern Cape. In: Nieuwoudt, K. and Groenewaldt, J. (eds). *The challenge of change: Agriculture, land and the South African economy.* Pietermaritzburg: University of KwaZulu-Natal Press.

GADZIKWA, L., LYNE, M.C. AND HENDRIKS, S.L. (2006) Collective action in small holder organic farming: a case study of the Ezemvelo Farmers Organisation in KwaZulu-Natal. *South African Journal of Economics,* 74: 344-358.

GARCIA, E. AND BARRETT, D.M. (2006) Evaluation of processing tomatoes from two consecutive growing seasons: quality attributes peelability and yield. *Journal of Food Processing and Preservation,* 30: 20–36.

GENOVA, C., WEINBERGER, K., HOANG, B.A., DANG, D.D., NGUYEN, T.T.L., LE, N.T. AND NGUYEN, T.T.T. (2006) *Postharvest loss in the supply chain for vegetables - the case of chili and tomato in Vietnam*, Available from: http://www.avrdc.org/pdf. [Accessed 15 May 2013].

GETINET, H., SEYOUM, T. AND WOLDETSADIK, K. (2008) The effect of cultivar, maturity stage and storage environment on quality of tomatoes. *Journal of Food Engineering,* 87: 467–478.

S S S O, A.C. AND DA COSTA, J.C.M. (2011) Meat handlers training in Portugal: A survey on knowledge and practice. *Food Control,* 22: 501-507.

GOMES-NEVES, E., ARAÚJO, A.C., RAMOS, E. AND CARDOSO, C.S. (2007) Food handling: Comparative analysis of general knowledge and practice in three relevant groups in Portugal. *Food Control,* 18: 707-712.

GREENE, W.H. (2003) *Econometric Analysis. 5th* Ed. New Jersey: Prentice Hall.

GRIFFITH, J. (2000) Food safety in catering establishments. In: Farber, J.M. and Todd, E.C.D. (eds). *Safe handling of foods*. New York: Marcel Dekker.

GUJARATI, D.N. AND PORTER, C.D. (2009) *Basic Econometrics.* 5th Ed. New York: McGraw-Hill.

HELLIN, J. and HIGMAN, S. (2002) Smallholders and niche markets: lessons from the Andes. *Overseas Development Institute Agricultural Research and Extension Network Paper No. 118: 1–6.* Oxford: ITDG Publishing.

HENDRIKS, S.L. (2005) The challenges facing empirical estimation of food (in) security in South Africa. *Development Southern Africa,* 22(1): 103-123.

HENDRIKS, S.L. (2003) The potential for nutritional benefits from increased agricultural production in rural KwaZulu-Natal. *South African journal of agricultural extension,* 32: 28-44.

HENDRIKS, S.L. AND LYNE M.C. (2009) *Does food security improve when smallholders access a niche market? Lessons from the Embo Community in South Africa.* Pietermaritzburg: University of KwaZulu-Natal Press.

HENDRIKS, S.L. AND LYNE, M.C. (2003) Expenditure patterns and elasticities of rural households sampled in two communal areas of KwaZulu-Natal. *Development Southern Africa,* 20(1): 105-127.

HENDRIKS, S.L. AND MSAKI, M.M. (2009) The impact of smallholder commercialisation of organic crops on food consumption patterns, dietary diversity and consumption elasticities. *Agrekon,* 48 (2): 184-199.

HOLLOWAY, G., NICHOLSON, C., DELGADO, C., STAAL, S. AND EHUI, S. (2000) Agro-industrialization through institutional innovation: Transaction costs, cooperatives and milk-market development in the east-African highlands. *Agricultural Economics,* 23(3): 279-288.

HOLLAWAY, G., SHANKAR, B. AND RAHMAN, S. (2002) Bayesian spatial probit estimation: a primer and an application to HYV rice adoption. *Agricultural Economics,* 27: 383-402.

HOSSAIN, S., ALAMGIR, M. AND CROACH, R. (1992) Patterns and determinants of adoption of farm practices: some evidence from Bangladesh. *Agricultural Systems,* 38: 1-15.

IDAH, P.A., AJISEGIRI, E.S.A. AND YISA, M.G. (2007) Fruits and vegetables handling and transportation in Nigeria. *AUJT,* 10(3): 175-183.

INSTITUTE OF NATURAL RESOURCES (INR) (2009) *Study to develop a value chain strategy for sustainable development and growth of organic agriculture.* Commissioned by the Trade and Industry Chamber Fund for Research into Industrial Development, Growth and Equity (FRIDGE). INR Investigational report no IR285.

JEVSNIK, M., HLEBEC, V. AND RASPOR, P. (2009) Survey of safe and hygienic practices among Slovenian sauerkraut growers. *Food Control,* 20(7): 677-685.

VŠ IK HL B V SP P (2008) Food safety knowledge and practices among food handlers in Slovenia. *Food Control,* 19(12): 1107–1118.

KADER, A.A. (2005) Increasing food availability by reducing postharvest losses of fresh produce. *Acta Horticulture,* 682: 2169-2175.

KADER, A.A. (2003) Perspective on postharvest horticulture. *Horticultural Science*, 38: 1004-1008.

KADER, A.A. AND ROLLE, R.S. (2004) *The role of post-harvest management in assuring the quality and safety of horticultural produce.* Rome: FAO.

KASSA, H., SILVERMAN, G.S. AND BAROUDI, K. (2010) Effect of a Manager Training and Certification Program on Food Safety and Hygiene in Food Service Operations. *Environ**mental** Health Insights*, 4: 13-20.

KATUNDU, M.G.C. (2008) *Does sequential harvesting affect the quality of and income from organically grown potatoes?* Unpublished PhD Thesis. University of KwaZulu-Natal.

KERETH, G.A., LYIMO, M., MBWANA, H.A., MONGI, R.J. AND RUHEMBE, C.C. (2013) Assessment of post-harvest handling practices: knowledge and losses of fruits in Bagamoyo district of Tanzania. *Food Science and Quality Management*, Volume 11.

KIBAARA, B.W. (2005) *Technical efficiency in Kenyan's maize production: An application of the Stochastic Frontier Approach.* USA: Colorado State University.

KILLICK, T., KYDD, J. AND POULTON, C. (2000) Agricultural liberalisation, commercialisation and the market access problem in the rural poor and the wider economy: the problem of market access. *Background Paper for IFAD Rural Poverty 2000 Report.* Rome: IFAD.

KIMATU, J.N., MCCONCHIE, R., XIE, X. AND NGULUU, S.N. (2012) The significant role of post-harvest management in farm management, aflatoxin mitigation and food security in sub-Saharan Africa. *Greener Journal of Agricultural Sciences*, 2(6): 279-288.

