Elicitation of risk preferences of smallholder irrigation farmers in the Eastern Cape Province of South Africa

By

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DECLARATION

I hereby certify that this dissertation is my own original work and has not previously been submitted to another university for the purpose of a degree. Where use has been made of the work of others, such work has been duly acknowledged in this text.

Signed ……………………………………………… Date: …………………………..

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DEDICATION

I dedicate this work to my loving parents Rebecca and Matome Mathlo, for the sacrifices they made towards my education. Thanks for believing in me and always seeking the best in me. ***Kea kgolwa lea itumela ka nna.*** To my daughter, Tsošeletšo Mathlo, you gave a new meaning to my life, real revival and a true blessing indeed; I have paved a way for you. I love you all

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ABSTRACT

Although several studies have investigated commercial farmers' risk preferences, there is still lack of information on the risk attitudes and risk preferences of smallholder farmers in South Africa. Risks associated with the adoption of new agricultural technology need to be explored in order to address the transition from homestead food gardening to smallholder irrigated farming. This study seeks to understand risk perception of smallholder irrigation farmers by linking constraints to commercialisation, adoption of new agricultural technologies and risk preferences of smallholder farmers in the Eastern Cape Province of South Africa.

The overall objective of this research is to determine risk preference patterns and attitudes that influence the transition from homestead food gardening to irrigated farming of smallholder farming systems in the Eastern Cape province of South Africa. Specifically the study was to pursue the following objectives: (i) describe the demographic and socio-economic characteristics of smallholder farmers; (ii) describe existing farming systems among smallholder farmers in the study area; (iii) analyse the adoption of new agricultural technology by smallholder irrigation farmers; (iv) assess the risk perception of smallholder irrigation farmers and elicit farmers risk preferences, and (v) empirically analyse farmers sources of risk and risk management strategies. The outcome of this will inform policy formulation that have implications for technology adoption, increase smallholders capacity to bear risk and enable government and other role players have a clear understanding of smallholder farmers decisions.

A total of 101 respondents were surveyed, consisting of 38 smallholder farmers and 63 homestead food gardeners in the Eastern Cape. Questionnaires were used to record household activities, socio-economic and institutional data as well as household demographics through personal interviews. 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 farmers'risk preference status. The ordered probit model successfully estimated the significant variables associated with the farmer's adoption decisions. These were the farmer's age, household size, land size, locational setting, risk attitude, number of livestock (goats and chicken) and asset

ownership. Homestead food gardeners were less risk averse that the smallholder farmers. Farmers who reside in the sub-wards Binfieldand Battlefield were more likely to take risk than those who reside in Melani. This suggests the presence of local synergies in adoption which raises the question about the extent to which ignoring these influences biases policy conclusions. The negative correlation between land size and adoption implies that smaller farms appear to have greater propensity for adoption of new agricultural technology. This finding is supported by several studies reviewed in the literature that allude to the fact that homestead food gardeners tend to be smaller than smallholder farmers.

By means of the Principal Component Analysis (PCA), seven principal components (PCs) that explained 66.13% of the variation were extracted. According to the loadings, the factors 1 to 7 can best be described as ‘financial and incentives index’, ‘input-output index’, ‘crop production index’, ‘ labour bottleneck index’, ‘lack of production information index’, ‘lack of market opportunity index’, and ‘input availability index’ respectively. In general, price, production and financial risks were perceived as the most important sources of risk. Socio economic factors having a significant effect on the various sources of risk are age, gender, education, location, information access and risk taking ability. The most important traditional risk management strategies used by the surveyed smallholder farmers in Eastern Cape are crop diversification, precautionary savings and participating in social network. The findings are consistent with economic theory which postulates that in the absence of insurance markets, poor farm households tend to be risk averse and are reluctant to participate in farm investment decisions that are uncertain or involve higher risk.

This study sought to identify among others, independent variables that explain the adoption of new agricultural technology and thereby facilitate policy prescriptions to augment adoption in South Africa and around the world. The technology adoption analysis of the independent variables used in the ordered probit analysis revealed some underlying patterns of influence. Given the limited prospect of identifying such variables through further research, it is concluded that efforts to promote new agricultural technology will have to be tailored to reflect the particular conditions of individual locales. The propensity of adoption decisions by neighbourhoods to affect others must be given due importance, for product marketing, extension delivery and

development purposes, while delineating target domains for introducing new technologies especially where resources are limited. An insight into the sources of risk has clear implications as to how the perceived riskiness of new agricultural technology may be reduced, thus increasing the likelihood that relatively more risk averse farmers will adopt the new agricultural technology.

Some of the sources of risk were common across the farmer groups. These include the uncertain climate and lack of cash and credit to finance inputs. This shows that communication and joint-problem solving may help to address some of the challenges. Investment in water harvesting technologies will ensure availability of water throughout the growing season and alleviate the risk associated with drought. Agricultural credit should be extended to farmers through service cooperatives and extension programmes. Input credit should be widely applied to enable farmers adopt improved agricultural technologies and more especially smallholder farming where the provision of cash credit services is limited.

Keywords: Risk preferences, agricultural technology adoption, Probit, Multinomial logit, Arrow Parratt Absolute risk, irrigation, smallholder farmers, commercialisation, principal component analysis

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CHAPTER 1

INTRODUCTION

1.1. Background

Agricultural production in low income developing countries is generally poorly diversified; focusing on rain fed staple crop production and raising livestock activities that are inherently risky. The significance of agriculture in the economies of developing countries has long been recognized. In Africa, the agricultural sector plays a significant role in terms of its contributions to the Gross Domestic Product (GDP), income and employment (Nkamleu, Gokowski and Kazianga, 2003). More than 80% of the population in some countries in Africa are dependent on small-scale farming as their primary source of livelihood. Agriculture contributes to industrial growth through endowment of cheap labour, capital for investment, foreign exchange earnings, and markets for manufactured consumer goods, enhanced rural incomes to support increasing numbers dependent on the industry, as well as food and raw material needs for the fast growth in urban populations (Kydd, Dorward, Morrison and Cadisch, 2001).

According to Van Rooyen (1997), agriculture contributes both directly and indirectly to economic growth. The direct contribution is reflected by the relative small proportion of GDP and employment. However, the indirect contribution through agriculture's linkages and multipliers is large. One of the most fundamental roles of agriculture is supplying food to the consumer at an affordable price. Agricultural production in South Africa has increased on average at a rate of 3.4% annually since the 1980's, while the population has increased at an average rate of 2.6% (FAO, 2010).

Increased agricultural production and food self-sufficiency have been part of economic growth and development of most countries around the world (Eicher and Staatz, 1985). There are approximately 2.6 billion people worldwide who derive their livelihood from small-scale agriculture. In Sub Saharan Africa (SSA), 80% of the population are small-scale farmers who cultivate less than 2 hectares of land (Biovision- Foundation for ecological Development, 2012). According to the Economic Report on Africa (2009), the sector employs over 70% of the labour force and contributes over 25% to the Gross Domestic Products (GDP) of developing countries. Smallholder farmers have a potential role of supplying an extra 70% of food needed to feed the growing populations globally (National Centre of Competence in Research (NCCR), 2012; Bruinsma, 2010). Further, the transformation of subsistence to commercial agriculture through efficient use of natural resources, farmer skills and knowledge, social networks, and adoption of new technologies like irrigation is seen as a crucial development path for economic growth in developing countries (Jaleta *et al.,* 2009).

In rural South Africa, Aliber *et al.* (2009) reported that the majority of smallholder farmers ‘goals are predominantly cultivating food crops for home consumption with less emphasis on generating farm incomes. Smallholders ‘less emphasis on farming as business may influence farmer‘s decision to cultivate small-plot with minimal investment leading to low productivity and marketable surplus (Padilla-Fernandez and Nuthall, 2001; Maskey, Lawler and Batey, 2010). According to Aliber *et al.* (2009), smallholder farmers‘output in South Africa contribute negligibly to the nation agricultural GDP although they are still regarded important for sustainable food security and self-employment among rural resource-poor households.

Despite the positive contributions to increased food security and employment, smallholder agriculture is faced with numerous challenges resulting from social, political, economic and environmental factors (Ortmann and King, 2010). According to Obi (2011), subsistence farmers, especially in the former independent homelands of South Africa, are locked in low productive traditional technologies. Like most rural farmers in Sub Saharan Africa, smallholder farmers in South Africa are faced with challenges such as lack of access to factors of production (mainly land and water), lack of access to credit, and limited technology accessibility and applicability (Spio, 1997). Poor rural farmers are also faced with high transaction costs associated with input/output markets and lack market information which may be as a result of poor infrastructures (Ortmann and King, 2010).

Agriculture is also faced with risks associated with climate change. Globally, climate change has led to extreme temperatures and less rainfall resulting in water shortage (NCCR, 2012). Atmospheric accumulation of greenhouse gas emissions caused by use of fossil fuels, increased population growth, and economic activities are some of the major factors responsible for increasing rate of climate change (Ancharaz and Sultan, 2010; and Vanhove and Van Damme, 2011). Global temperature is expected to rise by 1 or 2°C in the first half of the 21st century and this would lead to decreased crop yields especially in the semi-arid and tropical regions (Ancharaz and Sultan, 2010; and Vanhove and Van Damme, 2011).

By the end of the 21st century, 90% of climate simulation models predict decreases in precipitation (Vanhove and Van Damme, 2011). A decrease in precipitation would lead to water scarcity both for rain-fed and irrigation farming (Ancharaz and Sultan, 2010; and Vanhove and Van Damme, 2011). The indirect negative impact of climate change on agricultural production includes increase in resistant weeds, and plant pests and disease outbreaks (Vanhove and Van Damme, 2011). Extreme weather events like storms, floods, cyclones, hailstorms, typhoons, heat wave and drought as a result of climate change are also accountable for the disruption of agricultural production (Ancharaz and Sultan, 2010; and Tacoli, 2012). Both the direct and indirect negative impact of climate change not only affects crop yields but also the nutritional value of food. As would be expected, the negative impacts of climate change are felt to a much greater extent by the resource poor smallholder households (NCCR, 2012; Tacoli, 2012).

Specifically, in Sub-Saharan countries including South Africa, 14% decrease in precipitation would cause a decline in the net revenues of crops by USD 9 billion (Ancharaz and Sultan, 2010). Therefore, this calls for scientific and political interventions that promote increased biomass through changes in agricultural systems, improved access to natural resources (especially land and water), and reforms in social and institutional structures (Vanhove and Van Damme, 2011; NCCR, 2012; and Tacoli, 2012) . Adaptation to climate change can further be achieved through water harvesting technologies, establishment of infrastructure to guard against floods and storm surges, integrated approaches in water resource management and soil moisture conservation (Vanhove and Van Damme, 2011). Although some of these strategies have been incorporated in the provincial strategic plan, in 2010, the Eastern Cape Province was declared a disaster area in terms of increased temperatures and water scarcity (ECDRAR, 2011).

In addition to erratic rainfalls, high water evaporation caused by high temperatures has caused natural water sources to be unreliable yet they are the major sources of irrigation water in the Eastern Cape Province (ECDRAR, 2011). Reduced water levels from natural sources have led to restricted water use, resulting in a higher dependence on rainfall as an appropriate alternative for water source especially during summer (Kodua-Agyekum, 2009; Van Averbeke *et al.*, 2011). This implies that although the province receives low rainfall, rainfall still remains a perfect substitute for other natural sources like rivers, and springs. Due to its importance, rainwater harvest technologies have been developed to increase water accessibility especially in arid, semi-arid and other areas prone to long droughts (UN-HABITAT, 2005). Rainwater harvesting technologies range from small containers to larger water reservoirs. Rainwater harvest for meaningful smallholder agricultural production may require larger water reservoirs (UN-HABITAT, 2005). However, larger reservoirs may be costly and thus can be hardly afforded by the resourced-poor smallholders (DAFF, 2010).

Smallholders use of low production traditional techniques and farming on the same piece of land overtime has led to soil fertility exhaustion. This may be due to lack of farmers‘participation in designing appropriate technologies that suit their needs, and lack of access to modern knowledge and skills needed to improve productivity (Spio, 1997; Sishuta, 2005; Obi, 2011). All these have led to stagnant and declining smallholders‘agricultural productivity in South Africa. Therefore, there is a need for improved production efficiency and appropriate resource allocation for increased productivity and hence, increased marketable outputs, household incomes, and improved rural livelihoods.

South Africa has a dualistic agricultural economy comprising a large-scale commercial and a small-scale rural smallholder agricultural sector. The large-scale commercial sector comprises a large well-integrated and highly capitalized commercial farms, mostly owned by few white people and contributing about 95% of the country‘s agricultural output (Aliber and Hart, 2009; FANRPAN, 2012). The rural smallholder sector is mainly composed of black farmers the majority of whom are subsistence producers (Aliber and Hart, 2009; FANRPAN, 2012). Although about 8% of commercial farm land has been redistributed among previously disadvantaged black farmers under the land reform programmes, South African government claim that white commercial farmers still cultivate and control 87% of South African arable land, while smallholder farmers cultivate about 13% arable land (Mail & Guardian News, 2012; Political Analysis South Africa, 2013). The dualistic nature of the agriculture sector mirrors the broader South African economy which is said to be composed of the first world economy juxtaposed with an under-developed and traditional second economy (du Toit and Neves, 2007).

The notion of the second economy in South Africa was first introduced by the former South African president, Mr Thabo Mbeki in the now-famous August 2003 Letter from the President (du Toit and Neves, 2007). His argument was mainly based on the racial and geographical distribution of income inequalities and poverty level in the South Africa‘s economy. Mr Thabo Mbeki described the second economy as that characterized by poor people who are unskilled and lack access to financial support to lift them out of poverty and happen to be almost entirely black (du Toit and Neves, 2007). In 2004, in the South African Finance Minister‘s budget speech, Mr Trevor Manuel, bemoaned the existence of a second economy (Obi, 2006). Rural smallholder farmers were identified as part of this poverty stricken second economy (Machingura, 2007). After identifying smallholders as part of this economy, they were selected as beneficiaries of the South African Micro-finance Apex Fund, established to provide financial and institutional development support in the second economy (Machingura, 2007). In 2011, The National Planning Commission was set up, chaired by Mr Trevor Manuel to re-examine the country's economic status. Results of the commission indicated that many poor South Africans are still trapped in that second economy (Obi *et al.,* 2011).

In addition to the establishment of the South African Micro-finance Apex Fund, the post-apartheid land reform policies and legislations were formulated and enacted to trigger expansion of smallholder farms for increased productivity (Aliber and Hart, 2009). Despite the available land policies, few, if any, smallholder farmers have expanded their farms (Aliber and Hart, 2009). Partly, this may be attributed to increasing agricultural risks faced by the rural resourced-poor smallholders globally (Kisaka-Lwayo and Obi, 2012). These risks may be as a result of introduction of new technologies, change in economic environment and uncertainties resulting from changes in public policies (Spio, 1997; Kisaka–Lwayo and Obi, 2012). In order to reduce risks, farmers diversify by growing several crops on small pieces of land. The diversification consequently has resulted into low subsistence agricultural production, less marketable surplus, low household incomes, food insecurity, unemployment and increased poverty levels.

In South Africa the term smallholder irrigation is mostly used when referring to irrigated agriculture practiced by black people. South Africa has about 1.3 million ha under irrigation, of which 0.1 million ha is in the hands of smallholders (Backeberg, 2006). Smallholder irrigators have been categorized into the following four groups, namely, (i) farmers on irrigation schemes; (ii) independent irrigation farmers; (iii) community gardeners; and (iv)home gardeners (De Lange, 1994; Crosby, et al., 2000; Du Plessis, Van Averbeke and Van der Stoep, 2002). Backeberg (2006) estimated the number of South African smallholder irrigators to range between 200 000 and 250 000, but majority of these were farming very small plots, mainly to provide food for home consumption. South African smallholder irrigation schemes are multi-farmer irrigation projects larger than 5 ha in size that were either established in the former homelands or in resource-poor areas by black people or agencies assisting their development.

Smallholders farmers in most developing countries are somewhat land constrained, poorly linked to markets, and are more vulnerable to risk than larger farmers in the same area. Therefore, the logical starting point for identifying priority policy interventions that target smallholder farmers in a certain area would be recognizing important differences within and across that areas small- farm sector.

Risk is an issue of critical importance to smallholder farmer’s decision making and it complexes their livelihoods (Belaineh, 2000 and 2002, Belaineh and Drake, 2002). For the farmers the main issue raised by inconsistency of climate, price and other risk factors is how to respond and adapt systematically, contextually and enthusiastically to unfolding risks to reduce the possibility of losses and its downside consequences. Studies in experimental economics have tried to examine to what degree risk attitudes lead to impacts on economic performance. They find that the risk aversion has been inversely linked with economic outcome such as investment in physical, human capital and wage growth (Shwa, 1996).

However, most economic analysis assumes the preferences of individual farmers are taken as given and those preferences decide the farmer's selection. Based on this assumption, society's economic behavior is obtained by aggregating the choices in the society. This way leaves little room for investigating how the environment in which farmers make decisions affects those decisions (Postlewaite, 2011).

Other studies, however, suggest that individual experiences can have long term effects on preferences that can affect long term individuals' risk attitudes. In their study Malmendier and Nagel (2011), find that personal traumatic experiences such as the combat experiences of veterans have long term effects on financial decisions. Particularly their findings show that having experienced psychological shocks decrease an individual's willingness to take financial risks.

Information acquisition and learning would influence inactivity to cope with various sources of risks (Noell and Odening, 1997). Risk information that is traditional early warming techniques and those channels from government sources, the way it is communicated, reliability of the information and the eventual learning assumes importance to pilot in a complex and uncertain world. Noell and Odening (1997) further suggest that information collection and processing is, among other things, a significant risk management behavior over time. Adesina and Quattara (2000) argue that unless policy makers improve the accessibility of information that allows farmers to progress their managerial capacity for making more risk- efficient cropping decisions, it is unlikely that farmers will be able to cope with persistent risks that affect their welfare and livelihoods. Partially as provision of information to farmers could enable them to make more informed decisions- whilst attributing communication of technical information to farmers' sources alone is arguable, as there are various informal source of wisdom and information with varying contents and magnitude in the rural context.

The risk environment of farmers markets is changing, among others due to increasing market liberation and industrialization of agriculture (Boehlje and Lins, 1998). These changes lead to new risks management instruments are being developed. Risk management strategies adopted by farm managers will be in accordance with their personal preferences for risk. In this context it would be useful for developers and sellers of such new risk strategies to have insight into these preferences of farmers (Beal, 1996).

Risk preferences play an important role in economics. Studies in experimental economics have tried to examine to what degree risk attitudes lead to impacts on economic performance. They find that the risk aversion has been inversely linked with economic outcome such as investment in physical, human capital and wage growth (Shwa, 1996). However, most economic analysis assumes the preferences of individual farmers are taken as given and those preferences decide the farmer's selection. Based on this assumption, society's economic behavior is obtained by aggregating the choices in the society. This way leaves little room for investigating how the environment in which farmers make decisions affects those decisions (Postlewaite, 2011).

There are clear opportunities for commercialization of smallholder farming in Africa but the challenge lies in bringing markets to farmers – 'pulling' demand for goods that will encourage farmers to make investments, find innovative ways of overcoming spatial and technological constraints (Livingston, Schonberger and Delaney, 2002). Despite phenomenal success of the commercial sector in South Africa and significant progress in integrating smallholders since democratic reforms, food security concerns remain in South Africa. Recent global increases in food have further aggravated vulnerabilities and make it imperative to examine alternative food production questions in the country.

1.2. Problem statement

There are many obstacles to the growth of smallholder agriculture. One of the obstacles is the persistence of out-dated production technologies because farmers do not adapt to technologies whose benefits are not well demonstrated and they do not see any incentives to adoption to improved practices.

Smallholder farmers involved in agricultural production in developing countries come across a number of risks, including crop yield risks due to discrepancies in rainfall and fluctuating output prices. Farmers' decisions to forego welfare improving opportunities because of perceptions of risk have significant policy implications. While the existence of agricultural risk and its effects on developing countries is well known, there are few empirical estimations of the magnitude and nature of household risk aversion in this context. Moreover, there is some information on the basic household factors behavior affecting risk behavior. With developing countries, there may be vital linkages between risk aversion on the part of the farm households and seemingly distinct elements such as household fertility, educational attainment, and gender dynamics. Working on these elements can expand outcomes for technology adoption (Yesuf and Bluffstone, 2007).

According to Eswaran and Kotwal (2002), for a given risk aversion, under- investment in risky production activities will be greater for households who are constrained in their consumption smoothing activities. Whilst it is the role of constraints that is ultimately of concern and of policy interest (Zimmerman and Carter, 2003), the dependence on measures of wealth to identify the impact of risk on many contexts is challenging as it is not fully possible to deal with the endogeneity issues entailed in identifying the fundamental relationship between a measure of wealth and production decisions. An unobserved preference for risk will affect not only current production choices, but also past production choices and thus the asset-wealth of a household, causing a household's ability to deal with the risk to be endogenous to production choices. Only if an innate measure of risk preferences is also included can endogeneity problem be solved.

From a social learning theory perspective, Tucker and Napier (2001), the increased emphasis on formal information sources will yield higher levels of perceived risk. Of course, interpersonal sources such as friends and neighbours, should also play a substantial role in risk perception by dispensing information from formal and other sources more widely throughout the agricultural community. Relatively, Tucker and Napier (2001) argue that informal sources may also have access to information about specific local issues that formal sources do not. Therefore, increased communication with and/or within various farmers' groups are likely to be associated with risk perceptions and selection of risk management tools. To add on, Belaineh and Drake (2002) and Belaineh (2002) claim that smallholder farmers in Eastern Ethiopia perceive risk subjectively, that is, at individual and group levels, and respond accordingly. Perception of risk is subjective in a sense that it is vulnerable to variations depending on the past contextual experiential learning, provision of and/or access to information, confidence in institutions and bases of information, farm and farmer's characteristics, interaction and status in the community and psychological mindset of the individual farmers and the groups.

Studies reveal that households' response towards risk is due to a number of factors when faced with new agricultural technologies. Some of these factors are related to the nature of the transformation in agricultural production, whereas others are related to farmers past experiences and characteristics. This indicates that farmers are more sensitive to loss than gains. According to Yesuf and Bluffstone (2007) smallholders who stand to lose as well as gain more than their loss are significantly risk averse than those that face potential gains only. Therefore, there is a chance that agricultural extension intervention involving losses and gains may face systematic resistance by farmers in low income and high risk environments. Once initial successes convince farmers that technology is viable, risk aversion declines. Therefore, smallholder farmers base their investment and production decisions on historical experience and tend to be unwilling to adopt new agricultural technologies even when expected net returns are high. As such a better understanding of risk behaviour is necessary for identifying appropriate farm-level strategies for adoption of new technology by smallholder farmer (Yesuf and Bluffstone; 2007).

There is already some experiential evidence that hypothetical questions on risk correlate as expected with risk taking behavior (Knight, Weir and Woldehanna, 2003). These studies determine whether there is a correlation between risk preferences and behavior, but the focus is not to present an empirical model of risk- taking behavior under uncertainty. In particular, a household's ability to deal with risk is not controlled by a household's perception of risk in a given activity (Dercon, 1996). It focuses on risk preferences and risk perceptions to determine whether they influence individual behavior as a model of labour allocation under risk would, predict in particular recognizing that the ability of a household to deal with risk is crucially important in determining how preferences affect behavior.

South African studies where farm- level data sets were used to identify the importance of multiple risk sources include that of Hardman, Darroch, and Ortman (2002) and Stockil and Ortman (1997). In this studies it was found that factor analysis suggested that crop gross income, government policy, livestock gross income, credit access, government regulation and costs were described as risk sources. Stockil and Ortman analyzed the importance and dimensions of risk sources and the respondents, identified changes in the cost of farm inputs, government legislation, rand exchange rate and product prices as the most important sources of risk. Factor analysis of risk sources showed that various dimensions to risk exist including changes in government policy, enterprise gross income, credit access and cost changes.

Bullock, Ortman and Levin (1994) identified price, climate and yield variability as the most important sources of risk in vegetable production. The results also showed that government policies added to the level of uncertainty faced by vegetable farmers. However, a comparative analysis among large and small vegetable farmers portrayed differences in their perceptions of risk. Small farmers perceived changes in credit availability and changes in input costs to be more important risk sources than large farmers. In their studies Swanepoel and Ortman (1993) revealed that sources of and responses to risk in farm production, marketing and financing were considered to be variations in livestock production, rainfall and livestock prices, the threat of land reform, and changes in input costs.

Smallholder irrigation farmers are characterized by significant business risk and there is evidence that poor smallholder farmers are typically risk averse (Binswanger and Sillers, 1983). Although studies have investigated commercial farmers's risk preferences, there is lack of information on the risk attitudes of smallholder farmers in South Africa. This study seeks to understand risk perception of smallholder irrigation farmers by linking constraints to commercialisation, adoption of new agricultural technologies and risk preferences of smallholder farmers in the former Ciskei Homelands of the Eastern Cape.

1.3. Research objectives

The main objective of this research is to determine risk preference patterns and attitudes that influence the transition from homestead food gardening to irrigate farming of smallholder farming systems in the Eastern Cape province of South Africa.

Specifically the study will pursue the following objectives:

- To describe the demographic and socio-economic characteristics of smallholder farmers;
- Describe the existing farming systems among smallholder farmers in the study area;
- Analyse the adoption of new agricultural technology by smallholder irrigation farmers;
- Assess the risk perception of smallholder irrigation farmers;
- To elicit farmers risk preferences and empirically analyse farmers sources of risk and risk management strategies

1.4. Research questions

This study is guided by the main research question: what influence does risk preference attitudes and patterns have on the transition of homestead food gardeners to smallholder irrigation farming? This question is further guided by the following sub questions:

- What are the socio-economic and/or institutional characteristics that distinguish among smallholder irrigation farmers and homestead food gardeners in the study area?
- Which farming systems do smallholder farmers use?
- Do smallholder farmer risk preference matter in technology adoption among smallholder farmers?
- What are the farmers ‘sources of risk and how do they have a bearing on their risk management strategies?
- What constraints homestead food gardeners to irrigated smallholder farming?

1.5. Hypotheses

The hypotheses to be tested in this study are:

- Farmers use the same farming system in the study area
- Small holder farmers are late adopters of new agricultural technology
- Smallholder farmers are more risk averse

1.6. Justification of the study

Most smallholder farmers in South Africa are located in the former homelands mainly occupied by black people (Kodua-Agyekum, 2009). Smallholder farmers cultivate on farm sizes of less than 5ha, although there are a few outliers (Fanadzo, 2012). At the same time, agricultural practices are traditional, leading to very low productivities (Obi, 2011). Therefore, there is urgent need to tackle the problem, especially in respect of rural areas where the majority of the population, mostly the previously disadvantaged black people, still reside. In recent years, policy has targeted black farmers and new farms are now being established under the Land Redistribution for Agricultural Development (LRAD) Programme launched to redress the imbalance in land distribution (Machethe, 2004; Obi, 2006). Alongside the land redistribution programme are complementary programmes for economic empowerment through credit assistance, subsidization of farm infrastructure development, and other forms of support included under schemes like the Comprehensive Agricultural Support Programme (CASP), the Micro Agricultural Financial Institutional Scheme of South Africa (MAFISA), among several others (Obi and Pote, 2012). Despite all the support and incentives, productivity is still low and stagnant among smallholder farmers leading to reduced incomes of the rural family because all food is consumed by the increasing population and less is marketed (Aliber and Hart, 2009).

South Africa is faced with high poverty rate accompanied with the highest levels of income inequality in the world (Klasen, 1997; UNDP, 2007). In addition, there is declining agricultural output, and increased unemployment rates especially in the Eastern Cape Province where 41.4% of youths and 18.4% adults are unemployed (Majodina, 2011; Department of Rural Development and Agrarian Reform, Eastern Cape, 2011). As a way of reducing these pathetic conditions especially among rural population, President Zuma restated government‘s commitment to the implementation of the Comprehensive Rural Development Programme (CRDP) responsible for reviving land reform projects and irrigation schemes in the former homelands (Zuma, 2011). In addition to improved access to land and water, famers‘ goals and aspiration need to be incorporated in the agricultural development programmes for increased productivity (Padilla-Fernandez and Nuthall, 2001; Kibaara, 2005).

Unemployment is high and tends to rise as households lose jobs in the urban centres. Farmers in these areas are not really part of commercial agriculture. This is one of the reasons that the contribution of smallholder agriculture to the gross domestic product (GDP) is still limited in South Africa. The majority of disadvantaged farmers are not part of mainstream agriculture and practices smallholder agriculture in the former homelands. This kind of smallholder farming is characterized by low production and poor productivity, poor access to land and poor access to inputs and credit. In order to generate enough income, farmers engage themselves in off- farm or non- farm income generating activities.

It is, however, possible for smallholder farming to survive economically when given a set of opportunities. Smallholder farmers are used to take rational decisions in order to adapt to conditions they find themselves in. for example, given a set of resources, farmers will strive to optimize production. Another particular and critical set of opportunities involves opening access for smallholders to interact with other economic agents.

To some extend the process of agricultural transformation in South Africa involves moving households from smallholder production to producing for the market or commercializing. Commercializing has a number of benefits and advantages. In particular employment is promoted and income generated (Ngqangweni, 2000). The commercial environment provides a potential for increased production and thus for improving food security for the rural poor. Studies by Ngqangweni (2000); Delgado, Rosegrant, Steinfeld, Ehui and Courbois, (1999) have shown positive and strong multiplier effects of investing in agriculture. Therefore, agriculture has an important role to play in fostering rural development and poverty alleviation. It is through commercialization of smallholder agriculture that the previously disadvantaged groups can become a significant part of the economic base of rural economies. It is respected that efforts to promote structural change, such as land reform, improved access to credit and a number of markets have benefited some, although a small minority of black farmers. But the reforms have not been sufficient to improve the participation in commercial agriculture of the majority of smallholder and emerging farmers.

There is risk aversion of smallholders to commercialize. Therefore research is needed to identify policy options that will stimulate the transition of smallholder farmers to become commercial operators. This study aims to propose ways to alleviate constraints to commercialization by smallholder farmers. According to Binswanger (1982), poor smallholder farmers are risk averse and their production and economic environments are characterized by a high degree of uncertainty. Owing to their wealth smallholder farmers are also expected to be relatively vulnerable to risk and consequently, risk is expected to be an important determinant of their decisions. These general conclusions and observations have stimulated extensive research into the effects of risk on smallholder farmers' adaptation. The case of rural poor households whose capacity to bear risk is low, tend to exhibit a risk averse behavior. Income or production shocks could thus have a drastic impact on the households.

An insight into the sources of risk has a clear implication as to how riskiness of adoption of technology may be reduced, thus increasing the likelihood that relatively more risk averse farmers will adopt to new agricultural technology. Knowledge of farmers, risk preferences could help in the design of technological and institutional practices tailored to their economic behavior in order to improve the likelihood that rural development programmes will succeed in improving household incomes. The findings of the study will guide on how the government and/or the private sector can develop policies that help farmers reduce and/or manage risk and tailor literacy and risk This research output is thought to provide useful information to policy makers and rural development programmes implementers on the importance of transition from homestead food gardening to smallholder farming for farm productivity and improved farm incomes, and reduced unemployment rates and poverty alleviation in the Eastern Cape Province of South Africa management education and strategies towards the various farmer groups in South Africa.

CHAPTER 2

SOUTH AFRICA'S AGRICULTURE AND IRRIGATION ISSUES

2.1. Introduction

A comprehensive review was carried out in this chapter to avail information on smallholder farming systems in South Africa in particular the rural Eastern Cape Province. South Africa‘s smallholder agriculture is not different from other Sub-Saharan Africa‘s agricultural sector, thus, this chapter firstly presents a general overview of the rural smallholder agricultural sector in the region. For a better understanding of the contribution of smallholder farmers‘risk preferences patterns and attitudes in agricultural production, it is necessary to review the performance of the South African agricultural sector in order to better contextualize the discussion. This entails establishing the set-up of the sector based on differences in farm sizes (smallholders and large commercial farms), production share of different agricultural products (field crops, horticultural crops and animal products) and agriculture‘s contribution to the economy.

2.2. An overview of the South African agricultural sector

South Africa‘s agriculture is made up of a commercially oriented sector and the small-scale subsistence sector (Seneque, 1982; Obi, 2006; Aliber and Hart, 2009; AgriSETA, 2010; FANRPAN, 2012). The commercially oriented agricultural sector operates on a large scale, endowed with natural resources and well developed and skilled and semi-skilled labour, more purchased input and sophisticated technologies acquisition, and mainly composed of white people. The second sector includes the small scale subsistence agriculture predominantly occupied by resource poor black People (Black means—non-white and includes Africans, Coloured and Asians/Indians). Due to South African‘s post-apartheid agricultural reforms, a new category of black farmers known as transition/emerging farmers has been established.

All development policies and programmes formulated and launched by apartheid and post-apartheid governments for the sector have been following almost the same direction (ISRDS, 2000). Policies and programmes in the apartheid era and the immediate post-apartheid era mainly supported commercial farmers and virtually neglected the rural smallholder farmer‘s interests. This situation limited the extent to which rural smallholders, mainly black people, participated in both the national and international agricultural markets while the large commercial farms which are predominately white-owned earn enormous profits. The low participation of smallholders in the main stream of the economy has led to scarcity of information regarding this group especially on production and its importance in formulating appropriate policies for improved food security and rural development.

By 2003, the large scale commercial farms occupied about 87% of South Africa‘s agricultural land approximated at 82 million hectares and mainly owned by 60,000 white farmers (FANRPAN, 2012). The number of these farmers has significantly reduced to 35,000 with an average farm size of 2,500 hectares (FANRPAN, 2012). The reduction may be a result of post-apartheid land restitution and redistribution policies (FANRPAN, 2012). The post-apartheid government set a target of redistributing 30% of farm land from white commercial farmers to emerging black commercial farmers by 2014 (Obi, 2006; and FANRPAN, 2012). Although there is a reduction of large-scale commercial farmers, they still contribute 95% of South Africa‘s marketable output.

Large-scale commercial farmers mainly depend on irrigation farming to grow both horticulture and field crops. Commercial farmers have a well-coordinated social network both nationally and globally. These networks include linkages with agro-input/output industries, market outlets, and research and consultant services from both the public and private sector. The social networks ease access to technical and financial support, and market opportunities gained by commercial farmers. Furthermore, commercial farmers can easily practice precision farming system because they own relatively larger farm fields (Peter, 2001). The system allows farmers to subdivide their fields into small portions based on data gathered that avail important information on soil fertility, and this allows efficient input allocation (Peter, 2001). Efficient allocation of inputs results in maximization of returns to investment (Peter, 2001).

In contrast, South African smallholder farmers predominantly living in rural areas are faced with lack of basic resources such as economic, social and human capital (Obi *et al.,* 2011). They are resource poor and the majority lack access to credit. Due to limited access to credit, smallholders can hardly adopt new technologies which may require a combination of purchased inputs for increased productivity (Essa and Nieuwoudt, 2001). Low productivity limits them in participating in the local, national and international markets (Obi *et al.,* 2011). Further, smallholders' economic resource constraints frustrates their efforts to access the desired trainings, services, and market information which are essential for increased productivity and market participation (Grootaert and Van-Bastelaer, 2001). Smallholders'pathetic situation has been worsened by deepening monetization of the agrarian economy which led to the abandonment of their fields and resorted to intensifying'cultivation of small garden plots adjacent to their homestead (du Toit and Neves, 2007; and Nondumiso, 2009). For example, poor smallholders can hardlymeet additional input costs required to hire either a tractor or animal attraction to plough (du Toit and Neves, 2007).

Due to the introduction of schooling, children are no longer available to participate in farming activities and this prevents the transfer of skills from parents to the young generation, referred to as *bovine deskilling*" (du Toit and Neves, 2007). Lack of transfer of skills as the old generation fades, exposes the sector to increased abandonment of fields, declining productivity, high risks of food insecurity, unemployment, and increases in poverty levels (du Toit and Neves, 2007). Further, du Toit and Neves (2007) indicated that smallholders' undermine farmer groups/cooperatives which are a potential supplier of cheap group labour for weeding and ploughing, and collective marketing. Also, most smallholders are relaxed to invest and expand their farms due to indistinct land tenure system and water rights transfers especially in the former homelands (News24, 2011).
In the South African context, smallholder farmers can much be defined based on past racial differences and are subsistence farmers who mainly produce for home consumption with low, if any marketable surplus (Machethe *et al*., 2004). In other words, their priorities are dominated by the need to provide food for their households

and marketable surplus is subordinate to this basic need. There are approximately 4 million black people practicing subsistence smallholder agriculture in South Africa (FANRPAN, 2012).

Most smallholder farmers live in former homelands (rural, segregated and demarcated areas for black people during the apartheid era) including former Transkei and Ciskei in Eastern Cape Province of South Africa. Most smallholder farmers are illiterate, aging, resource poor and lack access to services like training/extension services, markets and good public infrastructure with less accumulated social capital. Smallholders depend on both rain-fed and irrigation farming, and mainly grow maize, beans, potatoes and horticulture crops in small quantities just enough for home consumption (Liebenberg and Pardey, 2010).

In its endeavour to stimulate rural economic growth and alleviate poverty among Black farmers in the former homelands, by 1996 the African National Congress (ANC) government embarked on formulating economic policies geared towards establishing and or strengthening the existing class of emerging black commercial farmers (Greenberg, 2003). This was implemented by restructuring the agricultural sector which resulted into three categories of farmers namely, the subsistence, emerging and commercial‖ farmers, respectively. Agricultural technicians, extension officers who served in the former homelands and former black employees of the Agriqwa were targeted as beneficiaries of the emerging black commercial farmers‘project (Greenberg, 2003; Obi, 2006). The major purpose of selecting these categories of people was that they had some resources that matched government funds and this could fasten the transition from subsistence to commercial agriculture (Greenberg, 2003). Emerging farmers are sometimes grouped together with smallholder farmers. This category of farmers is composed of approximately 200,000 black farmers since 1994 (FANRPAN, 2012). Machethe *et al*. (2004) cited Van Zyl *et al*. (1991) defining emerging farmers as those who have limited economic resources which prevent them from participating in the agricultural market economy in a meaningful way

2.3. Smallholder agriculture in Sub-Saharan Africa

In Sub-Saharan Africa, substantial proportions of the rural-poor households are smallholder farmers and derive their livelihoods largely from agriculture. Smallholder agriculture sector employs a significant number of the rural-poor households in the Sub-Saharan Africa and the scale of production is the basis for its characterization (Economic Report on Africa, 2009). Most of these farm units owned by rural-poor households are generally small in size, and the sector can therefore be referred to as smallholder agriculture‖ (Fanadzo, Chiduza & Mnkeni, 2010). Among the numerous problems faced by the smallholder agriculture in Sub-Saharan Africa, the stagnant low productivity and the prevalence of low-level technology rank very high. Despite the phenomenal improvements in crop yield in Latin America and Asia through adoption of the Green Revolution technologies, farmers on the African continent failed to adopt these technologies (Spencer *et al.,* 2003).

Sub-Saharan African agriculture has a number of distinguishing characteristics that probably explain its numerous definitions especially for the smallholder sector. According to Gilimane (2006) small-scale agriculture can be referred to as the sector of developing economies that presents the most difficult development problems. In support of the foregoing view, Ellis (1993) defined smallholder farmers as those farm households who rely primarily on family labour for farm production to produce mostly for self-subsistence due to limited access to alternative sources livelihoods. There are several other terms that are used to describe smallholder farmers and these include small-scale farmers' resource-poor farmers' peasant farmers' food-deficit farmers' household food security farmers, land-reform beneficiaries and emerging farmers‖ (Fanadzo, Chiduza & Mnkeni, 2010).