KINYURU, J.N., KAHENYA, K.P., MUCHUI, M. AND MUNGAI, H. (2011) Influence of post-harvest handling on the quality of snap bean (*Phaseolus vulgaris L.)*. *Journal of Agriculture and Food Technology*, 1(5): 43-46.

KIRSTEN, J., MAY, J., HENDRIKS, S.L., LYNE, M., MACHETHE, C. AND PUNT, C. (2007) The poverty alleviation and food security role of agriculture in South Africa. In: Bresciani, F. and Valdé, A. (eds). *Beyond food production: The role of agriculture in poverty reduction.* Rome: FAO.

KIRSTEN, J. AND SARTORIUS, K. (2002) Linking agribusiness and small-scale farmers in developing countries: Is there a new role for contract farming? *Development Southern Africa,* 19(4): 503-529.

KIRSTEN, J., TOWNSEND, R. AND GIBSON, C. (1998) Determination of agricultural production to household nutritional status in KwaZulu-Natal, South Africa. *Development Southern Africa*, 15(4): 573-587.

KISAKA-LWAYO, M. (2012) *Risk preferences and consumption decisions in organic production: the case of KwaZulu-Natal and Eastern Cape provinces of South Africa.* Unpublished PhD Thesis. University of Fort Hare.

KITINOJA, L. (2013) Returnable Plastic Crate (RPC) systems can reduce postharvest losses and improve earnings for fresh produce operations. *PEF White Paper No. 13-01.* Oregon: The Postharvest Education Foundation.

KO, W.H. (2010) Evaluating food safety perceptions and practices for agricultural food handler. *Food Control,* 21: 450-455.

KOSSOUDJI, S. AND MUELLER, E. (1983) The economic status of female-headed households in rural Botswana. *Economic Development and Cultural Change*, 31: 831-59.

LABADARIOS, D. AND NEL, J.H. (2000) Anthropometric status. In Labadarios, D. (ed). *The National Consumption Food Survey (NFCS): Children aged 1-9 years in South Africa - 1999.* Pretoria. Department of Health.

LABADARIOS, D. (ed). (2000). *The National Food Consumption Survey (NFCS): Children aged 1–9 years, South Africa, 1999.* Pretoria: Directorate of Nutrition, Department of Health.

LEHTO, M., KUISMA, R., MÄÄTTÄ, J., KYMÄLÄINEN, H.R. AND MÄKI, M. (2011) Hygienic level and surface contamination in fresh-cut vegetable production plants. *Food Control,* 22: 469-475.

LENNÉ, J.M. AND WARD, A.F. (2010) Improving the efficiency of domestic vegetable marketing systems in East Africa: constraints and opportunities. *Outlook on Agriculture,* 39(1): 31–40.

LOUW, A., JORDAAN, D., NDANGA, L. AND KIRSTEN, J.F. (2008) Alternative marketing options for small-scale farmers in the wake of changing agri-food supply chains in South Africa. *Agrekon,* 47(3): 287-308.

LOUW, A., VERMEULEN, H., KIRSTEN, J.F. AND MADEVU, H. (2007) Securing small farmer participation in supermarket supply chains in South Africa. *Development Southern Africa,* 24(4): 539-551.

LOUW, A., JORDAAN, D., CHIKAZUNGA, D. AND BIÉNABE, E. (2006) *Re-governing markets: restructuring food markets in South Africa: Dynamics in context of the tomato sub-sector.* London: International Institute for Environment and Development (IIED).

LYNE, M.C. (1996) Transforming developing agriculture: Establishing a basis for growth. *Agrekon,* 35(4):188-192.

LYNE, M.C. (1985) Using linear and logit functions to identify adopters and non-adopters of farm technology: Some policy considerations for KwaZulu. *Development Southern Africa*, 2: 495-500.

MACHETHE, C.L. (2004) Agriculture and poverty in South Africa: Can agriculture reduce poverty? In O*vercoming underdevelopment conference,* Pretoria. *28-29 October.* Pretoria.

MAGINGXA, L.L., ALEMU, Z.G. AND VAN SCHALKWYK, H.D. (2009) Factors influencing access to produce markets for smallholder irrigators in South Africa. *Development Southern Africa,* 26(1): 47-58.

MARAIS, M., CONRADIE, N. AND LABADARIOS, D. (2007) Small and micro enterprises aspects of knowledge, attitudes and practices of managers and food handlers knowledge of food safety in the proximity of Tygerberg Academic Hospital, Western Cape. *South African Journal of Clinical Nutrition,* 20(2): 50-61.

MARTEY, E., AL-HASSAN, R.M. AND KUWORNU, J.K.M. (2012) Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research,* 7(14): 2131-2141.

MARTINS, R.B., HOGG, T. AND OTERO, J.G. (2012) Food handlers' knowledge on food hygiene: The case of a catering company in Portugal. *Food Control,* 23: 184-190.

MASHAU, M.E., MOYANE, J.N. AND JIDEANI, I.A. (2012) Assessment of postharvest losses of fruits at Tshakhuma fruit market in Limpopo Province, South Africa. *African Journal of Agricultural Research,* 7(29): 4145-4150.

MATSHE, I. (2009) Boosting smallholder production for food security: Some approaches and evidence from studies in sub-Saharan Africa. *Agrekon,* 48(4): 483-511.

MATUNGUL, P.M., LYNE, M.C. AND ORTMANN, G.F. (2001) Transaction costs and crop marketing in the communal areas of Impendle and Swayimana KwaZulu-Natal. *Development Southern Africa,* 18(3): 347-363.

MAXWELL, J. (1997). Designing a qualitative study. In Bickman, L. and Rog, D.J. (eds). *Handbook of applied social research methods.* CA: Sage.

MAY, J. (2000) The nature and measurement of poverty and inequality. In: May, J. (ed). *Poverty and inequality in Southern Africa: Meeting the challenge.* Cape Town: David Philip.

MBUK, E.M., BASSEY, N.E., UDOH, E.S. AND UDOH, E.J. (2011) Factors influencing postharvest loss of tomatoe in urban market in Uyo, Nigeria. *Nigerian Journal of Agriculture, Food and Environment,* 7(2): 40-46.

MDLULI, F. (2013) *Investigation of selected hygiene parameters of Umbumbulu small-scale farmers' organic produce (leafy salad vegetables) and subsequent identification of factors affecting farmer practices and food security.* Unpublished Master of Agriculture Thesis. University of KwaZulu-Natal.

MDLULI, F., THAMAGA-CHITJA, J. AND SCHMIDT, S. (2013) Appraisal of hygiene indicators and farming practices in the production of leafy vegetables by organic small-scale farmers in Umbumbulu (Rural KwaZulu-Natal, South Africa). *International Journal of Environmental Research and Public Health,* 10: 4323-4338.

MÌNE, Y. (2006) The Political Element in the works of W. Arthur Lewis: The 1954 Lewis Model and African Development. *The Developing Economies,* 44: 329–355.

MIRAUX, M., COX, D.N., COTTON, N. AND EVANS, G. (2007) An adaptation of repertory grid methodology to evaluate Australian consumers' perceptions of food products produced by novel technologies. *Food Quality and Preference,* 18: 834–848.

MNKENI, P.N.S., CHIDUZA, C., MODI, A.T., STEVENS, J.B., MONDE, N., VAN DER STOEP, I. AND DLADLA, R.W. (2010) Best management practices for smallholder farming on two irrigation schemes in the Eastern Cape and KwaZulu-Natal through participatory adaptive research. Pretoria: *Water Research Commission.* (WRC Report No. TT 478/10).

MODI, M., MODI, A.T. AND HENDRIKS, S.L. (2006) Potential role for wild vegetables in household food security: A preliminary case in KwaZulu-Natal, South Africa. *African Journal of Food Agriculture Nutrition and Development,* 6(1): 1-14.

MODI, A.T. (2003) What do subsistence farmers know about indigenous crops and organic farming? Preliminary experience in KwaZulu-Natal. *Development Southern Africa,* 20(5): 675-684.

MOLOI, M.J. (2008) A Comparison of socioeconomic characteristics that determine the farm income of emerging livestock and horticultural farmers in South Africa. Unpublished MSc. Thesis. University of Limpopo.

MREMA, C.G. AND ROLLE, S.R. (2002) Status of the postharvest sector and its contribution to agricultural development and economic growth. *Proceedings of the 9th JIRCAS International Symposium 2002 on Value addition to agricultural products.* Japan: JIRCAS.

MUHAMMAD, R.H., HIONU, G.C. AND OLAYEMI F.F. (2012) Assessment of the postharvest knowledge of fruits and vegetable farmers in Garun Mallam L.G.A of Kano, Nigeria. *International Journal of Development and Sustainability,* 1 (2): 510-515.

NAIDOO, K.D. (2009) *The practice, constraints and perceptions of improving soil quality through manure application: a case study of three smallholder farmer groups.* Unpublished Master of Agriculture Thesis. University of KwaZulu-Natal.

NATIONAL DEPARTMENT OF AGRICULTURE (NDA) (2002) *The integrated food security strategy for South Africa.* Pretoria: Department of Agriculture Publishers.

NATIONAL DEPARTMENT OF AGRICULTURE SOUTH AFRICA (NDA) (2001) *The Strategic Plan for South African Agriculture.* Pretoria: Department of Agriculture Publishers.

NDOKWENI, M.F. (2002) *Evaluation of the potential for sustainable livelihoods from organic production: The Ezemvelo Farmer's Organisation.* Unpublished MSocSc. Community Resources Thesis. University of Natal.

NELL, W., WESSELS, B., MOKOKA, J. AND MACHEDI, S. (2000) A creative multidisciplinary approach towards the development of food gardening. *Development Southern Africa*, 17(5): 807-819.

NIODE, O., BRUHN, C. AND SIMONNE, A.H. (2011) Insight into Asian and Hispanic restaurant manager needs for safe food handling. *Food Control,* 22: 34-42.

NIETO-MONTENEGRO, S., BROWN, J.L. AND LABORDE, L.F. (2008) Development and assessment of pilot food safety educational materials and training strategies for Hispanic workers in the mushroom industry using the health action model. *Food Control,* 19(6): 616-633.

OBASI, P.C., HENRI-UKOHA, A., UKEWUIHE, I.S. AND CHIDIEBERE-MARK, N.M. (2013) Factors affecting agricultural productivity among arable crop farmers in Imo State, Nigeria. *American Journal of Experimental Agriculture,* 3(2): 443-454.

ORTMANN, G.F. AND KING, R.P. (2010) Research on agri-food supply chains in Southern Africa involving small-scale farmers: Current status and future possibilities. *Agrekon,* 49(4): 397-417.

ORTMANN, G.F. AND KING, R.P. (2007) Agricultural cooperatives II: Can they facilitate access of small-scale farmers in South Africa to input and product markets? *Agrekon,* 46(2): 219-244.

ORTMANN, G.F. AND MACHETHE, C.L. (2003) Problems and opportunities in South African agriculture. In: Nieuwoudt, L, and Groenewald, J. (eds). *The challenge of change: agriculture, land and the South African economy.* Pietermaritzburg: University of Natal Press.

PAGE, S. AND SLATER, R. (2003) Small producer participation in global food systems: policy opportunities and constraints. *Development Policy Review,* 21:641-654.

PARK, S.H., KWAK, T.K. AND CHANG, H.J. (2010) Evaluation of the food safety training for food handlers in restaurant operations. *Nutrition Research and Practice,* 4(1): 58-68.

PILLING, V.K., BRANNON, L.A., SHANKLIN, C.W., HOWELLS, A.D. AND ROBERTS, K.R. (2008) Identifying specific beliefs to target to improve restaurant employees' intentions for performing three important food safety behaviours. *Journal of the American Dietetic Association,* 108(6): 991-997.

PLAAS INSTITUTE FOR POVERTY LAND AND AGRARIAN STUDIES (2009) Strategies to support South African smallholders as a contribution to government's second economy strategy. *Draft report commissioned by the second economy strategy Project.* Cape Town: PLAAS.

POLSON, R.A. AND SPENCER, D.S.C. (1991) The technology adoption process in subsistence agriculture: the case of cassava in South Western Nigeria. *Agricultural Systems,* 36:65-78.

PONTE, S. AND GIBBON, P. (2005) Quality standards, conventions and the governance of global value chains. *Economy and Society,* 34(1).

RAVALLION, M. AND DATT, G. (1996) Is targeting through a work requirement efficient? Some evidence for rural India. In: van der Walle, D. and Nead, K. (eds). *Public spending and the poor: Theory of evidence.* Washington DC: The World Bank.

RENARD, M.C. (2005) Quality certification, regulation and power in fair trade. *Journal of Rural Studies*, 21.

RICO, D., MARTÍN-DIANA, A.B., BARAT, J.M. AND BARRY-RYAN, C. (2007) Extending and measuring the quality of fresh-cut fruit and vegetables: a review. *Journal of Food Science and Technology*, 18: 373-386.

ROOTHAERT, R. AND MUHANJI, G. (2009) Profit making for smallholder farmers. *Proceedings of the 5th MATF experience sharing workshop, 25th - 29th May 2009 held in Entebbe, Uganda.* Nairobi: FARM-Africa.

SANTOS, M.J., NOGUEIRA, J.R., PATARATA, L. AND MAYAN, O. (2008) Knowledge levels of food handlers in Portuguese school canteens and their self-reported behaviour towards food safety. *International Journal of Environmental Health Research,* 18(6): 387 - 401.