Across the African continent, studies in the field of Agricultural Economics have focused on smallholder agriculture in response to the equally growing official interest in the sub-sector as means to achieve the goal of reducing poverty by half in 2014 as part of efforts to meet the MGDs (Eastern Cape Province, Department of Rural Development and Agrarian Reforms, 2011). This has attracted many of the Agricultural Economists and rural agricultural development programmes advocates to gain a deeper understanding of the concept of smallholder agriculture. There are differing definitions of small scale farmers (WIEGO, 2012). According to Van Zyl, Kirsten and Binswanger (1996), smallholder farmers have generally been linked to small farm sizes, traditional practices, and high poverty levels caused by the low returns associated with insufficient market participation. In the context of Ghana in West Africa, Chamberlin (2007) characterized those farmers as constrained by limited land availability as smallholder. Smallholders are generally resource-poor‖ with limited capital, fragmented plots, and insufficient access to inputs for farming (Chamberlin, 2007). Jayne *et al.* (2003), identified small-scale/smallholder farmers in East and Southern Africa as those whose plot sizes fall below 1 ha. Ethical Trading Initiative (2005) defined small scale farmers as farmers who produce relatively small volumes of produce on relatively small plots of land; they are generally more resource poor than commercial-scale farmers and usually considered to be part of the informal economy. They lack social protection and have limited records and are highly dependent on family labour but may hire workers.

Though some agricultural economists suggests that small-scale farming plays an important role in rural economic growth, Nyandoro (2007) indicated that peasant or small-scale farming is an inadequate foundation for development. According to Nyandoro (2007), the majority of smallholders are committed to subsistence production resulting in a highly variable‘marketable surplus, thus imposing risk to both consumers and producers and ultimately the state‘s food security. This is an indication that larger-scale producers are viewed as more reliable source of marketable surplus and therefore creating a stronger basis for planning both in agricultural and national development.

The high predictability of the large-scale producers probably explains the seeming bias of national policy in their favour and the apparent neglect of the small farmers who are considered subsistence-minded‘and restricted by such factors as tradition, fatalism, lack of innovativeness, low aspirational level, limited time perspective and lack of differed gratification (Dorward, Moyo, Coetzee, Kydd and Poulton, 2001; Ngqangweni, 2000). Exclusion of smallholder farmers, particularly in South Africa has led to their extremely low participation from mainstream food markets (Louw *et al.*, 2008). One of the major reasons for excluding smallholder farmers was due to poor performance of their production systems, which were characterized by high production and transaction costs, resulting in poor quality, in addition (Louw *et al.,* 2008).

Food production is a global concern and changes in the global environment affect both the way it is conducted and its outcomes, in terms of the level of food supply, food pricing, and whether or not the objectives of food production are realized. In 2008, the price of food rose dramatically in many parts of the developing world. According to the World Bank (2008), although fluctuations in food prices and availability occur all the time, the rapidity and scale of recent swings was unprecedented. The sharp price rises of 2007 and 2008 were caused by a combination of increased global demand, rising fuel prices, biofuels production, export restrictions, crop failures, financial speculation and dwindling stockpiles (UNCTAD, 2009). As a result, the global grain reserves declined to about 50 days' worth of supply, compared with 115 days in 2000. This is partly because global demand for food outstripped supply in the past few years and partly because stockpiles reached historic lows when crops in some key producing countries failed in 2006/7(UNCTAD, 2009).

According to Clapp and Helleiner (2010), the extreme food price volatility that erupted in 2007–08 brought havoc to world food markets and pushed millions into a situation of food insecurity. It is estimated that 50–100 million more people in the developing world were pushed into hunger during 2007 (IISS, 2008). As millions of people were pushed into the category of food insecure' over the course of 2008, food riots broke out in a number of developing countries. South Africa on the other hand witnessed labour unrests with calls for wage increases to stem the rising food and fuel costs. The total number of undernourished people on the planet topped 1 billion for the first time in mid-2009, marking a dramatic setback for the UN goal of reducing the number of hungry people to no more than 420 million by 2015 (FAO, 2009a). After world food prices had risen by 40% on average in 2007, further sharp gains were seen in early 2008, according to the UN Food and Agriculture Organisation (FAO, 2009b). Because this global food crisis was widely attributed to the failure of food supply to meet rising demand, it prompted a number of high profile international initiatives to expand the global supply of food as well as its availability to poorer countries where chronic underinvestment in the agricultural sector has continued.

Mitchell (2008) reported that the International Monetary Fund (IMF) price index of internationally traded food commodities rose by 56 per cent from January 2007 to June 2008. Then, almost as suddenly, food prices on international markets fell back sharply in the latter half of the year. By November 2008, agricultural commodity prices had fallen by 50 per cent from their record high earlier in the year (FAO, 2008). This appeared to be mainly due to a reduction in consumption with people seemed to be eating less, particularly in the developing world.

Ultimately, the 2008 crisis has highlighted the fragility of the supply/ demand balance and the food system has proved vulnerable to external shocks (IISS, 2008). On the supply side, as a result of economic liberalization and industrialization, the numbers of small, local agricultural producers have decreased and the developing world has become more dependent on imports from developed nations (Nicoll, 2010). There is considerable scope to increase agricultural yields in poorer nations with the correct assistance and investment in agricultural technologies that aim at increase production and ensure food self-sufficiency as well as investment in infrastructure. This is because investment into agriculture has been steadily declining over the past 30 years (FAO, 2009c). Due to the growing perception that agriculture was unprofitable against the backdrop of low commodity prices, developing countries were pushed to open their markets and realize food security through low-cost imports, rather than investing in their own farmers.

While in 1979, aid for agriculture constituted 18% of total development assistance, it declined to 2.9% in 2006 (IFAD, 2008a). Naturally, agricultural productivity growth also decreased, from some 3.5 per cent in the 1980s to about 1.5 per cent today (IFAD, 2009b), as government spending and supportive policies were missing. The World Bank (2008) estimates that by 2030 global demand for food will rise by 50%. The situation is compounded by the fact that more than 1bn people live on less $1 a day, nearly 3bn on less than $2 a day and an estimated 923m are undernourished. In large parts of Africa, the World Bank says, two-thirds of disposable income is spent on food (Clapp and Cohen, 2009). Hence the urgent need to address the food and agricultural crisis bedeviling the world and more specifically the African Continent.

Agricultural growth is a crucial element in resolving food price crises, enhancing food security, and accelerating pro-poor growth (ASARECA, 2008). It is essential that the evolving response at national and international levels addresses the immediate challenges poor and food insecure people face. Sound economic and agricultural policies, including significant investments in agriculture, can prevent gruesome outcomes. In view of the financial crisis and the constraints and risk-averse behavior of the private banking sector, much of the investment would have to be facilitated by the public sector (IFPRI, 2008).

The food crisis was prioritised on the international agenda in 2007/2008 following the establishment of the High-Level Task Force (HLTF) on the global food crisis in April 2008. This task team brought together the UN system with its specialised agencies, funds and programmes and the Bretton-Woods Institutions, in order to develop a common strategy to combat the crisis and to coordinate this strategy‘s implementation (FIAN, 2008). The HLTF (2008) drafted the Comprehensive Framework of Action (CFA), in which it identified two sets of necessary short- and long-term actions to combat the crisis. The short term actions were aimed at meeting the immediate needs of vulnerable populations by firstly enhancing emergency food assistance, nutrition interventions and safety nets, secondly boosting smallholder farmer food production, thirdly adjusting trade and tax policies and fourthly to manage macroeconomic implications. The proposed long term actions aimed to build resilience and contribute to global food and nutrition security. The HLTF (2008) CFA also has four main foci; firstly to further expand social protection systems, secondly to sustain smallholder farmer-led food availability growth, thirdly to improve international food markets and fourthly to develop an international consensus on biofuels. The HLTF coordinates the implementation of this strategy and coordinates donor cooperation at all levels.

Other initiatives included the McGill University‘s Global Food Security Conference (2009) in Montreal which examined the effects of the recent financial crisis on global food security, identified investment priorities for the agricultural sector including critical areas for research and capacity building and evaluated the effects of markets and trade, biofuel production and climate change on current and future world food production and the environment. Delgado (2008)‘s presentation on the Global Food Crisis Response Program (GFRP) of the World Bank emphasized the need to reduce the negative impact of high and volatile food prices on the lives of the poor, support for governments in the design of sustainable policies that mitigate the adverse impacts of high and volatile food prices on poverty and support for broad-based growth in productivity and market participation in agriculture to ensure an adequate supply response as part of a sustained improvement in food supply. Beddington (2011) presented a compelling case for action in the global food system.

The author stressed the aim to place the food system within the context of wider policy agendas. Beddington (2011) argues for decisive action and collaborative decision making across multiple areas, including development, investment, science and trade, to tackle the major challenges that lie ahead and drew attention to the un-sustainability of the food system food currently being produced at the expense of ecosystem health.

The FAO is leading international efforts to eradicate hunger, improve nutrition and living standards world-wide, focusing on developing rural areas (FAO, 2008). It is one among various players in the field. The growing number of future harvest centres around the world has also been necessitated by the renewed interest in technology development to stimulate agricultural production among smallholders especially in the developing nations (HRC, 2008). The New Partnership for Africa‘s Development (NEPAD), an African initiative also aims to eradicate poverty, advance development and end marginalization with a special focus on Africa. The Comprehensive Africa Agriculture Development Programme (CAADP) of the NEPAD seeks to boost agricultural productivity in Africa through the four main pillars of land and water management, market access, food supply and hunger, agricultural research (CAADP, 2011).

The growing recognition of the importance of smallholder agriculture is a very positive trend. Smallholder agriculture is the key to local and global food security and the engine for development and economic growth for most developing countries. Seventy-five per cent of the world‘s poorest people 1.05 billion women, children and men live in rural areas and depend on agriculture and related activities for their livelihoods (IFAD, 2009a). Although smallholder agriculture can indeed be more productive in relative terms and environmentally friendlier compared to large-scale commercial farming, more and more farmland world-wide is now taken up by large plantations cultivating agro-export crops, agrofuels and transgenic soybean. Yet, world-wide, 1.4

billion smallholder farmers still support almost 2 billion people and in Africa alone, 33 million smallholder farmers account for 80% of the continent‘s agricultural outputs (Omiti, Otieno, McCullough and Nyanamba, 2007).

Dano (2009) argues that what is really needed is a truly *green* revolution in Africa based on sustainable production devoid of chemical fertilizers and energy intensive input that further marginalize smallholder farmers. The truly *green* revolution must be based on traditional and local knowledge, integrating smallholder‘s expertise and needs and taking into account regional diversities. Bindraban, Bulte, Giller, Meinke, van Oort, Oosterveer, van Keulen, Wollni (2009) reiterate that there is no one-size fits-all technology package, but rather there is need to aim for the diversification of local crops, organic fertilizers and promote agro-ecology. Respect for environmental protection is as crucial as the safeguarding of natural resources. Measures must be taken to regenerate soils and conserve water. A truly *green* revolution must be African-led and empower marginalised farmers, especially women, and improve their access to local, regional and global markets, in order to fight hunger and poverty.
Båge (2008) cites the case of Vietnam, which serves as a prime example of smallholders‘potential to drive economic growth and reduce poverty. Almost three quarters of its population live in rural areas and survive off agriculture. According to Bage (2008), in the last two decades, the country has successfully transformed from a major importer and food-deficit country into one of the largest rice-exporters in the world. Increased productivity and growth are largely due to development of the smallholder sector. Growth rates increased to 7 % and poverty rates dropped from 58% in 1993 to 13% in 2007 (Båge, 2008).

2.4. Defining Smallholder agriculture in the South African context

Agriculture is the main driver of many economies in Africa and it is mainly driven by the smallholder sector although its potential is hardly recognised. Smallholders are usually defined in many ways depending on the situation, country and even the ecological zone. In general the term smallholders refer to their limited resource endowment in relation to the other farmers in the sector. They can also be defined as farmers who own small- plots or small portion of land on which they grow subsistence crops or a few crops and relying mainly on family for labour (DAFF, 2012).

According to DAFF (2012), smallholder farmers can be characterised by production systems that are simple, outdated technologies, low returns, high seasonal labour fluctuations and woman playing a vital role in production. These farmers differ individually according to their different characteristics, farm- size, resource distribution between food and cash crops, livestock and off-farm activities, the way they use external outputs and hired labour, the proportion of food crops sold and household expenditure patterns (DAFF, 2012). They play an important role in creating livelihoods amongst the rural poor. Although smallholder farmers' production contributes to household food security, the productivity of this sub- sector is quite low. There is a need to considerably increase the productivity of these farmers in order to ensure long term food security.

Kirsten and van Zyl (2008) define smallholder as equated with a backward, non-productive, non-commercial, subsistence agriculture that are mainly found in the former homelands. Aliber et al. (2009) reported the in rural South Africa, the majority of smallholders' goals are predominantly cultivating food crops for personal use and home consumption with less concentration on commercialisation or farming as a business and that will have influence on a farmers decision to cultivate a small- plot with minimal investment to low productivity and market surplus (Padilla-Fernandez and Nuthall, 2001; Maskey, Lawler and Batey, 2010). In South Africa, Aliber et al (2009) reported that smallholder farmers, output contributes marginally to the national agricultural GDP although they are still regarded as important for sustainable food security and self- employment among resource- poor households.

According to Ortoman and King (2010) smallholder farmers are described as farmers with limited access to factors of production, credit, information, markets and are constrained by inadequate property rights and high transaction costs and mainly use household for labour on their farms. Aliber et al (2009) define smallholder farmers as black farmers who are associated with land reform programme and are expected to produce more for the market but are most probably not doing so (Van Averbeke et al, 2009). Van Averbeke et al., (2009) describes smallholder in South Africa as unevenly distributed and are assumed farmers who function independently, farm groups, subsistence farmers, and those that are market oriented and whose purpose is mainly commercial. Therefore, there are two categories of smallholder farmers who use a broader definition, that is, those that are farming mainly subsistence and the commercially oriented ones.

There are about 4 million smallholder individual farmers who take part in the agricultural sector in South Africa, 92% of those farmers are producing for household consumption and only 8% of these farmers are mainly producing for household income (Aliber et al, 2009). Labour force Services (LFS) of statistics South Africa categories smallholder farmers in terms of their major purpose of farming (Aliber et al., 2009). This may be used as proxy to distinguish between the substance smallholder and commercial smallholders' statistically.92% of the subsistence farmers indicated that their main reason for farming is for household consumption and the remaining 8% for accumulation of wealth. Although the subsistence- smallholder farmers minimally contribute the national agricultural market share and economic growth at large, their role in reducing poverty cannot be ignored (Aliber et al. 2009). This can be best explained by the high public expenditure incurred by the government to establish irrigation schemes and provided food parcels to needy households during the 1930s and the early 2000s hunger experiences in South Africa. Therefore, efforts to enhance subsistence production is necessary.

2.4.1. Homestead food gardeners

Pre-apartheid history, betterment planning and homeland settlement policies, and apartheid are the major contributors of establishment and dependence on subsistence homestead food gardens in the former homelands of South Africa (Butler, Rotberg, and Adams, 1978; McAllister, 2010). According to Perry (2012), a homestead garden is an old phenomenon where Bantu settlers in the Eastern Cape Province designed their homesteads based on location of natural resources such as water sources. Since they were mostly agro-pastoralists they designed their homesteads in such a manner that accommodates both livestock rearing and crop production. Most agrarian practices were dependant on nature and labour to plough, plant, weed and harvesting was mainly collectively rendered by the community, thus reducing costs of production. To date, despite changes in climatic conditions, the rural farmers in Eastern Cape Province have knowledge of how seasons evolve among most villagers, whereby they start to prepare land for planting in November (or before) for the planting of crops in December (Perry, 2012). During field preparations, activities like spreading of organic fertilizers from kraals into gardens and edges of the garden are done. The organic fertilisers is further soaked into soils during rain. Perry (2012) indicated that, these agronomic practices save labour which could have been used to move fertilizers to far gardens.

Partly, betterment planning and apartheid policies are responsible for the smallholders' shift from extensive field cultivation to homestead food gardening in the former homelands of South Africa (Hajdu *et al.,* 2012). During betterment planning and apartheid period, rural households in the homelands were constrained by labour shortages due to forced labour migration into urban areas, the mining sector and white commercial farms (Butler, Rotberg, and Adams, 1978). Wives and children were left to farm on the small plots and energetic men were forced to join the mainstream commercial sector in urban areas. According to McAllister (2010), most farm fields in rural villages were usually located 2 to 4km away from the homesteads and situated in low-lying areas near water bodies such as rivers and streams. Field labour was mainly dependent on sharing of agricultural work between households on a mutual basis (Hajdu *et al.,* 2012)

However, the far fields got less and less fertile with low output and people's investment interests towards these fields reduced (McAllister, 2010). Due to the resource poor rural farmers' inability to innovate methods of maintaining fertility of larger farm fields and the bureaucratic means of accessing land for extensive farm production in their communities, they resorted to establishment of gardens near their homesteads (McAllister, 2010). The homestead food gardens are meant for subsistence food production, bureaucratic means of accessing land for extensive farm production in their communities, they resorted to establishment of gardens near their homesteads (McAllister, 2010). The homestead food gardens are meant for subsistence food production, that is, enough for home consumption and sometimes supplemented with output market purchases (Hajdu, Jacobson, Salomonsson, and Friman, 2012).. However, they are considered to be efficient and intensive compared to distant fields which were less fertile and demanded more of the unavailable human labour (Hajdu, Jacobson, Salomonsson, and Friman, 2012).

The homestead food gardens produce diversified types of crops which include high value vegetables like tomatoes, cabbage, salads vegetable, and grain crops like maize, sorghum as well as legumes. Vegetables and other high value products are produced in the homestead gardens because it simplifies the management and other agrarian practices such as watering, pest control, and manure application. This strategy seem to save more labour than cultivating far field (Hajdu, Jacobson, Salomonsson, and Friman, 2012; Perry, 2012). In larger gardens that are a little farther away from homesteads, farmers grow crops that call for less attention like maize and legumes (Perry, 2012).

Maize is often planted with a variety of beans and squash, albeit beans and squash are often grown more along the edges of gardens. Legumes are planted for purposes of improving soil fertility derived from nitrogen fixing bacteria contained in the nodules. After harvesting, farmers leave the land to fallow (Hajdu, *et al.,* 2012; Perry, 2012). Homestead food gardening uses conservational type of agriculture though it yields small quantities of output. Therefore, for more meaningful transition from subsistence to smallholder commercial farming, there is need to scale-up and shift from homestead food gardening to smallholder irrigation schemes that are commercially oriented. Also, farmers may be encouraged to use their homestead gardening experiences and other skills where applicable (Butler, Rotberg, and Adams, 1978; Muchara, 2011; Van Averbeke *et al.,* 2011).

2.4.2. Contribution of the agricultural sector to the South African economy

South African's primary agricultural sector contributes 3% to GDP (FANRPAN, 2012). Considering the forward and backward linkages, agro-industries contribute about 12% to GDP (AgriSETA, 2010; FANRPAN, 2012). According to Liebenberg and Pardey (2010), agriculture's contribution to GDP significantly declined from 12.3% in year 1961 to 2.5% in year 2010 (Liebenberg and Pardey, 2010; FANRPAN, 2012). Although agricultural production has increased, South African's agricultural exports have reduced from 78.4% in year 1932 to 6.9% in year 2009. With exception of year 2002 when South Africa's agricultural export grew due to exchange rate depression, agricultural export growth has been reported to be slower with increasing agricultural products and food importation (AgriSETA, 2010; Liebenberg and Pardey, 2010; FANRPAN, 2012).

Actually, Machethe *et al*. (2004) reported a decline in the value of agricultural exports from over 10% in the 1970s to 4% in the 1990s. Therefore, there is need to scale-up agricultural marketable surplus to increase the country's agricultural export for increased incomes and also avail food enough for the rural poor households who cannot afford high prices of imported food. The major South African's agricultural exports include avocado, clementines, ostrich products, grapefruit, table grapes, plums and pears. The major agricultural imports include wheat, rice, vegetable oils and poultry meat (DAFF, 2012).

With increased production, agriculture has a strong multiplier effect on employment when based on the input-output analysis than any other sector of the economy (van Zyl and Vink, 1988) cited by Machethe *et al.* (2004). Thus, this fits into government's priorities and intentions of investing in agriculture and rural development for increased production to reduce on unemployment level and eradication of poverty. According to Liebenberg and Pardey (2010), and FANRPAN (2012), the sector is employing about 7% of South African labour work force and in 2006, the sector was reported to employ over 1.32 million farm workers, which is about 10.6% of the country's labour force (Liebenberg and Pardey, 2010). Agriculture employs in total 4.75 million people, 4 million of whom are engaged in subsistence small scale production and the sector has a potential of employing about 33% of smallholder farmers (FANRPAN, 2012).