SCHMIDT, K. (2005) *Food security in South Africa: Crop production as an intervention: the case of subsistence fishers.* Available from: http://www.aidc.alternativedevelopmentinformationcentre.fssa [Accessed 10 April 2013].

SCIALABBA, N.E. (2007) Organic agriculture and food security. *Paper presented at the International Conference on Organic Farming and Food Security, 3–5 May.* Rome: Food and Agriculture Organisation.

SEAMAN, P. AND EVES, A. (2008) Food hygiene training in small to medium sized care settings. *International Journal of Environmental Health Research,* 18(5): 365–374.

SEAMAN, P. (2010) Food hygiene training: introducing the food hygiene training model. *Food Control,* 21(4): 381-387.

SERIN, V., BAYYURT, N. AND CIVAN, A. (2009) Effects of formal education and training on farmers' income. *European Journal of Social Sciences,* 98(3): 52-62.

SINYOLO, S., MUDHARA, M. AND WALE, E. (2014) The impact of smallholder irrigation on household welfare: the case of Tugela Ferry irrigation scheme in KwaZulu-Natal, South Africa. *Water SA,* 40 (1): 145-156.

SOON, J.M. AND BAINES, R.N. (2012) Food safety training and evaluation of hand washing intention among fresh produce farm workers. *Food Control,* 23: 437-448.

SOUTHGATE, D., GRAHAM, D. AND TWEETEN, L. (2007) *The world food economy.* Oxford: Blackwell.

STATISTICS SOUTH AFRICA (STATS SA) (2012) *GHS Series: Food security and agriculture, Volume IV.* Pretoria: Statistics South Africa. [Report 03-18-03 (2002 – 2011)].

STATISTICS SOUTH AFRICA (STATS SA) (2010) Census of commercial agriculture 2007. Pretoria: Statistics South Africa. [Report no. 11-02-01 (2007)].

STATISTICS SOUTH AFRICA (STATS SA) (2002) *Report on the Survey of Large and Small Scale Agriculture.* Pretoria: Statistics South Africa.

STEFANO, L. (2004) *Printed information access, preferences and use by farmers with potential for small-scale organic production in KwaZulu-Natal.* Unpublished Master of Agriculture Thesis. University of KwaZulu-Natal.

TAKANE, T. (2008) Labour use in smallholder agriculture in Malawi: Six village case studies. *African Study Monographs,* 29(4).

TEDDLIE, C. AND FEN YU, F. (2007) Mixed methods sampling: A typology with examples. *Journal of Mixed Methods Research,* 1(1): 77-100.

TEFERA, A., SEYOUM, T. AND WOLDETSADIK, K. (2007) Effect of Disinfection, Packaging, and Storage Environment on the Shelf Life of Mango. *Biosystems Engineering*, 96(2): 201–212.

TODD, E.C.D., GREIG, J.D., BARTLESON, C.A. AND MICHAELS, B.S. (2007) Outbreaks where food workers have been implicated in the spread of foodborne disease - Part 3: Factors contributing to outbreaks and description of outbreak categories. *Journal of Food Protection,* 70(9): 2199-2217.

THAMAGA-CHITJA, J. AND HENDRIKS, S.L. (2008) Emerging issues in smallholder organic production and marketing in South Africa. *Development Southern Africa,* 25(3): 317-326.

VAN AVERBEKE, W. AND KHOSA, T.B. (2007) The contribution of smallholder agriculture to the nutrition of rural households in a semi-arid environment in South Africa. *Water South Africa,* 33: 413-418.

VENTER, G.C.R., VINK, N. AND VILJOEN, M.F. (1993) Factors which restrict the promotion of entrepreneurship in black agriculture. *Agrekon*, 32: 257-261.

VERBEEK, M. (2008) *A guide to modern econometrics.* John Wiley and Sons Ltd.

VERMEULEN, H., J KIRSTEN, J. AND K SARTORIUS, K. (2008) Contracting arrangements in agribusiness procurement practices in South Africa. *Agrekon,* 47(2). 198-221.

VIGNEAULT, C., THOMPSON, J. AND WU, S. (2009) Designing container for handling fresh horticultural produce. In: Benkeblia, N. (ed). *Postharvest Technologies for Horticultural Crops,* 2009, Vol. 2: 25-47. India: Sign Post.

VITAMIN INFORMATION CENTRE (2001) *National food consumption survey in children aged 1-9 years: South Africa 1999. Medical Updated Number 37.* Available from: http://www.nutrivit.co.za/profesionals/medical-updates/nfcs-37.pdf [Accessed 14 April 2013].

VYASS, S. AND KUMARANAYAKE, L. (2006) Constructing socioeconomic status indexes: How to use Principal Component Analysis. *Health Policy and Planning,* 21(6): 459-468.

WATKINSON, E. AND MAKGETLA, N. (2002) *South Africa's food security crisis.* Available from: www.naledi.org.za/pubs/2002/watkinson1.pdf [Accessed 20 July 2013].

WEGNER, L. AND ZWART, G. (2011) *Who will feed the world? The production challenge.* Unite Kingdom: Oxfam.

WILLS, R.B.H., MCGLASSON, W.B., GRAHAM, D. AND JOYCE, D.C. (2007) *Postharvest – An introduction to the physiology and handling of fruits, vegetables and ornamentals*. 5th Ed. Oxfordshire: CAB International.

WORLD HEALTH ORGANISATION (WHO) (2006) *Excreta and grey water use in agriculture: In WHO Guidelines for the safe use of wastewater excreta and grey water.* Switzerland: World Health Organization.

WORTH, S.H. (2006) Agriflection: A learning model for agricultural extension in South Africa. *Journal of Agricultural Education and Extension,* 12(3): 179-193.

YAHIA, E.M. (2006) Controlled atmospheres for tropical fruits. In: Yahia, E.M. (ed). *The current status and future application of modified and controlled atmospheres for Horticultural Commodities*. Stewart Postharvest review, 5(6):1-10.

APPENDICES

Appendix A: Research questionnaire

University of KwaZulu-Natal
Informed consent form

Research project information

The research project will be conducted by Garikai Maremera, passport number BN429076 who is a postgraduate student (Master of Agriculture in Food Security) at the University of KwaZulu-Natal. The aim of the research project is to assess vegetable postharvest losses among smallholder farmers in Umbumbulu area of KwaZulu-Natal province, South Africa. This study seeks to contribute to the body of knowledge that will inform policy recommendations on improved food availability and household incomes by smallholder rural communities, strategies to manage postharvest losses and increase the market potential for smallholder farmers. A structured questionnaire will be used to gather the required data.

Declaration

The following was clearly explained to me before the study, I understand the contents of the questionnaire and the nature of the research and I have agreed to participate in this research: All information provided for the study will be treated with **STRICT CONFIDENTIALITY;** anonymity will be ensured where appropriate through coding and questionnaires will be destroyed afterwards; participation in the study is voluntary and participants are free to withdraw from the study at any time without any negative or undesirable consequences to themselves. Due to the nature of the study and the budget for this research, the researcher is not promising any benefits for the participation in the research.

Name	**Signature**	**Date**

For any queries I can be contacted on my mobile number (084 638 7961) or by email 213568789@stu.ukzn.ac.za. You can also contact my supervisor Professor A. Bogale on 033 260 5855, Email: bogalea@ukzn.ac.za at the African Centre for Food Security and HSSREC Research Office Ms P Ximba, Tel: 031 260 3587, Email: ximbap@ukzn.ac.za.

University of KwaZulu-Natal

African Centre for Food Security

Assessment of vegetable postharvest losses among smallholder farmers in Umbumbulu area of KwaZulu-Natal province, South Africa

Research Questionnaire

All the information provided here will be treated as **STRICTLY CONFIDENTIAL.**

Date of survey……

Name of enumerator……..

Name of farmer……Ward…….....

A. Household demographics

			Code	
Q1.	Gender of household head	Female	0	
		Male	1	

Q2.	What is the household head's marital status?	Single	0	
		Married	1	

Q3. What is the age of the household head in years? …….

Q4. How many years have you been farming? ……..

Q5. What is your household size? ……..

Q6.	What is your formal education level?	None	1	
		Primary education	2	
		Secondary education	3	
		Tertiary education	4	

Q7.	What is your main occupation?	Farming	1	
		Regular salaried job	2	
		Temporary job	3	
		Unemployed	4	
		Self-employed	5	
		Retired	6	

Q8.	What is your main source of household income?	Farming	1	
		Social grant	2	
		Pension	3	
		Remittances	4	
		Salary/ wages	5	
		Other	6	

B. Key production issues

Q9.	Are you a member of any farmers group?	No	0	
		Yes	1	

Q10. What is the size of your farm in hectares? ……

Q11.	Do you own the farm?	Group owned	0	
		Own	1	

Q12.	Are you farming full time or part time?	Part time	0	
		Full time	1	

Q13.	Which farming method do you use?	Conventional	0	
		Organic	1	

Q14. Which vegetables do you grow?

Vegetable	**Yes / No**	**Vegetable**	**Yes / No**	**Vegetable**	**Yes / No**
Carrots		Amadumbe		Beetroot	
Green beans		Onions		Sweet Potatoes	
Potatoes		Lettuce		Green Mealies	
Spinach		Cabbage		Green Pepper	
Tomatoes		Butternut		Other	

Q15.	What is the main reason for growing these vegetables?	Sell	0	
		Consumption	1	

Q16.	Do you always have a surplus to sell?	No	0	
		Yes	1	

Q17.	When you have surplus, who do you supply?	Local community	1	
		Agri-hub	2	
		Agents / Hawkers	3	

C. Postharvest information

Q18.	What time do you harvest your crops?	Morning	1	
		Afternoon	2	
		Anytime	3	

Q19.	What packaging do you use to pack the vegetables?	Crates	1	
		Sacks	2	
		Boxes	3	
		Other	4	

Q20. How long do you keep the produce before transporting? ……...

Q21. What is the distance of the market from the farm in km? ……...

Q22.	Do you store the harvested vegetables refrigerated before transporting to the supplied organisations?	No	0	
		Yes	1	

Q23.	Which transport do you use to transport your produce?	Owned	1	
		Hired	2	
		Agri-hub	3	
		Public transport	4	
		Other	5	

Q24.	Is the transport system in use refrigerated or not?	No	0	
		Yes	1	

Q25. What quantity of produce is lost per harvesting season?

	1 – 25 %	**26 – 50 %**	**51 – 75 %**	**76 – 100 %**
CARROTS				
GREEN BEANS				
POTATOES				
SPINACH				
TOMATOES				
AMADUMBE				
ONIONS				
LETTUCE				
CABBAGE				
BUTTERNUT				
BEETROOT				
SWEET POTATOES				
GREEN MEALIES				
GREEN PEPPER				

Q26.	Are hands and postharvest handling equipment washed before handling produce?	No	0	
		Yes	1	

Q27. What could be the cause for postharvest losses on the crops being lost?

	Rotting (Microbiological)	Pest and diseases	Under / Over Maturity	Mechanical damages	Other
CARROTS					
GREEN BEANS					
POTATOES					
SPINACH					
TOMATOES					
AMADUMBE					
ONIONS					
LETTUCE					
CABBAGE					
BUTTERNUT					
BEETROOT					
SWEET POTATOES					
GREEN MEALIES					
GREEN PEPPER					

D. Training information

Q28.	Have you ever attended any fruit and vegetable training?	No	0	
		Yes	1	

Q29. If yes, tick the training that you have ever attended

Training	Yes / No	Training	Yes / No
Land preparation		Irrigation practices	
Soil management		Composting	
Planting		Postharvest handling	
Pest and disease control		Marketing	
Organic Farming		Other	

Q30.	If you attended any postharvest handling training, when did you last attend such training?	> month ago	0	
		< month ago	1	

Q31.	Who provided the training that you attended?	Government	0	
		NGO	1	

Q32.	Did you pay for the training?	No	0	
		Yes	1	

E. Agricultural extension services

Q33.	Do you receive agricultural extension services?	No	0	
		Yes	1	

Q34.	If you receive agricultural extension services, how frequently do you receive such extension services?	Rarely	1	
		Sometimes	2	
		Often	3	

Rarely – (Once or twice); Sometimes – (3 to 6 times); Often – (more than 6 times) per year

Q35.	Are the crops that you grow advocated for by your extension officers?	No	0	
		Yes	1	

F. Labour information

Q36.	Do you have enough family labour for your farming activities?	No	0	
		Yes	1	

Q37.	If you don't have enough family labour, during which operations do you often have labour shortage?	Land preparation	1	
		Planting	2	
		Weeding	3	
		Harvesting	4	

Q38.	If you don't have sufficient family labour, how do you deal with the shortage?	Other arrangements	0	
		Hired labour	1	

Q39.	If labour for harvesting is outsourced (hired or other arrangements), do you train them before harvesting?	No	0	
		Yes	1	

G. Problems encountered

Q40. What problems are you encountering in farming?

……
……
……
……
……
……
……
……

Thank you!