In their study, Liebenberg and Pardey (2010) indicated fluctuations in agricultural labour markets due to introduction of new technologies like tractors and combine harvesters between years 1947 to 1970s. Increased use of machinery was sparked by the government‘s introduction of farmers‘ easy access to credit and tax breaks (Liebenberg and Pardey, 2010). Further, the introduction of the Pass Law in 1952 resulted in farm labour scarcity because black farmer movement was restricted (Liebenberg and Pardey, 2010). However, when access to credit ceased, coupled with the devaluation of the rand in the early 1980s, use of imported machinery was relatively more expensive (Liebenberg and Pardey, 2010). Between the late 1980s and early 1990s, new legislations were introduced which advocated for provision of land tenure security to farm labourer working on commercial farms, and they also fixed a minimum wage rate (Liebenberg and Pardey, 2010). Owners of large-scale commercial farms perceived the new legislations as a threat to their wealth and farm profits, so, they resorted to use of machinery (Liebenberg and Pardey, 2010). Also, the long-term decline experienced in agricultural employment may be attributed to decreases in number of farming operations, younger generation being less interested in farming, and the market deregulation among others (FANRPAN, 2012).

2.4.3. The production and productivity of agriculture in South Africa

Liebenberg and Pardey (2010) carried out a study to estimate South African agricultural production and productivity trends between 1910 and 2007. Their findings generally indicate a steady growth in value of agricultural production in South Africa. However the country experienced stagnant growth in the value of agricultural production in the 1990s. The information presented indicates that the horticultural sector is growing faster than field crops and livestock sectors. The field crops category includes maize, wheat, oilseed, cotton, sugarcane, tobacco among others. Vegetables and citrus fruits combined are categorised as horticultural product. Livestock products as defined by the South African department of agricultural include slaughtered goat, sheep, cattle, calves, chicken, and ostriches.

According to the Department of Agriculture, Forestry and Fisheries (DAFF, 2011), the gross value of agricultural production (total output at a given production season valued using the prevailing average basic prices received by producers in the same season) declined from R127 568 to R126 433 million in the 2009/10 season. The decline could have been due to a decrease in the value of field crops (DAFF, 2011). DAFF (2011) results indicate that the contribution of livestock products, horticultural products and field crops to the total gross value of agricultural production in 2009/2010 was 51.3%, 25.7% and 23%, respectively. This concurs with the information in Table 2.1 and Figure 2.1 for the livestock product, because, it had the biggest share of production value of 44% compared to the 26% for horticultural products and 30% for field crops in 2000/2007, respectively (Liebenberg and Pardey, 2010). These results suggests that there was a percentage increase in livestock products' and a percentage decrease in horticulture products' and field crops' contribution to the total gross value of agricultural production between 2000/2007 and 2009/2010. Though volumes of field crop production may be higher than the horticulture and livestock volumes in tonnage, horticulture and livestock products fetch more gross value than the field crops because of their higher market prices (DAFF, 2011).

In 2012, a comparative analysis of South African agricultural production performance was carried out by the DAFF for period between 2009 and 2011 (DAFF, 2012). The comparison of the 2009/2010 and 2010/2011 results show that the volume of field-crops decreased by 4.5%. The decrease was mainly attributed to a decline in output of summer harvest. Although it was slight, horticulture production volumes increased by 0.2% and this was mainly attributed to increments in potato production by 6.8% (134 834 tons), onion by 14.6% (71 214 tons) and citrus fruits in particular grapefruit and lemons by 5.9% (31 744 tons) (DAFF, 2012). Increment in Cattle and calves slaughtered by 3.6% (24 698 tons) and poultry slaughtered by 3.3% (47 000 tons) contributed to a slight increase in animal production volumes (DAFF, 2012). The increment in horticultural and animal production was reflected in the increased total gross value of South African agricultural production estimated at R138 904 million in 2010/2011 compared to R 129 883 million in the previous year between 2009 and 2011 (DAFF, 2012), respectively (Liebenberg and Pardey, 2010). These results suggests that there was a percentage increase in livestock products' and a percentage decrease in horticulture products' and field crops' contribution to the total gross value of agricultural production between 2000/2007 . Though volumes of field crop production may be higher than the horticulture and livestock volumes in tonnage, horticulture and livestock products fetch more gross value than the field crops because of their higher market prices (DAFF, 2011).

However, it should be noted that about 98% of these estimated agricultural values are mainly attributed to commercial farmers with little smallholder production being considered in the national agricultural production and marketed output in South Africa (Kodua-Agyekum, 2009). Thus, commercial farmers account for the largest share of farm incomes, widening the income gap in the country. The insufficient consideration of smallholder statistics in the national agricultural production and market estimations may be attributed to negligible marketable surplus produced by smallholder farmers and scarcity of data for this category of farmers (Aliber and Hart, 2009; Cousins, 2013).

2.5. Irrigation and agricultural production

Nearly 70% of the world's water use is devoted to agricultural production, and majority of this water is used for irrigation (Disrude and Grossman, 2004). Irrigation accounts for more than 40% of the world's production on less than 20% of the cultivated land (UNWWD, 2012). Due to population pressure, there is increasing demand for water and food. Increased agricultural productivity is seen as a remedy to mitigate food shortage, hunger and high food prices in developed and developing countries. However, natural resources like land and water which are important for increased agricultural productivity are fixed. This has led to limited and uncertain water availability for agriculture and the situation may worsen in many developed and developing countries. However, South American and Sub Saharan African countries still have the potential of expanding their irrigated area to meet the rising food demands (UNWWD, 2012). Strategies to expand irrigation should consider physical, social and economic hazards associated with uncontrolled irrigation management practices.

Availability of water is essential for food security and sustainable development. However, water is increasingly becoming scarcer due to high demand caused by high rates of population growth and climate change (UN-HABITAT, 2005). In Sub Saharan

Africa, subsistence smallholders are dependent on rainfall as their major source of water for agricultural production (NCCR, 2012). Rainwater is left to drop and flow directly in farmers' fields without a systematic conservation method. More than 4000 years ago, rainwater harvesting has been practiced especially in low rainfall areas (UN-HABITAT, 2005). According to UN-HABITAT (2005), rainwater harvesting is a technology used for collecting and storing rainwater for human use. Rainwater can be harvested from house rooftops, land surfaces or rock catchments using simple techniques that range from simple containers to engineered techniques. Since agricultural production is a large user of water, rainwater harvest may not be reliable for all year production, and thus can be complemented with irrigation farming (Makombe *et al.,* 2011).

Irrigation can be defined as the artificial distribution and application of water to arable land to initiate and maintain plant growth (Disrude and Grossman, 2004). Irrigation can also be defined as the deliberate application of water by humans to the soil for the purpose of supplying moisture essential for plant growth (Kodua-Agyekum, 2009). Studies carried out worldwide indicate that irrigated crop yields are 2.7 times more than those of rain-fed farming (UNWWD, 2012). In the 1970s, both the developed and developing countries invested in irrigation infrastructures in order to increase agricultural production. An observable increase in agricultural production was achieved in countries which invested in irrigation infrastructures under appropriate management systems. However, in the 1980s, the rate of investing in irrigation infrastructures declined in both the developed and developing countries (Disrude and Grossman, 2004). Hervé (2003), and Svendsen and Turral (2007) identified some factors that are responsible for the declining rate of investing in irrigation infrastructure around the world and these include:

- In some countries around the globe, they have fully exploited the natural sources of fresh water and there is less room for expansion of the irrigated area.
- Rapid industrial growth and increasing urban population have resulted in increased inter- competition for water resource and hence, reducing the potential of expanding the irrigated area
- Introduction of restrictive environmental rules and regulation are also limiting increased investment in the irrigation infrastructure.

- The massive investment in the irrigation infrastructure in the previous decades led to increased yields, resulting into an historical low world food prices. In business, the low food prices are less attractive while the countries had a perception that they had attained their food sufficiency, and hence countries reduced investing in the irrigation infrastructure.
- Cost associated with the construction of new irrigation schemes are increasing day by day, and reported to have risen to two or three times compared to their previous levels. This makes the present irrigation development less profitable than it was in the past decades. Presently, most countries have resorted to revitalisation and rehabilitation of the existing schemes, because the costs associated with these processes are cheaper compared to establishing new ones.
- Donors have lost interest in funding irrigation infrastructure development due to the poor performance of irrigation schemes in developing countries caused by deficiencies in management, institution and policies.

Declining rate of investment in the irrigation infrastructure has a negative impact on the economic growth and development of most developing countries, especially in the Sub-Saharan Africa (IPTRID, 1999; and Svendsen and Turral, 2007). These negative impacts are mainly associated with declining agricultural productivity, increased food insecurity, unemployment, and poverty level (IPTRID, 1999; and Svendsen and Turral, 2007). Low investment in irrigation infrastructure development and increasing dependence on rain-fed agriculture will not be able to sustain the growing demands to feed the increasing populations (IPTRID, 1999). A slow growth rate in agricultural productivity could lead to increased food prices, low household incomes, and worsened by unemployment and high poverty level (Vanhove and Van Damme, 2011) Thus, there is a need to increase investment in irrigation infrastructure development to increase productivity to supply cheap and high-quality food, improve household incomes, and reduce people‘s vulnerability to risks associated with external shocks and climate change (Svendsen and Turral, 2007).

According to Steduto *et al.* (2007), water productivity is defined as the ratio of the net benefits from crop and mixed agricultural systems to the amount of water required to produce the benefits. Water use efficiency is sometimes defined as the relationship between water (input) and agriculture product (output) (Fairweather *et al*., 2003). Water productivity is divided into two, the physical water productivity and economic water productivity (Steduto *et al.,* 2007). Physical water productivity can be defined as the ratio of the mass of agricultural output to the amount of water used, and economic water productivity is defined as the value derived per unit of water used. Increased water productivity in semi-arid areas like Eastern Cape based on value produced per unit of water can be an appropriate entrepreneurial pathway for poverty alleviation (Hussain and Hanjra, 2004). Increased water productivity results in increased agricultural output, food security, employment and general livelihood in rural communities (Steduto *et al.,* 2007). Therefore, it is worth assessing the farmers' efficient water utilization as a basis for drawing up more effective policies towards improved efficiency.

Hill (1984) reported that the Mesopotamian plains are known to be the sites of the first systematic use of water in this form for purposes of growing crops throughout the year. According to IPTRID (1999), and UNWWD (2012), the importance of irrigation technology in agricultural production has been recognized for a long time, and can be discussed within the broader framework of the role of improved technology in agricultural development. The induced innovation model discussed by renown economists such as Hayami and Ruttan (1971), Grabowski (1979), Ruttan and Hayami (1984), made an excellent case for the importance of technical change in the process of agricultural development, observing how production coefficients change as a result of changes in resource allocation. The major contribution of the model was focused on explaining the mechanism which determines the choices made by society among alternative technological paths to achieve the desired agricultural development.

The neoclassical economists had earlier indicated that technical change and institutional reform were exogenous to the system. However, the development of the induced innovation model by Ruttan and Hayami (1984) established a firm basis for considering technical change as endogenous to the system because internal pressures exerted from the constraints imposed on the system by changing resource endowments are the major factors driving change. The induced innovation model has informed the development and use of new technologies like irrigation technology to bring about rapid improvements in agricultural development.

Due to its ability to increase agricultural productivity, there is strong evidence that in adequate supply of water leads households to shift from traditional self-sufficiency goals to profit/income-oriented decision-making and resource allocation where farm output becomes more responsive to market trends (Chirwa & Matita, 2011). According to the econometric study carried out by Dillon (2011), irrigation technology causes a shift of cropping patterns in favour of high value cash crops, culminating in increased value of crop production, greater investment in farm equipment and durable assets, with overall positive impact on socioeconomic status of smallholders. The positive impact can be observed through improved household incomes, nutrition and health. One of the concluding remarks of the study indicated that increased adoption of irrigation technology reduces poverty and inequality. Irrigation also increases physical output and the value of production through intensification of cropping and innovation in crop choice (IPTRID, 1999).

Further, the introduction of irrigation most commonly improves the overall level of quality and leads to less variation in quality between producers and from year to year (Riddell, Westlake & Burke, 2006). According to Riddell, Westlake and Burke (2006), the concentration of inputs around irrigated production offers a means to service specific export-market demand. Hanji (2006) asserts that with the common belief on the important role of irrigation in agricultural growth, many developing Asian countries have promoted irrigation development over the last five decades to achieve such broad objectives as economic growth, rural and agricultural development. In addition, irrigation boosts total farm output hence, with unchanged prices, raises farm incomes. Achieving such non-inflationary growth in output is particularly attractive in an era of dwindling real incomes as a result of general increases in prices that have ignited intense protests some of which have turned deadly as was witnessed recently in the North-West Province of South Africa (SABC, 2012).

A research carried by Lipton *et al.* (2003) declared that first direct impact of irrigation is on output levels. Irrigation brings a range of potential changes in agricultural production (FAO, 2009). Increased output levels in irrigated farming may arise for any of at least three reasons (Pundo, 2005; Hagos *et al.,* 2009). Firstly, irrigation improves yields through reduced crop loss due to erratic, unreliable or insufficient rainwater supply. Secondly, irrigation allows for the possibility of multiple-cropping, and so an increase in annual output. Thirdly, irrigation allows a greater area of land to be used for crops in areas where rain-fed production is impossible or marginal. Hence irrigation is likely to boost output and income levels. The higher yields, higher cropping intensity and all year-round farm production lead to increased market-oriented production, implying a shift in supply (marketable surplus production) and perhaps food Security (Hagos *et al.,* 2009). Gebreselassie and Ludi (2010) indicated that the introduction of irrigation scheme resulted to changes in cropping pattern which led to a significant improvement in the commercialization of smallholders in Ethiopia. Research findings in other African and Asia countries strongly indicate that farmers who have adopted irrigation technology have generally benefited from the intervention as the number of cash crop growers increased after the introduction of irrigation technology.

It should be noted that in the struggle to promote increased use and expansion of irrigated area for increased agricultural productivity, there is a need to consider the negative effects that can emanate from uncontrolled irrigation. These negative attributes can be physical, social and economic resulting from poor irrigation management style and farming practices (Backeberg, 2005; Disrude and Grossman, 2004). The water conflicts within communities and across international boundaries as a result of competition for surface water rights are parts of the social negative impacts. Depletion of underground aquifers, ground subsidence and build-up of toxic salts on soil surfaces in regions of high evaporation rates, salinization are the physical negative attributes of poor irrigation management. Reduced soil fertility and human health hazards caused by toxic and contaminated water lead to low farm income earnings and increased health expenses or even deaths (Backeberg, 2005; Disrude and Grossman, 2004).

Irrigation can also be a source of water contamination through infiltration into the ground or runoff of applied irrigation water mixed with fertilizers, pesticides, herbicides and other agro-chemicals into streams, dams and other water bodies whose waters are used domestically by households especially in rural areas of developing countries (Disrude and Grossman, 2004). Domestic use of contaminated water exposes people to health hazards like water borne diseases. Contaminated water also exposes livestock drinking of it to health hazards (Disrude and Grossman, 2004). Use of too much irrigation water exposes soils to heavy leaching. Through leaching agro-chemicals infiltrate through the soil into the ground water (Munguambe, 2007; Van Rensburg *et al.,* 2011). In places where there are high rates of leaching crops are deprived of enough uptake of nitrogen and this leads to low productivity (Disrude and Grossman, 2004; Munguamb, 2007; Van Rensburg *et al.,* 2011). Therefore, irrigation farming needs a more integrated system for improved efficiency of water use without causing much of the social, economic and physical disruption in communities both nationally and internationally.

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2.6. Irrigation and agriculture in South Africa

South African‘s agriculture suffers from limited water availability. Only 49 228 million m3 per year of runoff water, mainly from rivers, is available for over 51.7 million people in South Africa, thus, only 952m3 per year of water is available for use per person. According to Samuel (2009), for a country to be declared *water stressed*, the annual water supplies drops below 1,700m3 per person, while Backeberg (2005) indicated a threshold of 1000m3 of water supply per person per year. Therefore, the per capita water availability of 952m3 per year is below the two thresholds, indicating that South Africa is a w*ater stressed* country (Backeberg, 2005). Furthermore, the country is faced with erratic rainfalls and semi-arid conditions which can hardly prevent high rates of water evaporation (Van Averbeke *et al.,* 2011). For example, Backeberg (2005) reported variation in rainfall patterns across South Africa ranging from over 800 mm/year in the East, less than 200 mm/year in the West, and about 65% of the area countrywide receiving less than 500 mm/yr. This amount of precipitation is insufficient to support the agricultural sector in the country. Therefore, irrigation is indispensible for maintaining agricultural production at acceptable levels.

Irrigation farming utilizes more than 50% of South Africa‘s water resource on over 1.3 million hectares (Van-Averbeke *et al*., 2011; FANRPAN, 2012; GoSA, 2012, CIA, 2012). There are over 300 irrigation schemes in South Africa established 60 years ago on both smallholder and large commercial scale (Manona *et al*., 2010; Van-Averbeke *et al*., 2011). These irrigation schemes support over 25% of national agricultural production, and largest area (80%) is used to mainly grow crops such as potatoes, vegetables, grapes, fruit and tobacco, maize and about 20% of the area is mainly under sugarcane and cotton production (Backeberg, 2005; Manona *et al*., 2010; Van-Averbeke *et al*., 2011)

Irrigation farming started as early as 1652 at the arrival and settlement of Europeans in South Africa on a private basis. From 1912 onwards systems have been developed to coordinate irrigation operations countrywide (Perret and Touchain, 2002; Kodua-Agyekum, 2009). The developed and coordinated category of irrigation schemes include, the irrigation board schemes, white settlement schemes and Bantustan schemes‘food plots and community garden schemes (Perret and Touchain, 2002). During the severe drought and economic depression of the 1930s, South African development and economic growth programmes were directed toward irrigation farming as a remedy for increased agricultural productivity, food security and rural employment (Van Averbeke *et al,* 2011).

However, there was unfair distribution of access to irrigation facilities in terms of land sizes, where white farmers receiving areas under the large irrigation schemes (8 ha to 20ha), often 10 times larger than the 1.5 ha allocated to black farmers (Van Averbeke *et al*., 2011). Even the smallest irrigation plots allocated to black farmers collapsed due to the management gaps and institutional failures that existed among the smallholder irrigation scheme operators (Van Averbeke *et al*., 2011). The revitalization of these schemes began in 1994 through the introduction of canal irrigation schemes in the Eastern Cape and these included Ncora, Keiskammahoek, Tyefu, Shiloh and Zanyokwe. Despite these developments, smallholder farms still faced low outputs and productivity (Van Averbeke *et al.,* 2011). The reasons for this unrelenting poor performance remain a puzzle to researchers and policy makers alike.

2.6.1. Operational Status of the Smallholder Irrigation Schemes in South Africa

The Smallholder irrigation schemes account for 4% of irrigated land of South Africa (Manona *et al*., 2010). South African registered irrigated land amounts to 1 675 822 ha in 2008 (Van Averbeke *et al.,* 2011). Only 1 399 221 ha is irrigated annually, of which in 2010, only 47 667 ha were under smallholder irrigation schemes (Van Averbeke *et al.,* 2011). The 96.7% of total smallholder irrigated land draws water from rivers, sometimes diverted by means of dykes, and stored in dams. Smallholder irrigation makes use of 3.0% ground water, 0.2% municipal water, and only 0.1% spring water (Van Averbeke *et al.,* 2011). Methods used to withdraw water from the rivers, underground and springs include water pumps, gravity flow and a combination of gravity and pumping (Van Averbeke *et al*., 2011).

The government meets 68% of costs needed to pump or avail the water to the smallholder irrigation schemes (Perret, 2004). The most frequently used smallholder irrigation system is overhead (≈59%) followed by gravity-fed surface (≈28%), micro (≈9%) and pump surface (≈4%), respectively. Table 2.2 indicates that 34% of the smallholder irrigation schemes were not operating by year 2010. Available evidence (Van Averbeke *et al.,* 2011) indicates that Limpopo had the highest number of smallholder irrigation schemes with 101 operational and 69 non-operational followed by the Eastern Cape Province with a total of 67 (50 operational and 17 non-operational).