Appendix B: Multicollinearity test for cabbage regression variables

```
. regress Qnty_Cab GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mkt Trn_P
> HH, vce(robust)

Linear regression                               Number of obs =     108
                                                F( 12,    95) =   19.22
                                                Prob > F      =  0.0000
                                                R-squared     =  0.5025
                                                Root MSE      =  .37371

------------------------------------------------------------------------------
             |               Robust
    Qnty_Cab |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         GND |   .0914754   .0888567     1.03   0.306    -.0849275    .2678783
    Mar_Stat |  -.0731393   .0793118    -0.92   0.359    -.2305931    .0843145
      Fam_Xp |  -.0120742   .0032272    -3.74   0.000    -.0184811   -.0056673
     Edu_Lvl |  -.1270145   .0767058    -1.66   0.101    -.2792949    .0252659
     Fam_Grp |  -.1623089   .1119463    -1.45   0.150    -.3845505    .0599326
      Fam_Sz |  -.0036011   .0246773    -0.15   0.884    -.0525916    .0453895
 Hnd_Eqp_Was |   .0677642   .1115038     0.61   0.545    -.1535988    .2891272
     Tm_Hvst |  -.0460129   .0994804    -0.46   0.645    -.2435065    .1514806
     Pck_Usd |  -.2626743     .08938    -2.94   0.004     -.440116   -.0852325
    Sto_Drxn |  -.0073906   .0121399    -0.61   0.544    -.0314913    .0167101
     Dst_Mkt |   .0107965   .0061874     1.74   0.084    -.0014871    .0230802
     Trn_PHH |  -.3240683   .0962387    -3.37   0.001    -.5151262   -.1330104
       _cons |   2.114663   .1336378    15.82   0.000     1.849359    2.379968
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
    Sto_Drxn |      1.56    0.641120
     Pck_Usd |      1.53    0.652971
     Trn_PHH |      1.52    0.659706
     Fam_Grp |      1.42    0.706390
     Dst_Mkt |      1.37    0.732132
 Hnd_Eqp_Was |      1.25    0.798565
     Tm_Hvst |      1.24    0.808839
      Fam_Xp |      1.23    0.814321
         GND |      1.21    0.827539
     Edu_Lvl |      1.13    0.888551
    Mar_Stat |      1.10    0.911144
      Fam_Sz |      1.05    0.948379
-------------+----------------------
    Mean VIF |      1.30
```

Appendix C: Multicollinearity test for spinach regression variables

```
. regress Qnty_Spin GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mkt Trn_
> PHH, vce(robust)

Linear regression                               Number of obs =     102
                                                F( 12,    89) =   21.10
                                                Prob > F      =  0.0000
                                                R-squared     =  0.5298
                                                Root MSE      =  .31138

------------------------------------------------------------------------------
             |               Robust
   Qnty_Spin |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         GND |   .1107989   .0723447     1.53   0.129    -.0329485    .2545463
    Mar_Stat |  -.0111482   .0660542    -0.17   0.866    -.1423966    .1201002
      Fam_Xp |  -.0039005   .0027012    -1.44   0.152    -.0092676    .0014667
     Edu_Lvl |  -.0094806   .0610444    -0.16   0.877    -.1307745    .1118134
     Fam_Grp |  -.0179912   .0793543    -0.23   0.821    -.1756664     .139684
      Fam_Sz |   .0018224   .0292448     0.06   0.950    -.0562864    .0599312
 Hnd_Eqp_Was |  -.3435785    .196535    -1.75   0.084    -.7340894    .0469324
     Tm_Hvst |  -.5141001   .1111569    -4.62   0.000    -.7349665   -.2932337
     Pck_Usd |  -.0152447    .071233    -0.21   0.831    -.1567832    .1262939
    Sto_Drxn |   .0223349   .0081335     2.75   0.007     .0061739     .038496
     Dst_Mkt |   .0053635   .0047255     1.14   0.259     -.004026    .0147531
     Trn_PHH |  -.0830696    .067253    -1.24   0.220    -.2166999    .0505608
       _cons |   1.906283   .2372676     8.03   0.000     1.434838    2.377729
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
    Sto_Drxn |      1.50    0.664750
     Pck_Usd |      1.48    0.675102
     Trn_PHH |      1.47    0.680192
     Dst_Mkt |      1.40    0.714990
     Fam_Grp |      1.32    0.759456
      Fam_Xp |      1.23    0.814795
 Hnd_Eqp_Was |      1.21    0.829202
     Tm_Hvst |      1.19    0.837548
         GND |      1.16    0.860714
     Edu_Lvl |      1.11    0.901030
    Mar_Stat |      1.08    0.924747
      Fam_Sz |      1.07    0.932366
-------------+----------------------
    Mean VIF |      1.27
```

Appendix D: Multicollinearity test for tomato regression variables

```
. regress Qnty_Tom GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mkt Trn_PHH, vce(robust)

Linear regression                               Number of obs =      92
                                                F( 12,    79) =   16.45
                                                Prob > F      =  0.0000
                                                R-squared     =  0.4268
                                                Root MSE      =  .40609

------------------------------------------------------------------------------
             |               Robust
    Qnty_Tom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         GND |   .1161241   .0932217     1.25   0.217    -.0694291    .3016772
    Mar_Stat |  -.1144965   .1000942    -1.14   0.256     -.313729     .084736
      Fam_Xp |  -.0158809   .0051886    -3.06   0.003    -.0262086   -.0055532
     Edu_Lvl |   -.042979   .0896344    -0.48   0.633    -.2213918    .1354337
     Fam_Grp |  -.1608913   .1237239    -1.30   0.197    -.4071575     .085375
      Fam_Sz |   .0755576    .030965     2.44   0.017     .0139232     .137192
  Hnd_Eqp_Was |   -.167951    .116263    -1.44   0.153    -.3993668    .0634648
     Tm_Hvst |  -.0295641   .1065077    -0.28   0.782    -.2415623    .1824341
     Pck_Usd |  -.2184484   .1170634    -1.87   0.066    -.4514573    .0145605
    Sto_Drxn |   .0009917   .0116673     0.08   0.932    -.0222315    .0242149
     Dst_Mkt |   .0203474   .0072878     2.79   0.007     .0058414    .0348533
     Trn_PHH |   -.082389   .1256992    -0.66   0.514    -.3325871    .1678091
       _cons |    1.79477   .1890161     9.50   0.000     1.418543    2.170997
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
     Pck_Usd |      1.60    0.626573
    Sto_Drxn |      1.58    0.633290
     Dst_Mkt |      1.48    0.674682
     Trn_PHH |      1.45    0.688460
     Fam_Grp |      1.41    0.708254
     Tm_Hvst |      1.23    0.815234
  Hnd_Eqp_Was |      1.22    0.816648
      Fam_Xp |      1.18    0.845654
     Edu_Lvl |      1.17    0.853083
         GND |      1.15    0.870640
    Mar_Stat |      1.12    0.890569
      Fam_Sz |      1.12    0.894439
-------------+----------------------
    Mean VIF |      1.31
```

Appendix E: Ordered probit regression results for cabbage postharvest losses

```
. oprobit Qnty_Cab GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mk
> HH, vce(robust)

Ordered probit regression                       Number of obs   =        108
                                                Wald chi2(12)   =      59.00
                                                Prob > chi2     =     0.0000
Log pseudolikelihood = -38.568874               Pseudo R2       =     0.4801
```