Table 2.1: Operational status of irrigation schemes in South Africa

Province	**Operational irrigation schemes**	**Non-operational irrigation schemes**	**Total number of irrigation schemes**
Limpopo	101	69	170
Mpumalanga	7	12	19
kwaZulu Natal	2	0	2
Free State	35	0	35 + 1*
Northern Cape	1	1	2
Eastern Cape	50	17	67+5*
Western Cape	7	1	8
Total	185	101	296+6*

There are 6 irrigation schemes whose status is unknown; source: Averbeke et al (2011)

Regardless of their operational status, smallholder irrigation plots in rural areas of South Africa are not intensively utilized and most of them are lying idle (Manona *et al*., 2010; Perret, 2004). Sub-optimal use of land and water resources by smallholder farmers in the irrigation scheme may be due to poor land markets and indistinct land tenure system (Machethe *et al*., 2004; Perret, 2004; Manona *et al*., 2010). Other factors that impede intensive and productive use of smallholder irrigation facilities in former homelands of South Africa include lack of appropriate user-friendly irrigation infrastructural design, poor management and maintenance of the facilities. Lack of requisite irrigation skills among beneficiaries and government extension officers, low farmer‘s interest and participation, inadequate institutional structures, a history of dependency and subsistence orientation, low land productivity and high investment costs, also negatively affected these irrigation schemes (Machethe *et al*., 2004 and Perret, 2004).

According to Perret (2004), Backeberg (2005), Manona *et al*. (2010) and UNWWD (2012), attempts to resolve these challenges need an understanding of the complex interaction of the natural, physical, social and economic factors using an integrated systems framework. There are eight major factors that influence the interaction within the system and these include natural resources; knowledge; institutions; infrastructure and technology; economic location and factors; financial services; feasibility of farming systems; and support to farming systems (Manona *et al*., 2010).

Backeberg (2005) indicates that the most important steps needed for efficient use of smallholder irrigation facilities is to enhance management capacity of both smallholder farmers and extension officers working in rural areas, improving land-tenure security on state and tribal land especially in former homelands where chiefs have more influence on land accessibility, and using dialogues that are pro-resource poor farmers. In addition, farmers should be helped to increase their farm size holdings, and provide appropriate technology which can be easily operated and managed by those who are less skilled (Machethe *et al.,* 2004; Backeberg, 2005; Kodua-Agyekum, 2009; Manona *et al.,* 2010). There is a need for improved access to agricultural finance through credit or loan facilities with manageable interest rates and long payback period to enable farmers acquire capital enough to invest in their fields (Machethe *et al.,* 2004; Backeberg, 2005; Manona *et al.,* 2010). Also, improved access to training and extension services for improved human capital and reducing the dependency on the government through establishment of the necessary supportive infrastructures that ease farmers‘ access to input and output markets and market information flow is needed to facilitate efficient utilization of smallholder irrigation schemes (Machethe *et al.,* 2004; Backeberg, 2005; Manona *et al.,* 2010).

2.6.2. Irrigation in the Eastern Cape Province of South Africa

Establishment of irrigation schemes in semi-arid and areas prone to prolonged droughts in the rural communities of former homelands of South Africa was viewed as one of the development pathways for increased agricultural productivity, improved food security, increased employment and poverty alleviation (Backeberg, 2005; Kodua-Agyekum, 2009, Van Averbeke *et al*., 2011). Following the recommendations by the Tomlinson Commission many irrigation schemes were established in the Transkei and Ciskei former homelands of the current Eastern Cape Province during the 1960s and 1970s. These irrigation schemes were established to stimulate economic growth and rural development (Sishuta, 2005 and Kodua-Agyekum, 2009).

The use of irrigation is informed by international experience, for example, Lipton *et al.* (2003) indicated that, regions like Eastern Asia and the Pacific, and North Africa and Middle East have experienced a greater poverty reduction because they established some of the large proportions of irrigated land. In Nepal, with the implementation of the irrigation projects, agricultural labour increased by 25%, employing most of the smallholders, and increased the production potential by over 300% and income by over 600%. This greatly enhanced increased food security, increased employment and poverty reduction (Lipton *et al.,* 2003). However, the results in the Eastern Cape Province have not matched the international experience (Legoupil, 1985; Lipton, 1996; Kodua-Agyekum, 2009; Manona *et al*., 2010; Averbeke *et al*., 2011). In 2008, at Qamata irrigation scheme, established in the late 1960s, 87.1% of the population in the surrounding communities was unemployed and 76% of households were still affected by high levels of poverty. At Tyefu irrigation scheme, established in the late 1970s under Peddi area, by 2007, 78% of the population was unemployed and 79.9% of the population was below the poverty line (Insika Yethu Municipality, 2008; Ngqushwa Municipality, 2007).

Many small scale irrigation schemes were abandoned because the black rural farmers lacked knowledge and skills on how to manage and operate them and thus calling for simplified systems (Kodua-Agyekum, 2009). The government established small scale irrigation schemes mainly for increased agricultural productivity with less attention given to commercialising of small scale farming in former homelands in Eastern Cape. Lack of commercialisation of agriculture concept in government‘s rural development programmes jeopardised smallholder farmers‘entrepreneurship and management capabilities for sustainable development and general improvement of livelihood among black people communities (Sishuta, 2005). Currently, Eastern Cape Province has a total of 154 930ha of land under irrigation and an additional 48 629ha of undeveloped irrigation land (Machethe *et al*., 2004). According to Bembridge (2000), by the end of 1999, there were more than 50 small scale irrigation schemes run by 6350 farmers on over 9500ha of land in the Eastern Cape province, and by 2010, the number of these irrigation schemes had risen to more than 67 (Van Averbeke *et al,* 2011). Some irrigation schemes were modified during their revitalisation using modern and sophisticated technologies.

Expensive technological investment, high operational and maintenance costs, and sophisticated management systems exposed the resource-poor farmers‘ inability to sustain their operations for increased marketable agricultural productivity resulting into low farm output, low incomes, food insecurity and ever increasing levels of poverty in communities where they exist. Furthermore, Van Averbeke *et al*. (2011) cited several studies, including Bembridge (1997), Bembridge (2000), Kamara *et al*. (2001), Shah *et al*. (2002), Machethe *et al*. (2004), Iseneke Developments (2004), Tlou *et al*. (2006), Speelman *et al*. (2008), Yokwe (2009), Mnkeni *et al*. (2010) evidently indicating that poor management, theft and corruption were among the major contributors of failure and below-expected performance of smallholder irrigation schemes in South Africa. Results from Van Averbeke *et al.* (2011) study indicate that famers had insufficient management capabilities and these negatively affected the performance of these schemes. Thus, there is need to address the management deficiencies among smallholder irrigators to uplift the rural poor from the widespread poverty in the Eastern Cape Province. Figure 2.2 presents the major Smallholder irrigation schemes located in the Eastern Cape Province.

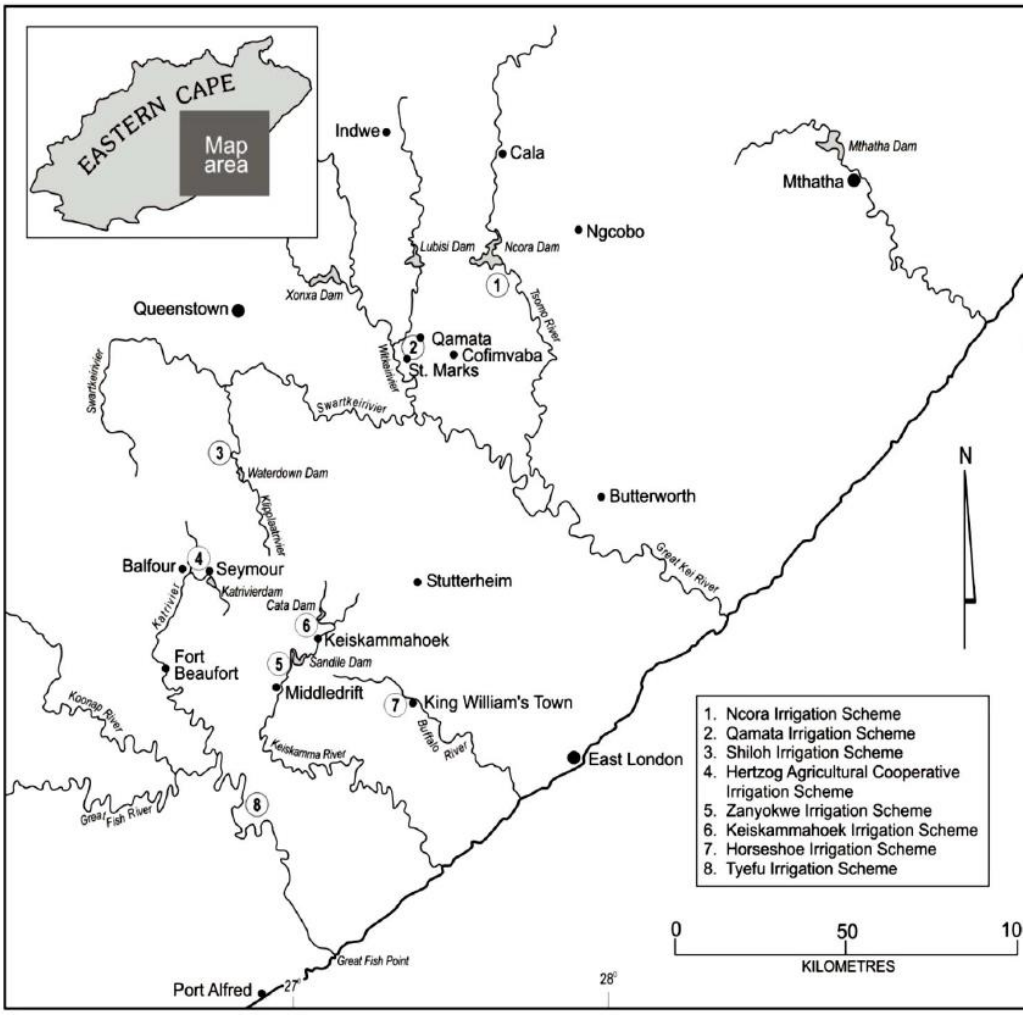

Figure .2.2. Major Irrigation Schemes in the Former Homelands in the Eastern Cape Province
Source: Kodua-Agyekum (2009)

2.7. Agricultural production and food security in Africa

Agricultural production in most African countries is dominated by small-scale farmers who produce 90% of the food consumed and make up at least 73% of rural African households (IFAD, 2005). Despite this situation where a high percentage of the population depend on farming, the food demand cannot always be met from this source. According to Southgate (2009), food demand has grown to unprecedented levels while agricultural growth has declined. Ndhleve, Jari, Musemwa and Obi (2011) note that in fact agricultural production in general has been on the decline for the past three decades. The estimated agricultural production per capita declined by 22% between 1971 and 1984. Castelfranco (2010) quoting the United Nations Food Agency, FAO states that food import bills for the world's poorest countries are predicted to rise 11 % in 2011 and by 20% for low-income food-deficit countries while the previous forecast of 1.2% expansion in world cereal production is expected to shrink downward due to bad weather. The central issue therefore is how to accelerate the agricultural production growth rate to meet the needs of the ever growing population. The role of agriculture as a fundamental instrument for sustainable development, poverty reduction and enhanced food security in developing countries cannot be over-emphasized (Bindraban *et al*., 2009). It is a vital development tool for achieving the Millennium Development Goals, one of which is to halve by 2015 the share of people suffering from extreme poverty and hunger (World Bank, 2008). Throughout the developing world, agriculture accounts for around 9% of the GDP and more than half of total employment.

Pinstrup-Aderesen (2002) states that in countries where more than 34% of the population are undernourished, agriculture represents 30 % of GDP and nearly 70% of the population relies on agriculture for their livelihood. This fact has in the past been used in support of the argument as to why developing countries should move away from agriculture and invest in technology. Because over 70% of the poor live in rural areas, where also the largest proportion of the food insecure live, it is evident that we cannot significantly and sustainably reduce food insecurity without transforming the living conditions in these areas. The key lies in increasing the agricultural profitability of smallholder farmers and creating rural off-farm employment opportunities.

In Africa, agriculture is a strong option for spurring growth, overcoming poverty, and enhancing food security. Agricultural productivity growth is also vital for stimulating growth in other sectors of the economy. However, agricultural productivity in Africa has continued to decline over the last decades and poverty levels have increased. Currently, agricultural productivity growth in Sub-Sahara Africa lags behind that of other regions in the world, and is well below that required to achieve food security and poverty goals (World Bank, 2008). Increasing agricultural productivity in Africa is an urgent necessity and one of the fundamental ways of improving agricultural productivity is through introduction and use of improved agricultural technologies. Therefore the question is will investments in agricultural technology by themselves be sufficient to ensure long-term productivity growth in the farm sector and, more importantly, for rural poverty reduction? As rapidly rising food prices threaten food security and the poverty gains made by developing countries, many have blamed declining funding for agricultural technology development for this state of affairs (Smil, 2000).

As noted by Duflo, Gale, Liebman, Orszag and Saez (2006), the rapid population growth has made Africa to be no longer viewed as a land-abundant region where food crop supply could be increased by expansion of land used in agriculture. Large areas in Africa are increasingly becoming marginal for agriculture and arable land has become scarce in many African countries. This makes the need for intensification of land use through use of productivity enhancing technologies critical for achieving food security. Yet, the rate of adoption of productivity enhancing technology options like organic agriculture have been substantially lower in Africa than in Asia and Latin America (Byerlee and Eicher, 1997). Similar observations are also made by Ariga, Jayne, and Nyoro (2006). According to Howard, Kelly, Maredia, Stepanek, and Eric (1999), high external input technologies, lack of infrastructure, research, development, and even extension are major obstacles to increasing fertilizer application rates in sub-Saharan Africa.

African countries need to increase their investment in long-term interventions such as dietary diversification, food sufficiency and bio-fortification. These have lower maintenance costs, a higher probability of reaching the poor who are vulnerable to food insecurity, and produce sustainable results. Johns and Eyzaguirre (2007) state that dietary diversification still remains the best way to provide nutritious diets to the sustainability of any population. It is possible to obtain the right mix of food to alleviate malnutrition from that which is locally produced (Mwaniki, 2003). The probability of so doing is increased with increase in locally produced foods.

Barrett (2010) states that food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern. Food security has three aspects; food availability, food access and food adequacy (Latham, 1997). Food availability relates to the supply of food. This should be sufficient in quantity and quality and also provide variety.

Food access addresses the demand for the food. It is influenced by economic factors, physical infrastructure and consumer preferences. Hence food availability, though elemental in ensuring food security, does not guarantee it. For households and individuals to be food secure, food at their access must be adequate not only in quantity but also in quality. It should ensure an adequate consistent and dependable supply of energy and nutrients through sources that are affordable and socio-culturally acceptable to them at all times. Ultimately food security should translate to an active healthy life for every individual (Heidhues, Atsain, Nyangito, Padilla, Ghersi and Vallée, 2004). The illustration of the definition of food security emphasizes the *'stability', 'availability'* and *accessibility.'*

In developing countries over 85% of the food consumed by poor households in rural setting is obtained from the farm (IFPRI 2008). The importance of foods purchased from markets in meeting household food security depends on household food income and market price. The seasonality of foods available at the household level may highly influence food availability in places where little to no food preservation is practiced. This is the case with fruits and vegetables, which are highly perishable. Food security in poor developing countries has been severely undermined by food price rises of recent years, especially the spike in grain prices during 2007/2008. That event graphically illustrated that food in particular and agriculture more generally is not a sector' in developing countries in the same sense as energy or health, but simultaneously is a way of life, a pathway to poverty alleviation, and a primary contributor to economic welfare and political stability for the majority of the population (Voegele, 2010)

According to STATSSA (2000), about 35% of the South African population or 14.3million South Africans are vulnerable to food insecurity. Among these, women, children and the elderly are the most vulnerable. In South Africa the cause of hunger and malnutrition is not due to a shortage of food but rather an inadequate *access* to food by certain categories of individuals and households in the population (Vogel and Smith, 2002). Statistics South Africa has shown that food insecurity is not an exceptional, short-term event, but is rather a continuous threat for more than a third of the population (HSRC, 2004). The vast majority of South Africans buy their staple foods from commercial suppliers, rather than growing it themselves and are therefore dependent on having (direct or indirect) access to cash (Department of Agriculture, 2002).

2.8. Chapter summary

This chapter gives an overview of the South African agricultural sector. South African agricultural sector is dualistic, comprising of large-scale commercial farmers and smallholder farmers. Large-scale commercial farmers are mainly white people who control the largest portion of South African arable land, and use sophisticated and mechanised farming and control about 95% share of the country‘s agricultural market. The rural smallholders constitute the largest population of South Africa‘s farmers, mostly black people and aged, illiterate. It continues to define smallholder farmers according to the South African context. It further gives a background of homestead food gardeners, explaining the current situation in South Africa and specifying the conditions within which these gardens live in. the study continues to explain the contribution of agricultural sector to the South African economy. It introduces irrigation and agriculture production globally and then narrows it down to the South African situation. Furthermore, it gives an overview of the operational status of the smallholder farmers in South Africa and then continues to narrate about irrigation in the Eastern Cape. There is now some consensus that agricultural production is driven both by tangible and intangible capital which must function in complementarity with other resources like land, labour, water, and a host of other factors which are mediated by new and emerging circumstances and challenges. Thus, this chapter presents a comprehensive review of these issues, focusing particularly on the major agricultural natural resources available in South Africa, their acquisition and how they are used to achieve improved productivity. Land (in this case for crop production), and water (for irrigation) and adoption of technologies like irrigation are seen as the major primary factors of production and are described in this chapter. The broader theoretical and conceptual questions around these issues are also reviewed and placed in the context of the specific task of determining the role of human dimensions in farm investment decision making in the smallholder sector. The chapter elaborates on agriculture production and food security in the African continent and further engages on the issues of commercialisation of and aspirations, entrepreneurship spirit and risk perception (Sishuta, 2005).

CHAPTER 3

RISK AND RISK MANAGEMENT

3.1. Introduction

Risk is quintessential in agricultural activities and central to any decision making framework on organic farming adoption. The case of the passage from conventional to organic agriculture exemplifies how a better understanding of risk may provide relevant contributions to fill that frequent gap between technologists and farmers in the evaluation of the possibilities to adopt and implement organic agriculture technologies necessary to achieve a more sustainable agriculture. This chapter commences with a background discussion of risk in agriculture and agriculture development as well as its importance in agricultural economics research. The types and sources of risk in agriculture are presented and discussed. In order to deepen understanding of the farmers risk behaviour, literature on the agricultural risk management strategies employed by farmers is presented and reviewed. The expected utility theory as defined by von Neumann and Morgenstern is explored and the measures of risk aversion commonly used in the literature examined. The need to adjust the Arrow Pratt Absolute Risk Aversion is argued with supporting literature and the three common methodologies for eliciting farmers risk preferences are reviewed.

3.2. Background to risk in agriculture

Risk and uncertainty are pervasive characteristics of agricultural production. They could arise due to several biophysical factors such as highly variable weather events, diseases or pest infestations (Adesina & Brorsen, 1987). Other factors such as changing economic environment, introduction of new crops or technologies, and uncertainties surrounding the public institutions and their policy implementation also combine with these natural factors to create a plethora of yield, price, and income risks for farmers (Anderson, Dillon, and Hardaker, 1985; Mapp, Hardin, Walker and Persaud, 1979; Heyers, 1972). The risk situation is acute for the majority of agricultural producers in sub-Saharan Africa. The low and highly erratic rainfall (Sivakumar, 1988)), and the absence of institutional innovations (e.g. crop insurance, disaster payments, emergency loans) to shift part of the risks from the private sector to the public sector, makes risk-management a critical part of farmers' decision making (Shapiro, Sanders, Reddy and Baker, 1993; Adesina and Sanders, 1991; Matlon, 1990).

In the rural areas, risk is a central issue that affects many different aspects of people‘s livelihoods in the developing world. It is a pervasive characteristic of life in developing countries, especially in rural areas (IFAD, 2008b; World Bank, 2005; (Adesina & Quattara, 2000). The economic stability of an entire rural area can be jeopardized by crises caused by different types of natural disasters, from climatic events to livestock or plant diseases. Economic crises caused by the changes of market conditions may also endanger the farm's viability (World Bank, 2005 and Turvey, 2001). According to the (IFAD, 2008b)) nearly 1.4 billion people live on less than US$1.25 a day. Seventy per cent live in rural area where they depend on agriculture, but where they are also at risk from recurrent natural disasters. Natural disasters have a devastating impact on the food security and overall social and economic development of poor rural households.

The World Bank‘s (2001) World Development Report indicates that agriculture and agri-business are the prime sources of income for most families and businesses in developing countries; in 1999, 69% of the population in low-income countries lived in rural areas, compared to 50% in middle-income countries and 23% in high-income countries. Agriculture accounted for 27% of GDP in low-income countries, compared to 10% in middle-income countries and only 2% in high-income countries (World Bank, 2001). These numbers understate the importance of agriculture for economic growth, which is magnified by multiplier effects (through linkages from agriculture to other economic sectors). Agriculture‘s inherent dependence on the vagaries of weather, such as the variation in rainfall leads to production (or yield) risk, and affects the farmers‘ ability to repay debt, to meet land rents and to cover essential living costs for their families. Ultimately, the precariousness of farmers and producers translates into macroeconomic vulnerability (Guillaumont, Jeanneney and Brun, 1999; Benson and Clay, 1998).

Unless well managed, weather risks in agriculture slow development and hinder poverty reduction, ultimately resulting in humanitarian crises. According to Beddington (2011) the effects of climate change to the global food system will become increasingly apparent in the next 40 years. The need to reduce greenhouse gas emissions and adapt to a changing climate will become imperative. Poor farmers have few options for coping with significant losses, and in order to reduce their exposure to risk, they often forgo opportunities to increase their productivity (IFAD, 2008b).
In the empirical literature, many researchers have found that risks cause farmers to be less willing to undertake activities and investments that have higher expected outcomes, but carry with them risks of failure (Alderman, 2008 and Adebusuyi, 2004). The failure to cope with agricultural risk is not only reflected in household consumption fluctuations but also affects nutrition, health and education and contributes to inefficient and unequal intra-household allocations (Dercon, 2002). The absence of formal credit and insurance markets however, does not imply that rural households have no strategies left to deal with income uncertainty. Traditional risk reducing strategies, however incomplete, helps to cope with risky incomes (Morduch, 1999; Hazell and Norton, 1986). There is vast literature which documents strategies used by rural households to offset the adverse effects of income shortfalls and entitlement failures (Alderman, 2008; Dercon, 2002; Besley, 1995).

Alderman and Paxson (1994) presented a whole range of strategies and distinguish between risk management strategies and risk coping strategies. According to Siegel and Alwang (1999) risk management strategies are decisions and actions taken *ex ante* to lower the probability of a risky event. Jacoby and Skoufias (1998) refer to risk coping strategies as decisions and actions taken *ex post* after the risky event has occurred. While the distinction between risk management and risk coping strategies is very useful from a theoretical perspective, its importance is less crucial from a practical point of view. According to Dercon (2007), in their daily lives, farmers experience at the same time.

3.3. Definition of risk

Given the ubiquity of risk in almost every human activity, it is surprising how little consensus there is about how to define risk. The early discussion centred on the distinction between risk that could be quantified objectively and subjective risk. In 1921, Frank Knight summarized the difference between risk and uncertainty thus3: "… Uncertainty must be taken in a sense radically distinct from the familiar notion of Risk, from which it has never been properly separated. The essential fact is that "risk" means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating. It will appear that a measurable uncertainty, or "risk" proper, as we shall use the term, is so far different from an un-measurable one that it is not in effect an uncertainty at all." In short, Knight defined only quantifiable uncertainty to be risk and provided the example of two individuals drawing from an urn of red and black balls; the first individual is ignorant of the numbers of each color whereas the second individual is aware that there are three red balls for each black ball. The second individual estimates (correctly) the probability of drawing a red ball to be 75% but the first operates under the misperception Knight, F.H., 1921, Risk, Uncertainty and Profit, New York Hart, Schaffner and Marx, that there is a 50% chance of drawing a red ball. Knight argues that the second individual is exposed to risk but that the first suffers from ignorance.

The emphasis on whether uncertainty is subjective or objective seems to us misplaced. It is true that risk that is measurable is easier to insure but we do care about all uncertainty, whether measurable or not. In a paper on defining risk, Holton (2004) argues that there are two ingredients that are needed for risk to exist. The first is uncertainty about the potential outcomes from an experiment and the other is that the outcomes have to matter in terms of providing utility. He notes, for instance, that a person jumping out of an airplane without a parachute faces no risk since he is certain to die (no uncertainty) and that drawing balls out of an urn does not expose one to risk since one’s well being or wealth is unaffected by whether a red or a black ball is drawn. Of course, attaching different monetary values to red and black balls would convert this activity to a risky one.

3.4. The Importance of risk in agriculture economics research

Uncertainty and risk are typical features in agriculture and basic to any decision making framework (Aimin, 2010). These terms are intertwined and central to any decision making framework. There is substantial literature on defining risk and uncertainty spanning the past several decades (Flaten, Lien, Koesling, Valle and Ebbesvik, 2005; Hardaker *et al*., 1997; Martin, 1996; Anderson, Dillon and Hardaker, 1988). Greiner, Patterson and Miller (2009) and Knight‘s (1921) definition of risk and uncertainty is in line with the one given by Hardaker, Huirne, Anderson and Lien (2004) who defined risk as imperfect knowledge where the probabilities of the possible outcomes are known, and uncertainty exists when these probabilities are not known. However, less emphasis is usually placed on the differences between uncertainty and risk because the two have similar effect (variation in level of income) on the farm business enterprises. Hence the two terms are used interchangeably because both contribute to the risk perceived by the decision maker (Greiner *et al*., 2009; Marshall and Hildebrand, 2002; Gremillion, 1996; Goland, 1993; Mace, 1993; Scarry, 1993). What is important is that risk constitutes an essential feature of the production environment and cannot be ignored when addressing agricultural economics problems (Moschini and Hennessy, 2001). Virtually all the decisions that farm managers are involved in are subject to risk and their responses to the risk that they perceive will continue to influence the efficiency, structure and performance of agriculture.

The importance of risk as a consideration in agricultural economics research is evident from the large amount of related work that has been conducted both locally and internationally over many years. Studies emphasizing the importance of risk include those where risk has been identified as an important component in supply response models (Aradhyula and Holt, 1990). Chavas (2008) as well as Foster and Rausser (1991) also showed that risk is an important consideration in agriculture where sunk costs associated with the asset fixity of capital items and human capital exist. Despite risk being a farmer‘s perennial problem and farming typically a risky business (Hardaker *et al*.,2004), unfortunately, paradoxically agricultural economists have made little progress in analysing and measuring agricultural risk in ways that provide useful information for farm management (Antle, 1983). The conventional risk framework used in risk analysis has not led agricultural economist to ask the most important questions of the effects of risk in agricultural decision making.

Many researchers modeling risk prefer to deal with objective probabilities and impact (Bouma, Francois and Troch, 2005; Ermoliev, Ermolieva, MacDonald, Norkin and Amendola, 2000b; Melnik-Melnikov and Dekhtyaruk, 2000; Johnson-Payton, Haimes and Lambert, 1999; Pradlwarter and Schueller, 1999). Contrary to this, risk perception is a subjective statement of risk by decision-makers, their degree of belief. Risk perception is more like the mental interpretation of risk, broken down into the chance to be exposed to the content and the magnitude of the risk (Hardaker *et al.,* 2004; Pennings, Wansink and Meulenberg, 2002; Senkondo, 2000; Smidts, 1990*).* Like risk perception, risk attitude plays an important role in understanding the decision-maker's behaviour. Risk attitude is a personal characteristic and deals with the decision-maker's interpretation of the risk and how much he dislikes the outcomes resulting from the risk (Pennings *et al.,* 2002). According to Dillon and Hardaker (1993), risk attitude is the extent to which a decision-maker seeks to avoid risk (risk aversion) or prefers to face risk (risk preference).

There is therefore a need for agricultural economists to understand specifically how risk affects agricultural production. This will in turn suggest how risk affects agricultural decision making and why farmers should be concerned about it. Antle (1983) argues that risk matters primarily because agriculture is a dynamic phenomenon therefore production and price uncertainty affect productivity and expected income. Optimal use of limited resources in the agricultural sector is important for agricultural development (Sargordi, Sharifi, Boerboom, and Keulen Van, 2008) particularly in developing countries where resources are relatively more limited. Resource poor farmers faced with uncertainty that characterises agriculture have to make the decision to make a trade-off between producing for food security or profitability. The individual farmers repeatedly make decisions about what commodities to produce, by what method, in which seasons time period and in what quantities. These decisions are made subject to the prevailing farm physical and financial constraints and often in the face of considerable uncertainty. According to Jeffrey, Gibson and Faminow (1992), traditionally farmers have relied on experience, intuition and comparison with neighbours to make their decisions.

3.5. Type and sources of risks in agriculture

All agricultural enterprises, most especially in developing countries, operate under a situation of risk or uncertainty (Meuwissen, Huirne and Hardaker, 2001). Five general types of risk are described by Hardaker *et al*. (2004). These are described below as: production risk, price or market risk, institutional risk, human or personal risk, and financial risk (Schaffnit-Chatterjee, 2010; Harwood, Heifner, Coble, Perry and Somwaru, 1999).

- **Production risk** derives from the uncertain natural growth processes of crops and livestock. Weather, disease, pests, and other factors affect both the quantity and quality of commodities produced (Langeveld, Verhagen, Van Asseldonk and Metselaar, 2003)

- **Price or market risk** refers to uncertainty about the prices producers will receive for commodities or the prices they must pay for inputs. The nature of price risk varies significantly from commodity to commodity.

- **Financial risk** results when the farm business borrows money and creates an obligation to repay debt. Rising interest rates, the prospect of loans being called by lenders, and restricted credit availability are also aspects of financial risk.

- **Institutional risk** results from uncertainties surrounding government actions. Tax laws, regulations for chemical use, rules for animal waste disposal, and the level of price or income support payments are examples of government decisions that can have a major impact on the farm business (Wolf, Just, Wu and Zilberman, 1998).

- **Human or personal risk** refers to factors such as problems with human health or personal relationships that can affect the farm business. Accidents, illness, death, and divorce are examples of personal crises that can threaten a farm business (Hartman, Frankena, Oude, Nielen, Metz and Huirne. 2004; Huirne, Meuwissen, Van Asseldonk, Tomassen and Mourits, 2003).The above mentioned risks can be often interrelated, so one event can create several impacts on other realities. All the categories of risk have an effect on the income of the stakeholder. Risk perception can vary from farmer to farmer, from sector to sector and from product to product, it depends on the farmer's experience and on the degree of risk-aversion. Similarly, the risk sources vary in importance from one enterprise to another and from a group of farmers to another (Adesina and Quattara, 2000).

3.5.1. Review of empirical studies on farmers risk sources

A comprehensive review of the literature revealed considerable studies that have been done to identify the sources of risk that affect agricultural producers (Le and Cheong, 2009; Salimonu and Falusi, 2009; Meuwissen *et al*., 2001; Kinsey, Burger and Gunning, 1998; Stockil and Ortmann, 1997; Osotimehin, 1996). Flaten *et al*. (2005) and Duram (1999) argue that organic farmers are exposed to additional and different sources of risk compared to conventional farmers. Restrictions on pesticide use, fertilizers, synthetic medicines, purchase of feeds etc. influence production risk. Smaller organic markets may mean greater price fluctuations (Lien, Flaten, Ebbesvik, Koesling and Valle, 2003). On the other hand, specific direct payments in organic farming result in greater income stability (Offermann and Nieberg, 2000). At the same time, and for both production types, uncertainty about future government payments may be of concern to farmers. This relative lack of information about organic farmers' risky environment and their reactions to it means that there are few useful practical insights for policy makers, farm advisers and researchers.

In comparing risk and risk management perceptions of organic and conventional dairy farming in Norway, organic dairy farmers had the least risk aversion perceptions (Flaten *et al*., 2005). Both groups of dairy farmers rated institutional and production risks as major sources of risk, with farm support payments at the top. In contrast, organic farmers put more weight on institutional factors than production systems, in comparison to their conventional colleagues. Conventional farmers are more concerned with the cost of purchased inputs and animal welfare policies. However, both groups had similar responses on the efficacy of risk management strategies. Financial measures such as: liquidity and cost of production, disease prevention, and insurance were perceived as important ways to handle risks (Flaten *et al*., 2005). A study among Finnish farmers found changes in agricultural policy as the most important risk factor, while maintaining adequate liquidity and solidity was the most important management response (Sonkkila, 2002).

A study on risk perceptions and management responses of crop and livestock producers in 12 states in the US found that farmers‘ perception of sources of risk and management responses were significantly different across farm categories and product types (Hall, Knight, Coble, Baquet and Patrick, 2003). According to Harwood *et al*. (1999), for crop producers, weather conditions, crop price and government program were the most important sources of risk, however, a small group of ranchers considered variability in price as relatively unimportant (Wilson, Dahlgran and Conklin, 1993). Dairy farmers in New Zealand ranked price risk and rainfall variability highest, met by routine spraying, drenching, and maintaining feed reserves (Martin, 1996)

Le and Cheong (2009) conducted a study on 256 Vietnamese catfish farming to get an insight into the farmers‘ perceptions of risk and risk management strategies in their catfish farming. Results suggested that, in general, price and production risks were perceived as the most important sources of risk. Salimonu and Falusi (2009) examined the sources of risk in the last three years in the Osun state, Nigeria. The study identified that five sources constituted the major sources of risk in each of the three years under consideration. These were classified as market failure, price fluctuation, drought, pest and diseases attack and erratic rainfall are the most important sources of risk facing by food crop farmers in Osun State, Nigeria. Others included crop diseases, bush fire outbreak and flood disaster. These had effects on the reduction in farmers' productivity, reduction in farmers' income and food shortage.

Meuwissen *et al*. (2001) studied farmers‘ perceptions of risk and risk management, by using factor and regression analyses, amongst Dutch livestock farmers. Results showed that price and production factors were perceived as important sources of risk.

Insurance schemes were perceived as relevant strategies to manage risks. The California agricultural producers ranked output price and input cost highest among their production and financial risks (Blank and McDonald, 1995). Ezeh and Olukosi (1991) identified irregularity in input availability, fluctuations in market prices, irregularity in water supply and variability in weather conditions as major risk sources responsible for variation in farmers‘ income in dry season farming.

Osotimehin (1996) opined that many factors including vagaries of nature, diseases, insect infestations, general economic and market conditions contribute to the price, yield or net return variability of agricultural producers. Kinsey *et al*. (1998) identified harvest failures of rural households in a resettlement area in Zimbabwe as the major risk source. A few studies have found that geographic location, farm type, institutional structures, and other factors affecting the operating environment of farmers influenced farmers‘ perceptions of risk and risk management (Meuwissen *et al*., 2001; Patrick and Musser, 1997; Wilson *et al*., 1993; Boggess, Anaman and Hanson, 1985;). The studies also pointed to the highly complex and individualistic nature of risk perceptions and selection of management tools (Wilson *et al*., 1993).

3.5.2. Review of literature on sources of risk among South African farmers

South African studies where farm-level data sets were used to identify the perceived importance of multiple risk sources include those by Hardman, Darroch, and Ortmann (2002), Stockil and Ortmann (1997), Woodburn, Ortmann and Levin (1995), Bullock, Ortmann and Levin (1994), Swanepoel and Ortmann (1993). Ortmann, Woodburn and Levin (1995) conducted a study among 199 commercial farmers in the province of KwaZulu-Natal, South Africa and determined risk sources and strategies. Factor analysis suggested that crop gross income, government policy, livestock gross income, credit access, government regulation and cost were (described as) risk sources. Stockil and Ortmann (1997) in a survey conducted on the perceptions of risk among 112 commercial farmers in KwaZulu-Natal analyzed the importance and dimensions of risk sources. The respondents identified changes in the cost of farm inputs, government legislation (tax, labour, and land redistribution), the Rand exchange rate, and product prices as the most important sources of risk. Factor analysis of risk sources showed that various dimensions to risk exist, including changes in government policy, enterprise gross income, credit access and cost changes.

3.6. Risk in Agricultural Production in Developing Countries

Households engaged in agricultural production in low-income countries face a number of risks, including crop yield risks due to variance in rainfall timing and level, animal mortality due to infectious livestock diseases, and changing output prices.

Agricultural production is also affected by crop diseases, flooding, frost, illness of household members, war, and crime, all of which can have major effects on rural livelihoods. The existence of such risks has been found to alter household behavior in ways that at first glance seem suboptimal. For example, it has been found that farm households use less fertilizer, fewer improved seed varieties, and lower levels of other production inputs than would have been the case had they simply maximized expected profits. Farmers' decisions to forgo welfare-improving opportunities because of perceptions of risk have significant policy implications. In rural areas of low-income countries, futures and insurance markets do not exist for most types of agricultural risk.

Additionally, credit markets, which allow debtors and creditors to share risk, are thin. One policy response, therefore, is to develop or improve these markets by ensuring that insurance is available and by strengthening rural credit markets. Other measures could be to provide new technologies or inputs, together with long-term support through extension services. Some advances have been made in these areas. Microcredit schemes abound in the developing world, allowing villagers to pursue production opportunities with less risk. Initiatives are also under way in Sub-Saharan Africa to develop crop insurance markets under the auspices of the World Bank and the World Food Programme. While the existence of agricultural risk and its effects on low-income countries are well known, there are few empirical estimations of the magnitude and nature of household risk aversion in this context. Further, little is known about the basic household factors affecting risk behavior. Within low-income countries, there may be important linkages between risk aversion on the part of farm households and seemingly disparate elements such as household fertility, educational attainment, and gender dynamics. Working on these elements could thus improve outcomes for technology adoption.

3.6.1. Factors That Affect Risk Aversion

The study conducted by Yesuf and Bluffstone (2006) reveals a number of factors that affect households' reactions to risk when faced with new agricultural technologies. Some of these factors relate to the nature of the change in agricultural production, whereas others relate to households' past experiences and characteristics. Results indicate that households are more sensitive to potential losses than they are to gains. Respondents who stand to lose as well as gain from adopting a new technology even if the potential gain more than offsets the loss are significantly more risk averse than those that face potential gains only. This finding strongly suggests agricultural extension efforts involving losses as well as gains may face systematic resistance by farmers in lowincome, high-risk environments. However, once initial successes convince farmers that technologies are viable, risk aversion declines.

The study also identifies a positive relationship between the size of the expected payoff and the degree of risk aversion that is; households are more risk averse the greater the expected return (even without the possibility of loss). Moreover, lower income households are more sensitive to risk than higher income households.
Wealth whether in the form of oxen, domestic animals, cash, or land seems to reduce risk aversion. In terms of past experiences, the study finds that farm households are more willing to accept risk if they have experienced successful past harvests. Similarly, households encountering a series of droughts may be more reluctant to undertake risky investment decisions. Other factors that affect households' reaction to risk include household fertility (though not total household size), as well as the age and sex of the household head. The study suggests that families with a large number of dependents are more likely to avoid risky but potentially high-value technologies, such as improved seed varieties and chemical fertilizers. Furthermore, older household heads are more likely to avoid risk. Finally, male household heads prevalent in Ethiopian farm households were found to be less risk averse than female household heads.

3.7. Sources of risk

Considerable studies have been conducted to identify the sources of risk that affect agricultural producers. Flaten, Lien, Koeslig, Valle and Ebbesvik (2005) argue that smallholder farmers are exposed to additional and different sources of risk compared to commercial farmers. Le Cheong (2010) conducted a study on cat fish farmers to get an understanding of farmer's perception of risk and risk management strategies in catfish farming. The results suggested that, the price and production risks were seen as the most important sources of risk. Salmonu and Falusi (2009) examined the sources of risk in Nigeria for the last three years, and the study identified the five major sources of risk which were classified as market failure, price fluctuations, drought, pest and disease attack and erratic rainfall as the most important sources of risk affecting food crop farmers in Nigeria. Some of the sources were crop diseases, bush fire out break and flood disaster. These had effect on the reduction in farmers' productivity, reduction in farmers' income and food shortage.