Qnty_Cab	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
GND	.6895252	.364673	1.89	0.059	-.0252207	1.404271
Mar_Stat	-.3358924	.345185	-0.97	0.331	-1.012443	.3406578
Fam_Xp	-.0579523	.0193401	-3.00	0.003	-.0958581	-.0200464
Edu_Lvl	-.7538317	.3542386	-2.13	0.033	-1.448127	-.0595368
Fam_Grp	-.8321268	.5187463	-1.60	0.109	-1.848851	.1845972
Fam_Sz	.0498329	.1315081	0.38	0.705	-.2079182	.3075841
Hnd_Eqp_Was	-.284018	.5406638	-0.53	0.599	-1.3437	.7756636
Tm_Hvst	-.2833236	.3700952	-0.77	0.444	-1.008697	.4420497
Pck_Usd	-1.035688	.3699833	-2.80	0.005	-1.760842	-.310534
Sto_Drxn	-.0592113	.0427462	-1.39	0.166	-.1429923	.0245696
Dst_Mkt	.0557278	.0240671	2.32	0.021	.0085572	.1028984
Trn_PHH	-1.186676	.4070592	-2.92	0.004	-1.984497	-.3888544
/cut1	-3.15935	.701155			-4.533588	-1.785111

Appendix F: Marginal effects for cabbage postharvest losses

```
. mfx compute, predict (outcome (1))

Marginal effects after oprobit
      y  = Pr(Qnty_Cab==1) (predict, outcome (1))
         =  .38145856
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|  -.2500141      .12523   -2.00   0.046  -.495458  -.00457   .361111
Mar_Stat*|   .1261266      .12776    0.99   0.324  -.124283  .376536   .601852
  Fam_Xp |   .0220913      .00733    3.01   0.003   .007729  .036454   8.96296
 Edu_Lvl*|   .2844628      .12928    2.20   0.028   .031081  .537845   .444444
 Fam_Grp*|   .2843528      .13883    2.05   0.041   .012251  .556454   .759259
  Fam_Sz |  -.0189962      .04991   -0.38   0.703  -.116818  .078826   1.82315
Hnd_Eq~s*|   .1033412      .18863    0.55   0.584  -.266376  .473059   .925926
 Tm_Hvst*|   .1050491      .13354    0.79   0.431  -.156691  .366789   .759259
 Pck_Usd*|   .3691511      .11494    3.21   0.001   .143871  .594432   .583333
Sto_Drxn |   .0225713      .01637    1.38   0.168  -.009514  .054657   2.94444
 Dst_Mkt |  -.0212433      .00912   -2.33   0.020  -.039127  -.00336   8.48148
 Trn_PHH*|   .4112464      .11374    3.62   0.000   .188311  .634182   .611111
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

```
. mfx compute, predict (outcome (2))

Marginal effects after oprobit
      y  = Pr(Qnty_Cab==2) (predict, outcome (2))
         =  .61854144
---------+--------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|   .2500141      .12523    2.00   0.046    .00457  .495458   .361111
Mar_Stat*|  -.1261266      .12776   -0.99   0.324  -.376536  .124283   .601852
  Fam_Xp |  -.0220913      .00733   -3.01   0.003  -.036454 -.007729   8.96296
 Edu_Lvl*|  -.2844628      .12928   -2.20   0.028  -.537845 -.031081   .444444
 Fam_Grp*|  -.2843528      .13883   -2.05   0.041  -.556454 -.012251   .759259
  Fam_Sz |   .0189962      .04991    0.38   0.703  -.078826  .116818   1.82315
Hnd_Eq~s*|  -.1033412      .18863   -0.55   0.584  -.473059  .266376   .925926
 Tm_Hvst*|  -.1050491      .13354   -0.79   0.431  -.366789  .156691   .759259
 Pck_Usd*|  -.3691511      .11494   -3.21   0.001  -.594432 -.143871   .583333
Sto_Drxn |  -.0225713      .01637   -1.38   0.168  -.054657  .009514   2.94444
 Dst_Mkt |   .0212433      .00912    2.33   0.020    .00336  .039127   8.48148
 Trn_PHH*|  -.4112464      .11374   -3.62   0.000  -.634182 -.188311   .611111
---------+--------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

Appendix G: Ordered probit regression results for spinach postharvest losses

```
. oprobit Qnty_Spin GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mk
> PHH, vce(robust)

Ordered probit regression                       Number of obs   =        102
                                                Wald chi2(12)   =      39.91
                                                Prob > chi2     =     0.0001
Log pseudolikelihood = -20.860626               Pseudo R2       =     0.6252

------------------------------------------------------------------------------
             |               Robust
   Qnty_Spin |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         GND |    1.569661   .5980216     2.62   0.009     .3975603    2.741762
    Mar_Stat |   -.5078927   .5048756    -1.01   0.314    -1.497431    .4816453
      Fam_Xp |   -.1329232   .0617688    -2.15   0.031    -.2539879   -.0118585
     Edu_Lvl |   -.2650063   .4653011    -0.57   0.569     -1.17698     .646967
     Fam_Grp |   -.0071552   .5489454    -0.01   0.990    -1.083068    1.068758
      Fam_Sz |    .0027424   .1640322     0.02   0.987    -.3187548    .3242397
 Hnd_Eqp_Was |   -2.246796    .581399    -3.86   0.000    -3.386317   -1.107274
     Tm_Hvst |   -3.693944   .7225992    -5.11   0.000    -5.110213   -2.277676
     Pck_Usd |   -.0447725   .5053857    -0.09   0.929     -1.03531    .9457652
    Sto_Drxn |    .1685681   .0498747     3.38   0.001     .0708155    .2663208
     Dst_Mkt |    .0378579   .0315462     1.20   0.230    -.0239715    .0996873
     Trn_PHH |   -.8797711   .5188041    -1.70   0.090    -1.896608    .1370663
-------------+----------------------------------------------------------------
       /cut1 |   -3.755894   1.226581                   -6.159949   -1.351839
------------------------------------------------------------------------------
```

Appendix H: Marginal effects for spinach postharvest losses

```
. mfx compute, predict (outcome (1))

Marginal effects after oprobit
      y  = Pr(Qnty_Spin==1) (predict, outcome (1))
         =  .97302646
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|  -.1561828      .09884   -1.58   0.114    -.3499  .037535   .401961
Mar_Stat*|   .0357115      .04213    0.85   0.397  -.046866  .118289   .598039
  Fam_Xp |   .0082785       .0046    1.80   0.072  -.000743    .0173   9.51961
 Edu_Lvl*|   .0163067      .02874    0.57   0.571  -.040032  .072645   .460784
 Fam_Grp*|   .0004473      .03445    0.01   0.990  -.067066  .067961    .77451
  Fam_Sz |  -.0001708      .01025   -0.02   0.987  -.020259  .019918   1.84608
Hnd_Eq~s*|   .5392674      .18046    2.99   0.003   .185566  .892969   .921569
 Tm_Hvst*|   .8126956      .11586    7.01   0.000    .58561  1.03978   .764706
 Pck_Usd*|   .0027985      .03197    0.09   0.930  -.059852  .065449   .539216
Sto_Drxn |  -.0104985      .00746   -1.41   0.159  -.025123  .004126   2.93137
 Dst_Mkt |  -.0023578       .0025   -0.94   0.345   -.00725  .002534    8.0098
 Trn_PHH*|   .0662562      .05883    1.13   0.260  -.049057  .181569   .568627
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