Meuwissen, Huirne and Hardaker (2001) studied farmers' perception of risk and risk management strategies among livestock farmers and the results revealed that price and production factors were perceived as the important sources of risk. Insurance schemes were perceived as the relevant strategies to manage risks. Output price and cost were ranked as the highest among the production and financial risks of California agricultural producers (Blank and McDonald, 1995). Irregularity in input availability, fluctuations in market prices, and irregularity in water supply and variability in weather conditions were also identified as major sources of risk responsible for variation in farmers' income in dry season farming.

Many factors including vagaries of nature, diseases, insect infestations, general economic and market conditions contribute to the price, yield or net return variability of agricultural producers (Ostotimehi, 1996). According to Kinsey, Burger and Gunning (1998) harvest failures were identified as major sources of risk of rural households in a resettlement area in Zimbabwe. A few studies have found out that geographic location, farm type, institutional structures, and other factors affecting the operating environment of farmers influenced farmers' perception of risk and risk management.

The study also revealed the complexity and individualistic nature of risk perceptions and selection of management tools (Wilson, Dalhran and Conklin 1993).

3.8. Sources of risk among South African farmers

Studies conducted in south Africa were used to identify the perceived importance of multiple risk sources include studies by Hardman, Darrock, and Ortman (2002), Woodburn, Ortman and Levin (1995). The study by Woodburn et al (1995) was to determine risk sources and strategies, the study suggested that crop gross income, government policy, livestock gross income, credit access, government regulation and costs as the source of risk. Stockil and Ortman (1997) conducted a survey on the perception of risk among commercial farmers and analyzed the importance and dimensions of risk sources. The study concluded that the changes in costs of farm inputs, government legislation (tax, labour, and land redistribution). The rand exchange rate and product prices were the most important sources of risk. The analysis showed that risk exists, including changes in government policy, enterprise gross income, credit access and cost changes.

A similar study among vegetable farmers was conducted in Kwazulu Natal by Bullock, Ortman and Levin (1994) and identified price, climate and yield variability as the major sources of risk in vegetable production. The results showed that governmental policies added to the level of uncertainty faced by vegetable farmers. A comparative analysis among small and large farmers showed differences in their perceptions of risk. Small farmers perceived changes in credit availability and changes in input costs to be more important risk sources than large farmers, while large farmers are more concerned with changing interest rates. Another study revealed that sources and responses to risk in farm production, marketing and financing. The main sources of risk were considered to be varieties in livestock production, rainfall and livestock prices, the threat of land reform, and changes in input costs.

3.9. Risk management strategies

Farmers perception of and responses to risk are important in understanding their risk behaviour (Flaten et al., 2005). Beal (1996) stated that it is to be expected that management strategies adopted by farm managers reflect their personal perceptions of risk and managing such risks is critical for the long term success of individuals and economic systems alike. The specific strategies through which food producers attempt to control risk, however, are varied and diverse. Some combination of diversification and intensification methods for risk management may be employed in a given area, community, or household and neighbouring groups may choose different mechanisms for risk reduction when faced with practically identical subsistence challenges (Hendrich and Mc Elreath, 2002). Risk management can be defined choosing among alternatives to reduce the effects of risk. This requires an evaluation of tradeoff between the changes in risk, expected returns and entrepreneurial freedom among others. For an individual farmer, risk management involves finding the preferred combination of uncertain outcomes and varying levels of expected returns (Boehlje and Lins, 1998). Risk management strategies can reduce the exposure of the farm business such as enterprise diversification; transfers risk to another party through outsourcing certain aspects of the farm operations, such as production contracting, or improve the farmers' capacity to bear risk, such as maintaining liquidity assets (Scarry, 2008). Risk management cannot be viewed as a "one size fits all" action. Several key decision making criteria that play into the risk management planning process include the goals established from the operation, the risk bearing ability of the farm and the managers' attitude towards risk. Each one of these will be different for individual family members and each farming unit (Wilson, et.al, 1993).

The United States Department of Agriculture (USDA) (2000) in a review of risk management strategies used by US farmers established that while enterprise diversification can be efficient for risk reduction for smaller farms it is not necessarily the case for large farms and wealthier operators. The degree of diversification in farming also varies significantly across regions and farm sizes. The reason that could account for this situation are the differences and limitations in farm resources, expertise, market out let, weather conditions and farmers risk aversion(Harwood, 1999). Alderman and Paxson (1994) presented a whole range of strategies and distinguished between risk management strategies and risk coping strategies. Each category involves a number of specific actions but can be summarised as in Fafchamps (1999). He classified them into 1) to reduce exposure to shocks ex-ante 2) to cope with shocks ex-post (fate), rural households use self assurance via precautionary savings, borrowing, liquidation of assets, smoothing consumption, labour sales and solidatory through risk sharing networks.

When farmers do not have or when they are not willing to sell their productive assets, they increase their labour supply. This includes being engaged in nonfarm activities during less extreme conditions, using child labour and labour bonding during extreme conditions (Fafchamps, 1999). De Weerdt and Dercon (2006) found that risk sharing is mainly achieved through private gifts, private loans and labour transfers. However, risk sharing among households from the same village will not adequately insure them against covariate risks like hurricane, drought or other negative shocks that have a positive covariance between households such as price shocks. All households in the same area are affected at the same time. Therefore, nobody from the same area can help each other. Assistance has to come from outside the affected area.

Although traditional risk management strategies mitigate only a small part of overall risk (Alderman, 2008) in the absence of insurance and financial markets, households use a combination of these strategies as substitutes to deal with agricultural risks. According to Tomek and Hikaru (2001), farmers are assumed to select a combination of strategies, for example, maximize net expected returns (profits) subject to the degree of risk they are willing to accept clearly, risk management strategies in agriculture vary with farm characteristics and the risk environment. Farmers risk perception, risk attitudes, objectives as well as the available resource base, influence their decisions and actions.

3.10. Analysis of smallholder farmers risk preferences in developing countries

Dillon and Scandizzo (1978) measured the risk preferences for 103 subsistence farmers in Brazil. Mind experiments involving choice between risky and sure farm alternatives were used to assess risk attitudes of samples of small farm owners and sharecroppers in Brazil. According to Dillon and Scandizzo (1978), results indicate that most subsistence farmers are risk averse, and that risk aversion tends to be more common and perhaps greater among owners than sharecroppers. In an expected utility context, distribution of risk attitude coefficients (based on mean-standard deviation, mean-variance, and exponential utility functions) was diverse and not necessarily well represented by an average sample value (Dillon and Scandizzo, 1978). Further, econometric analysis done by regressing the risk preference against various socioeconomic variables indicated that income level and other socioeconomic variables influenced peasants' risk attitude.

Binswanger (1980) conducted a field experiment with 330 farmers in rural India for both real and hypothetical gambles using lottery choice tasks. When payoffs were small, about half the respondents were in the intermediate and moderate risk-aversion categories. Binswanger‘s (1980) study found that nearly a third of the respondents were close to risk-neutral or risk-loving, and less than 10% were severely risk-averse. However, as payoffs rose, nearly 80% of the subjects displayed moderate risk-aversion, and risk-neutral or risk-loving behavior almost disappeared. Arrow's prediction held - absolute risk-aversion declined as payoff increased. Here an individual's willingness to accept small bets of a fixed size increased as wealth increased (Arrow, 1971). However, contrary to Arrow's hypothesis, the subjects also displayed decreasing relative risk aversion (Binswanger, 1980).

A series of laboratory experiments were conducted in China by Kachelmeier and Shehata (1992) to elicit people's certainty equivalents for a sequence of lotteries. Ten sessions were conducted with 185 student volunteers at Beijing University. The study differed from Binswanger's (1980) in that here, subjects were not asked to choose between lotteries. Rather, certainty equivalents were elicited for individual lotteries. Several percentages depicting different win levels were used (not just the uniform 50-50% chances that Binswanger (1980) used). Subjects were presented with a lottery involving a prize of value G with probability P, and zero with probability (1-p). If the subject drew a card with a number less than or equal to p, they were awarded the prize. Kachelmeier and Shehata (1992) found that the average ratios of certainty equivalents to expected values for the high-prize trials were systematically lower than the ratios for low-prize trials, across win percentages. Once again, there was a marked trend from risk-loving or risk neutral preferences to risk-averse, as payoffs increased.

Holt and Laury (2002) presented subjects with simple choice tasks that may be used to estimate the degree of risk aversion as well as specific functional forms. They conducted this experiment under both real and hypothetical conditions, using a menu of paired (Option A and option B) lottery choices, similar to Binswanger (1980). The payoffs for Option A, $2.00 or $1.60, were less variable than the potential payoffs of $3.85 or $0.10 in the "risky" option B. The probabilities were explained using throws of a ten-sided die, and ranged between 1/10 and 10/10(sure win). Holt and Laury (2002) controlled for wealth effects between the high and low real-payoff treatments, by subject being required to give up what they had earned in the first low-payoff task in order to participate in the high-payoff decision. Results from Holt and Laury (2002) showed that most subjects chose the safe option when the probability of the high payoff was small, and then "crossed over" to option B, almost never returning to A. A few more returned in the hypothetical treatment. Once again, the subjects showed increasing degrees of risk-aversion in the high-payoff treatments than the low-payoff treatments.

This result is qualitatively similar to that reported by Kachelmeier and Shehata (1992) and Smith and Walker (1993) in different choice environments. The results indicate that most individuals are risk averse with little variation according to personal characteristics, although wealth has a slight negative effect on risk aversion especially at low pay offs (Holt and Laury, 2002). Distribution of risk aversion was more widely spread at low levels and for hypothetical gambles, suggesting at higher pay offs one is more likely to elicit true risk preferences. The results support the hypothesis of increasing partial risk aversion with increasing payoff levels similar to Bas-Shira et al. (1997).

3.11. South African research on farmers risk preferences

Lombard and Kassier (1990) conducted a study on risk preferences of farmers in South Africa and found the degree on intertemporal stability in risk attitudes varied between the specified income levels and there seemed to be a negative relationship between the accuracy of the risk interval on the one hand and the consistency of choice on the other hand. The response to two control questions indicated a varying degree of consistency at each income level. Risk averse, risk seeking and risk indifferent attitudes are observed (Lombard and Kassier, 1990).

In their study Meiring and Oosthizen (1993) measured irrigation farmers' absolute risk aversion coefficient by means of the interval approach. The study analysed the influence of adjustment of the absolute risk- aversion scale, as well as the cumulative distributions on respondents' risk preferences. The consistency of risk- attitudes was also determined. Results of elicitation of risk preference established that majority of farmers is extreme risk preference: either risk- seeking or risk aversion. They further established that, the decision makers who completed who completed the questionnaire at the higher levels of bank balances were more constant than those who complete the questionnaire at lower levels. If the width, over which the distributions extend, increases, the preferences of a few farmers tend to change risk-neutral to risk- averse. Meiring and Osthuizen (1993) concluded that by propagating the concept of probability distributions for the evaluation of risky alternatives, a better understanding of risk and risk management can be brought about, which will result in easier obtaining of risk measuring results.

3.12. Agricultural risk management strategies

Farmers' perceptions of and responses to risk are important in understanding their risk behaviour (Flaten *et al*., 2005). Beal (1996) stated that it is to be expected that risk management strategies adopted by farm managers reflect their personal perceptions of risk and managing such risks is critical for the long-term success of individuals and economic systems alike. (Gremillion 2002, 1996; Cashdan, 1990). The specific strategies through which food producers attempt to control risk, however, are varied and diverse. Some combination of diversification and intensification methods for risk management may employed in a given area, community, or household, and neighboring groups may choose different mechanisms for risk reduction when faced with practically identical subsistence challenges (Henrich and McElreath, 2002); Baksh and Johnson, 1990; Halstead and O'Shea, 1989). According to Harwood *et al*. (1999) risk management can be defined as choosing among alternatives to reduce the effects of risk. This requires an evaluation of tradeoff between changes in risk, expected returns and entrepreneurial freedom among others. For an individual farmer, risk management involves finding the preferred combination of uncertain outcomes and varying levels of expected returns (Boehlje and Lins, 1998). Risk management strategies can: (1) reduce the exposure of the farm business to risk such as enterprise diversification (Scarry 2008 and Smith, 2006); (2) transfer risk to another party through outsourcing certain aspects of the farm operations, such as production contracting (Goodwin and Ker, 1998); or (3) improve the farmer's capacity to bear risk, such as maintaining liquid assets. Risk management cannot be viewed as a one size fits all‖ action (Boggess *et al*., 1985 and Wilson, Luginsland and Armstrong 1988). Several key decision making criteria that play into the risk management planning process include the goals established for the operation, the risk bearing ability of the farm, and the manager's attitude towards risk (Patrick, Wilson, Barry, Boggess and Young, 1985). Each one of these items will be different for individual family members and each farming unit (Wilson *et al*., 1993).

Organic farming, which is distinguished from conventional farming by its reliance on the natural processes of ecosystems, may present particular risks and ways of managing risks (Hanson *et al*., 2004). Organic farming systems virtually exclude what are often thought of as important risk management tools in conventional farming, such as the use of synthetic chemicals and antibiotics (Duram, 1999). Instead, organic farmers rely on their understanding and management of cultural practices such as crop rotation, timing of planting and harvesting, mechanical cultivation, and development of beneficial insect populations (Greene and Kremen, 2003). Organic production techniques, particularly crop rotation, can reduce risk in the longer term. Hanson, Johnson, Peters and Janke (1990) compared a conventional grain rotation with an organic grain rotation during the first nine years of production. He stated that without organic price premiums, the average annual profits of the conventional rotation were higher than the organic rotation. However, using a safety-first criterion, the risk-averse farmer would choose the organic system over conventional (Harrington and Niehaus, 1999). More specifically, Diebel, Williams and Llewelyn (1995) noted that with diverse cropping systems, the yields and prices of these various crops do not necessarily move together, which reduces variability of overall farm income.

The United States Department of Agriculture (USDA) (2000) in a review of risk management strategies used by US farmers established that while enterprise diversification can be an efficient strategy for risk reduction for smaller farms it is not necessarily the case for large scale farms and wealthier operators. The degree of diversification in farming also varies significantly across regions and farm sizes. The reasons that could account for this situation are: differences and limitations in farm resources, expertise, market outlets, weather conditions and farmers‘ risk aversion (Harwood *et al*., 1999). Alderman and Paxson (1994) presented a whole range of strategies and distinguished between risk management strategies and risk coping strategies. Each category involves a number of specific actions but can be summarized as in Fafchamps (1999). He classified actions as follows: 1) to reduce exposure to shocks ex-ante (fear) farmers carefully choose their location or diversify their plots and crops; 2) to cope with shocks ex-post (fate), rural households use self-insurance‘ via precautionary savings, borrowing, liquidation of assets, smoothing consumption, labour sales and solidarity through risk sharing networks.

Poor households in developing countries are known to hold significant amounts of extra saving in a wide variety of forms such as stored grain, cash holdings, jewelry, and livestock (Park, 2006; Fafchamps, Udry and Czukas, 1998; Alderman, 1996; Townsend, 1995; Rosenzweig and Wolpin, 1993.). Park (2006) argued that grain stocks are the most important form of extra saving in developing countries despite their negative returns. This puzzling behavior may be due to the lack of access to credit and/or reliable saving opportunities. Deaton (1991) argued, in the event of unexpected negative shocks, households utilize the financial and physical assets that they have previously accumulated. Indeed, when farmers happen to be unable to or fail to reduce their exposure to risks ex-ante, they have to deal with the shocks *ex post*. Their precautionary savings include assets like food stocks, gold, jewellery, cash or when possible, deposits on savings and checking accounts (Fafchamps, 1999; Behrman, Foster and Rosenzweig, 1997). Sometimes, when they face a long series of negative shocks their precautionary savings run out and they have to borrow. Productive assets usually liquidated to face shocks are livestock, oxen, bullocks, farm tools, artisanal equipment, vehicles and farm buildings (Fafchamps, 1999; Rosenzweig and Wolpin, 1993). Instead of selling their productive assets, some farmers prefer to reduce their consumption even in the face of extreme shocks like drought (Kazianga and Udry, 2006; Fafchamps *et al*., 1998).

When farmers do not have or when they are not willing to sell their productive assets, they increase their labour supply (Wilson *et al*., 1988). This includes being engaged in nonfarm activities during less extreme conditions, using child labour and labour bonding during extreme conditions (Barrett, Sherlund and Adesina, 2000; Fafchamps, 1999). In a survey administered in rural Tanzania, De Weerdt and Dercon (2006) found that risk sharing was the most frequently mentioned coping strategy. They also discovered that risk sharing is mainly achieved through private gifts, private loans and private labour transfers. However, risk sharing among households from the same village will not adequately insure them against covariate risks like floods, hurricanes, drought or other negative shocks that have a positive covariance between households such as price shocks. All households in the same area are affected at the same time. Therefore, nobody in the same area can help the other. Assistance has to come from outside the affected area.

Rosenzweig and Stark (1989) in their study found that Indian families marry their daughters in distant villages as a coping strategy against covariate risks. Salimonu and Falusi (2009) identified cooperative society, borrowing of money and off farm-work as major risk management strategies used by Nigerian food crop farmer. Although traditional risk management strategies mitigate only a small part of overall risk

(Alderman, 2008; Dercon, 2002) in the absence of insurance and financial markets, households use a combination of these strategies as substitutes to deal with agricultural risks. According to Tomek and Hikaru (2001), farmers are assumed to select a combination of strategies that, for example, maximize net expected returns (profits) subject to the degree of risk they are willing to accept. Clearly, risk management strategies in agriculture vary with farm characteristics and the risk environment (Hope and Lingard, 1992). Farmers‘ risk perceptions, risk attitudes, objectives as well as the available resource base, influence their decisions and actions.

3.13. Expected utility theory and the measure of the risk aversion of producers

Expected utility theory (EUT) was defined by Von-Neumann and Morgenstern (1944) to explain the reasons behind individual choices involving risk. Since then EUT has been the basis for much of the decision-making theory (Gomez-Limon, Arriaza and Riesgo, 2003) and has the support of most agricultural economists (Schoemaker, 1982; Robison and Hanson, 1997). All theoretical aspects of EUT related to agricultural economics have been discussed in classic works such as those of Hardaker et al. (1997), Robison and Barry (1987), Anderson et al. (1985) and Barry (1984). The theory assumes that there is a utility function U that assigns a numerical value to each alternative. As most economic decisions are expressed in monetary terms, the utility function may have wealth as argument (U (W)), measuring the satisfaction obtained from a given amount of money. However, the satisfaction from either a gain or a loss *(U(X))* may also be used (Hardaker et al., 1997). In doing so, EUT allows the ranking of alternatives within the context of risk.

The seminal works of Arrow (1965) and Pratt (1964) paid attention to one of the key elements of decision theory (the measure of risk aversion of the economic agents). Arrow (1965) and Pratt (1964) proposed two indicators that overcame the limitations in the use of a cardinal utility function in order to compare differences in risk attitudes. As such, the Arrow Pratt measure of risk aversion for von Neumann-Morgenstern expected utility function have been used extensively to analyse problems in the micro economics of uncertainty (Ross, 1981). The risk aversion concept in based on the behaviour of individuals whilst exposed to uncertainty. It is the reluctance of an individual to accept a bargain with an uncertain payoff rather than another bargain with more certain, but possibly lower, expected payoff (Gill, 2007 and Levy, 2006). The Expected Utility (EU) theory essentially defines risk aversion in terms of the concavity or convexity of the decision makers utility function at any particular point (Cox and Sadiraj, 2006; Eisenhauer, 2006). Friedman and Savage (1948) showed that the local concavity or convexity of to von Neumann-Morgenstern expected utility function *u(x),* indicates the local risk preference of a decision maker.