```
. mfx compute, predict (outcome (2))

Marginal effects after oprobit
      y  = Pr(Qnty_Spin==2) (predict, outcome (2))
         =  .02697354
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|   .1561828      .09884    1.58   0.114  -.037535    .3499   .401961
Mar_Stat*|  -.0357115      .04213   -0.85   0.397  -.118289  .046866   .598039
  Fam_Xp |  -.0082785       .0046   -1.80   0.072    -.0173  .000743   9.51961
 Edu_Lvl*|  -.0163067      .02874   -0.57   0.571  -.072645  .040032   .460784
 Fam_Grp*|  -.0004473      .03445   -0.01   0.990  -.067961  .067066    .77451
  Fam_Sz |   .0001708      .01025    0.02   0.987  -.019918  .020259   1.84608
Hnd_Eq~s*|  -.5392674      .18046   -2.99   0.003  -.892969 -.185566   .921569
 Tm_Hvst*|  -.8126956      .11586   -7.01   0.000  -1.03978  -.58561   .764706
 Pck_Usd*|  -.0027985      .03197   -0.09   0.930  -.065449  .059852   .539216
Sto_Drxn |   .0104985      .00746    1.41   0.159  -.004126  .025123   2.93137
 Dst_Mkt |   .0023578       .0025    0.94   0.345  -.002534   .00725    8.0098
 Trn_PHH*|  -.0662562      .05883   -1.13   0.260  -.181569  .049057   .568627
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

Appendix I: Ordered probit regression results for tomato postharvest losses

```
. oprobit Qnty_Tom GND Mar_Stat Fam_Xp Edu_Lvl Fam_Grp Fam_Sz Hnd_Eqp_Was Tm_Hvst Pck_Usd Sto_Drxn Dst_Mkt
> HH, vce(robust)

Ordered probit regression                       Number of obs   =         92
                                                Wald chi2(12)   =      71.81
                                                Prob > chi2     =     0.0000
Log pseudolikelihood = -35.645216               Pseudo R2       =     0.4362
```

Qnty_Tom	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
GND	.4015922	.3550755	1.13	0.258	-.294343	1.097527
Mar_Stat	-.4090918	.3595989	-1.14	0.255	-1.113893	.2957092
Fam_Xp	-.1133756	.0310157	-3.66	0.000	-.1741653	-.0525858
Edu_Lvl	-.2592342	.3646504	-0.71	0.477	-.9739359	.4554675
Fam_Grp	-.8373539	.4345087	-1.93	0.054	-1.688975	.0142674
Fam_Sz	.4147555	.1721199	2.41	0.016	.0774067	.7521043
Hnd_Eqp_Was	-1.529938	.4742214	-3.23	0.001	-2.459394	-.6004809
Tm_Hvst	-.3651827	.399143	-0.91	0.360	-1.147489	.4171233
Pck_Usd	-.8319087	.4289329	-1.94	0.052	-1.672602	.0087843
Sto_Drxn	.018049	.0430417	0.42	0.675	-.0663112	.1024092
Dst_Mkt	.0815688	.0282525	2.89	0.004	.026195	.1369427
Trn_PHH	-.3083764	.4010815	-0.77	0.442	-1.094482	.4777288
/cut1	-2.480972	.6949998			-3.843147	-1.118798

Appendix J: Marginal effects for tomato postharvest losses

```
. mfx compute, predict (outcome (1))

Marginal effects after oprobit
      y  = Pr(Qnty_Tom==1) (predict, outcome (1))
         =  .59144027
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|   -.156011      .13625   -1.15   0.252  -.423058  .111036   .423913
Mar_Stat*|   .1595638      .13936    1.14   0.252  -.113579  .432707   .630435
  Fam_Xp |   .0440369      .01172    3.76   0.000   .021066  .067008   8.81522
 Edu_Lvl*|   .1001583      .14005    0.72   0.475  -.174344  .374661   .456522
 Fam_Grp*|   .3245457      .15893    2.04   0.041   .013046  .636046   .771739
  Fam_Sz |  -.1610979      .06704   -2.40   0.016  -.292493 -.029702   1.86957
Hnd_Eq~s*|   .5174044      .11285    4.58   0.000   .296224  .738585   .923913
 Tm_Hvst*|   .1434848      .15684    0.91   0.360  -.163922  .450892       .75
 Pck_Usd*|   .3173319       .1557    2.04   0.042   .012163    .6225   .554348
Sto_Drxn |  -.0070105      .01674   -0.42   0.675  -.039811   .02579   2.82609
 Dst_Mkt |  -.0316827      .01112   -2.85   0.004   -.05347 -.009896   7.83696
 Trn_PHH*|   .1199421      .15637    0.77   0.443  -.186532  .426416   .576087
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

```
. mfx compute, predict (outcome (2))

Marginal effects after oprobit
      y  = Pr(Qnty_Tom==2) (predict, outcome (2))
         =  .40855973
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     GND*|    .156011      .13625    1.15   0.252  -.111036  .423058   .423913
Mar_Stat*|  -.1595638      .13936   -1.14   0.252  -.432707  .113579   .630435
  Fam_Xp |  -.0440369      .01172   -3.76   0.000  -.067008 -.021065   8.81522
 Edu_Lvl*|  -.1001583      .14005   -0.72   0.475  -.374661  .174344   .456522
 Fam_Grp*|  -.3245457      .15893   -2.04   0.041  -.636046 -.013046   .771739
  Fam_Sz |   .1610979      .06704    2.40   0.016   .029702  .292493   1.86957
Hnd_Eq~s*|  -.5174044      .11285   -4.58   0.000  -.738585 -.296224   .923913
 Tm_Hvst*|  -.1434848      .15684   -0.91   0.360  -.450892  .163922       .75
 Pck_Usd*|  -.3173319       .1557   -2.04   0.042    -.6225 -.012163   .554348
Sto_Drxn |   .0070105      .01674    0.42   0.675   -.02579  .039811   2.82609
 Dst_Mkt |   .0316827      .01112    2.85   0.004   .009896   .05347   7.83696
 Trn_PHH*|  -.1199421      .15637   -0.77   0.443  -.426416  .186532   .576087
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```