A decision maker is described as locally risk averse (concave utility function), risk neutral (linear utility) function or risk loving (convex utility function) for a particular outcome level if *u"(x) < 0; =0; or > 0* respectively where *u"(x)* is the second derivative of u *(•)* of the expected utility model of Von Neumann and Morgernstern (1944) which has recently been generalised by Machina (1982). This measure merely indicates the decision makers risk preference, but is not an appropriate measure of risk aversion as *u"(x*) is affected by the linear transformation of *x*, and consequently its magnitude provides no insight into the severity of the risk attitudes (Rabin and Thaler, 2001; Rabin, 2000; Pratt, 1964). Arrow (1971) and Pratt (1964) independently developed equivalent measures of risk preferences that allow for comparisons of interpersonal preferences- the Arrow-Pratt absolute and relative risk aversion coefficients. Arrow developed them from the probability premium (Babcock, Choi and Feinerman, 1993), whilst Pratt worked from the risk premium (Pratt, 1964). A third and relative measure of risk aversion is the partial risk aversion coefficient developed by Menezes and Hanson (1970). These measures are invariant to positive linear transformations of *x*. A decision maker is defined as risk averse, neutral or risk loving if these measures are less than, equal to, or greater than zero (Menezes and Hanson 1970; Pratt 1964).

3.13.1. Arrow-Pratt measure of Absolute Risk Aversion (ARA)

Also known as the coefficient of absolute risk aversion, mathematically the coefficient for the ARA is calculated as:

$$A(W) = -\frac{U''(w)}{U'(w)}$$

$$A(W) = A(x) = -\frac{U''(x)}{U'(x)} \quad \text{--} \quad (3.1)$$

Where *w* indicates total wealth and *U*'' and *U*' indicate the second and first derivatives of the von Neumann-Morgenstern utility function, respectively. The measure of ARA is appropriate to describe situations in which total wealth has a fixed stochastic part-income and a variable non stochastic part- initial wealth (Bar-Shira, Just and Zilberman, 1997). Arrow (1971) pointed out that it is natural to hypothesize that the individual's willingness to undertake a certain risky project is greater when he or she is wealthier. In other words, wealthier individuals should have a greater amount of risky assets in their portfolio. Thus the measure of ARA should decrease with wealth.

The coefficient *A(w)* takes either positive or negative values for risk-loving or risk averse economic agents respectively. When the coefficient decreases as monetary value increases we have Decreasing Absolute Risk Aversion (DARA). Alternatively, if the coefficient increases under the same set of circumstances we have Increasing Absolute Risk Aversion (IARA). Finally, if the coefficient does not change across the monetary level, the decision-maker exhibits Constant Absolute Risk Aversion (CARA), which implies that the level of the argument of the utility function does not affect his or her decisions under uncertainty (Menezes and Hanson, 1970); Pratt, 1964). Since *A(w)* is not a non-dimensional measure of risk aversion, its value is dependent on the currency in which the monetary units are expressed. To overcome the impossibility of comparing risk aversion among different economic agents Arrow (1965) and Pratt (1964) devised a non-dimensional measure called the Relative Risk Aversion (RRA) coefficient.

3.13.2. Arrow-Pratt measure of Relative Risk Aversion (RRA)

Also known as the coefficient of relative risk aversion, mathematically the coefficient for the RRA is calculated as:

$$R\,(w) = -\frac{u''(w)}{u'(w)} = wA(w) = wA(x) \quad \text{--} (3.2)$$

In situations where both the stochastic and non stochastic components of the wealth are changing proportionally, the appropriate measure is R(*w*). Arrow's (1971) hypothesis is that when both initial wealth and the risky project are increased by the same proportion, the individual's willingness to undertake the risky project is smaller. In other words, wealthier individuals should hold a smaller portion of risky assets in their portfolio. The R*(w)* coefficient measures the percentage change in marginal utility in terms of the percentage change in the monetary variable. Hence, relative risk aversion represents the elasticity of the marginal utility function which ranges from 0.5 (slightly risk averse) to 4 (extremely risk averse). Anderson and Dillon (1992) classify agricultural producers according the R (w) coefficient. Although most authors consider values above 5-10 very unlikely (Kocherlakota, 1996), some studies report values of up to 30 (Kandel and Stambaugh, 1991). According to them, these values can be reasonable when the alternatives in place represent a gain or loss of 1% of the total wealth. As with the absolute risk aversion coefficient, there is Decreasing Relative Risk Aversion (DRRA), Constant Relative Risk Aversion (CRRA) or Increasing Relative Risk Aversion (IRRA) behaviour (Menezes and Hanson, 1970; Pratt, 1964).

3.13.3. Measure of Partial Risk Aversion (PRA)

Also known as the coefficient of partial risk aversion, mathematically the coefficient for the PRA is calculated as:

$$P(wo, \pi) = - \frac{[u''(Wo + \pi)]}{[u'(wo + \pi)]} \quad \text{--} \quad (3.3)$$

Where

Wo denotes non stochastic initial wealth, and

π denotes stochastic income

At the point ($w = wo + \pi$), PRA is related to the measure of ARA and RRA as follows:

$$P(wo, \pi) = \pi A\,(wo + \pi)$$

$$P(wo, \pi) = R(wo + \pi) \quad \frac{\pi}{wo+\pi} \quad \text{--} \quad (3.4)$$

The measure of partial risk aversion is unit less and appropriate to describe situations in which initial wealth is fixed and income is variable. Bar-Shira, et al. (1997) show that Decreasing Absolute Risk Aversion (DARA) implies Decreasing Partial Risk Aversion (DPRA) with respect to initial wealth and that Increasing Relative Risk Aversion (IRRA) implies Increasing Partial Risk Aversion (IPRA) with respect to income. The opposite does not necessarily hold. It is possible to have DRRA and IRRA at the same time. Menezes and Hanson (1970) alludes that partial risk aversion examines behavior when the prospect changes but wealth remains the same. Increasing Partial Risk Aversion (IPRA) implies a decrease in the willingness to take a gamble as the scale of the prospect increases.

3.14. Using ARA to measure the decision makers risk aversion

The Absolute Risk Aversion Coefficient defined as *A(x) =- u"(x)/u'(x)* has appeared extensively in literature (Just, 2011; Bar-Shira, et al., 1997; Chavas and Holt, 1996). Although the ARA are invariant to linear transformations of the *u* (King and Robison, 1981) they are not invariant to arbitrary rescaling of *x* or a change in the range and scale of *x* (Raskin and Cochran, 1986), rendering ARA neither employable in secondary studies, nor comparable between studies without prior adjustments (Just, 2011). The Initial work of Pratt (1964) best demonstrates the impact of both scale and range on ARA *[A(x)]*. According to Pratt (1964), to measure a decision maker's local aversion to risk, it is natural to consider his risk premium for a small, actuarially neutral risk *Ў*.

Pratt (1964) developed a relationship between risk premium, the variance of the risky prospects and ARA as being:

П (x, Ў) = $\frac{1}{2}\sigma_y^2 A(x) + o(\sigma_y^2)$ -- (3.5)

Where:

П (x, Ў) is the risk premium given a level of wealth and a risky prospect;

σ_y^2 is the variance of the risky prospect;

A(x) is the Absolute Risk Aversion at level of wealth *x*; and

$\sigma(^2_y)$ are the higher order terms in the Taylor series expansion of the expected utility function around the mean of *x*

Solving for *A(x)* in equation 5 yields:

A(x) = $\frac{2[\pi(x,\ddot{y}) - 0(\sigma_{\ddot{y}}^2]}{\sigma_{\ddot{y}}^2}$ -- (3.6)

If, following Tsiang (1972) the dispersion of the risk prospect is assumed small relative to wealth, then $(\sigma_{y}^{2})/\sigma_{y}^{2}$ may be neglected.

Thus, *A (x)* is approximately given by:

A(x) ≈ 2π(x, Y̌)/ σ_{y}^{2} -- (3.7)

This exposition is similar to that presented by Mc Carl and Bessler (1989) as part of their discussion on estimating an upper bound on the ARA when the utility function is unknown. The exact and approximate expression of *A(x)* clearly indicates that *A(x)* is dependent on both *x* and the risk situation, *Y̌*. Thus the ARA has associated with it a unit, the reciprocal of that unit with which *Y̌* is measured since the certainty equivalent is divided by the variance of *Y̌*. Because σ_{y}^{2} and *E(Y̌)* affects *A(x)*, the magnitude of *A(x)* is not affected by the use of incremental rather than absolute returns, or vice versa.

Furthermore it is apparent that the change in σ_{y}^{2} will affect ARA. For example a mean preserving increase in risk i.e. σ_{y}^{2} increases whilst *x* and the expected value of *Y̌* remain constant will decrease *A(x)*. This discussion provides an explanation to McCarl's(1988) concern that if the magnitude of ARA is unaffected by use of incremental rather than absolute terms as hypothesized by Raskin and Cochran (1986) then one could abandon the wealth concept and only look at income. Cochran and Raskin's (1987) reply agrees with McCarl (1988) without explaining how ARA are a function of both initial wealth and stochastic income.

Given the sensitivity of ARA to the scale of data as well as the range of data it is somewhat surprising that ARA have appeared in so many publications without also providing sufficient information about the source of the ARA coefficients or the range and scale of stochastic wealth to allow comparisons with other studies (Cochran, et al., 1985; Collender and Zilberman, 1985; Danok, McCarl and White ,1980; Holt and Brandt, 1985; King and Oamek, 1983; King and Robinson, 1981; Tauer, 1986; Ye and Yeh, 1995; Zacharias and Grube, 1984).

Arrow Pratt Risk Aversion coefficients are expressed in several studies to five decimal places and ranges from 12.17 (Chavas and Holt, 1996) and 6.0 (Meyer, 1977) to .000000921 (Collender and Zilberman, 1985). Cochran (1986) stated that it "appears reasonable to expect that the preferences of the majority of farmers will be represented with the interval -.0002 to .0015 when measured at after tax net farm annual income levels" However Raskin and Cochran (1986) demonstrate that a pair of decision makers exhibiting seemingly close values of *A*(*x*) such as .0002 and .0003, respectively, would disagree on the value of the 10,001st dollar by a factor of three and on the value of the 50,001st dollar by a factor of 160. This demonstration emphasizes that researchers should not underestimate the importance of scale.

The need for the explicit specification of the unit of the Arrow-Pratt Risk Aversion might arise when elicited values are used outside the context of the original study (Mac Nicol, 2007; Just, 2011). If a risk aversion coefficient elicited over an outcome space measured in one unit is later applied over outcomes measured in another unit, it must be converted by the appropriate factor (Ferrer, et al., 1997). Raskin and Cochran (1986) propose 2 theorems to guide the approximation to necessary conversions:

THEOREM 1 *$A(x) = r(x)$, Let $r(x) = -u''(x)/u'(x)$. Define a transformation of scale on x such that $w = x/c$, where c is a constant, x is the outcome variable and w is a wealth level. Then $r(w) = cr(x)$.*

THEOREM 2 *$A(x) = r(x)$. If $v = x + c$, where c is a constant, and v is a wealth level, then $r(v) = r(x)$. Therefore, the magnitude of the risk aversion coefficient is unaffected by the use of incremental rather than absolute returns (or vice versa).*

The notion that range affects Arrow-Pratt Risk Aversion is not new, Wiesensel and Schoney (1989) stated that Arrow-Pratt Risk Aversion elicited from different income levels is not directly comparable. The notion that range affects Arrow-Pratt Risk Aversion is also implied in Mc Carl and Bessler's (1989) approach of estimating an upper bound on Arrow-Pratt Risk Aversion when the utility function is unknown. Kachelmeir and Shehata (1992) also suggested that risk preferences be measured as the ratio of the certainty equivalent to the equivalent value of the income distribution to permit comparison of risk preferences across lotteries of different range.

Feinerman and Finkelshtain (1996) used a similar approach based on the probability premium. These approaches have a drawback in that results cannot be directly applied to some stochastic efficiency techniques, e.g. mean-variance programming models and stochastic dominance with respect to a function. Babcock, et al. (1993) also note that when the range of wealth distributions varies, the risk premium, expressed as a proportion of gamble size (amount of wealth at risk) and the probability premium convey more information on risk preference than does Arrow-Pratt Risk Aversion. Consequently Eisenhauer (2006) advocates consideration of these measures when selecting Arrow-Pratt Risk Aversion coefficients to demonstrate the effects of risk preferences on decisions. It is apparent from the range of Arrow-Pratt Risk Aversion elicited, borrowed and assumed, even in recent studies that many agricultural economists are unaware of the impact of range on Arrow-Pratt Risk Aversion e.g. Bar-Shira et al. (1997), Chavas and Holt (1996), Saha et al. (1994b), Pope and Just (1991), Chavas and Holt (1990), Lins, Gabriel and Sonka (1981). Despite this suggested amendments to Raskin and Cochran's(1986) first theorem, not all risk situations may easily be adjusted to be represented in terms of Rand income or wealth to enable comparison or analysis e.g. in environmental risk (Just and Pope, 2003). An approach is suggested entailing standardization of the data to uniform scale and range prior to calculating an adjusted Arrow Pratt Absolute Risk Aversion coefficient *(ג*)* (Nieuwoudt and Hoag, 1993).

The approach outlined by Nieuwoudt and Hoag (1993) may be extended to multivariate utility analysis and applied to environmental analyses where say both wealth and environmental risks may be important. Elicited values are consistent with the absolute risk aversion matrix, R, derived by Duncan (1977) and defined by: *R(x) = [-Uij /Ui- R*] provides a complete representation of an agent's risk preferences for multiple attributes that is consistent with the Arrow Pratt Absolute Risk Aversion coefficient. The diagonal elements represent the agent's absolute risk attitudes with respect to the *ith* risky attributes.

Whilst Raskin and Cochran (1986) have successfully made agricultural economists aware of the effects of the scale of data on the Arrow-Pratt Risk Aversion many still seem unaware of the effect of range. This discussion has focused on the abilities of the Arrow-Pratt Risk Aversion to convey information about risk aversion assumptions or measurements in research programs. It is shown that an amendment is necessary for Raskin and Cochran's (1986) first theorem if Arrow-Pratt Risk Aversion is to be adjusted for the range as well as the scale of data. It is imperative that sufficient information regarding the risk situation and the population are reported with elicited risk preferences (Ferrer and Nieuwoudt, 1997). Hence it is important that risk preferences should be reported in a consistent manner such that studies can easily be compared to one another.

3.15. Methods for measuring the risk attitudes of agricultural producers

Several approaches have been used to assess smallholder farmers' risk attitudes. According to Robison, Barry, Kliebenstaein and Patrick (1984), Lins et al.(1981) and Young (1979), there are three basic methods of measuring the attitudes to risk of agricultural producers: i) Direct estimation of the utility function (DEU); ii) Experimental methods (EM); and iii) Observed economic behaviour.

- Direct estimation of the utility function (DEU): This method involves direct interaction with the decision-maker, with the interview procedures designed to determine respondents' points of indifference between certain outcomes and hypothetical risky options. Respondents' preferred choices among alternative options are thus considered to be indicative of their risk preferences. Empirical application of the DEU approach includes Hardaker et al. (1997), Abadi Ghadim and Pannell (1999) and Feinerman and Finkelshtain (1996).

  The DEU method has been criticized as being prone to interviewer bias if conducted using hypothetical rather than real lotteries (Binswanger, 1980), subjectivity involved in the identification of the functional form of the utility function, preferences for specific probabilities (for example a 50:50 bet), confounding from extraneous variables, and negative preferences towards gambling (Young, 1979). Although risk preferences elicited using EM may be more reliable than those elicited using DEU methods (Gunjal and Legault, 1995), budgetary restraints may preclude the researcher from asking meaningful questions (Kachelmeier and Shehata, 1992), in which case use of DEU may be preferred to EM.

- Experimental methods (EM): This can be regarded as a variant of the DEU method, in which real gambles/bets are used instead of hypothetical gains and losses and from their responses, derive the respondents'utility function. Because this approach requires that financial compensation is paid to respondents as a function of their responses to each gamble, this approach has generally been carried out in populations with low per capita income and wealth, example Miyata (2003) in Indonesia, Grisley and Kellog (1987) in Thailand and Binswanger (1980) in India.

- Observed economic behaviour: This method was developed in order to represent risk behaviour, tuning the models to fit actual data by adjusting the risk aversion coefficients, usually along with other coefficients. Furthermore, these models rely on either production theory under uncertainty (econometric models) or cropping pattern selection (mathematical programming). Bar-Shira et al., (1997), Chavas and Holt (1996, 1990); Saha et al. (1994); Pope and Just (1991); Myers (1989), Moscardi and Janvry (1977) and Wolgin (1975) present good examples of the first category, while for the latter we have Brink and McCarl (1978) and Wiens (1976).

This approach is criticised for confounding risk behaviour with other factors such as resource constraints faced by decision makers (Eswaran and Kotwal, 1990), thus making an individual appear more risk averse than he/she truly is (Binswanger, 1982). This is particularly important in developing countries where market imperfections are prominent and production and consumption decisions, therefore, are non-separable (Sadoulet and de Janvry, 1995). Econometric approaches have advanced considerably over the past three decades, but remain data intensive and open to model misspecification problems. The advantage of EM and DEU approaches over econometric approaches is that the researcher can design experiments where many of the features are under the control of the experimenter.

Young's (1979) review shows that the principle uses of elicited risk aversion coefficients are for (a) farm management extension application, (b) technology adoption and rural participation applications, and (c) policy and predictive applications. He concluded that considerable heterogeneity in risk preferences among individuals; requirements of frequent updating of individual risk preferences in response to changing objectives, information and attitudes; time, cost and practical problems associated with elicitation of risk preferences are likely to limit their use in extension programmes (Young, 1979).

3.15.1. Elicitation and analysis of farmers risk preferences in developing countries

Dillon and Scandizzo (1978) measured the risk preferences for subsistence farmers in Brazil. Mind experiments involving choice between risky and sure farm alternatives were used to assess risk attitudes of samples of small farm owners and sharecroppers in Brazil. According to Dillon and Scandizzo (1978), results indicate that most subsistence farmers are risk averse, and that risk aversion tends to be more common and perhaps greater among owners than sharecroppers. In an expected utility context, distribution of risk attitude coefficients (based on mean-standard deviation, mean-variance, and exponential utility functions) was diverse and not necessarily well represented by an average sample value (Dillon and Scandizzo, 1978). Further, econometric analysis done by regressing the risk preference against various socioeconomic variables indicated that income level and other socioeconomic variables influenced peasants‘ risk attitude.

Binswanger (1980) conducted a field experiment with 330 farmers in rural India for both real and hypothetical gambles using lottery choice tasks. When payoffs were small, about half the respondents were in the intermediate and moderate risk-aversion categories. Binswanger‘s (1980) study found that nearly a third of the respondents were close to risk-neutral or risk-loving, and less than 10% were severely risk-averse. However, as payoffs rose, nearly 80% of the subjects displayed moderate risk-aversion, and risk-neutral or risk-loving behavior almost disappeared. Arrow's prediction held - absolute risk-aversion declined as payoff increased. Here an individual's willingness to accept small bets of a fixed size increased as wealth increased (Arrow, 1971). However, contrary to Arrow's hypothesis, the subjects also displayed decreasing relative risk aversion (Binswanger, 1980).

A series of laboratory experiments were conducted in China by Kachelmeier and Shehata (1992) to elicit people's certainty equivalents for a sequence of lotteries. Ten sessions were conducted with 185 student volunteers at Beijing University. The study differed from Binswanger's (1980) in that here, subjects were not asked to choose between lotteries. Rather, certainty equivalents were elicited for individual lotteries. Several percentages depicting different win levels were used (not just the uniform 50-50% chances that Binswanger (1980) used). Subjects were presented with a lottery involving a prize of value *G* with probability *p*, and zero with probability (*1-p*). If the subject drew a card with a number less than or equal to *p*, they were awarded the prize. Kachelmeier and Shehata (1992) found that the average ratios of certainty equivalents to expected values for the high-prize trials were systematically lower than the ratios for low-prize trials, across win percentages. Once again, there was a marked trend from risk-loving or risk neutral preferences to risk-averse, as payoffs increased.

Holt and Laury (2002) presented subjects with simple choice tasks that may be used to estimate the degree of risk aversion as well as specific functional forms. They conducted this experiment under both real and hypothetical conditions, using a menu of paired (Option A and option B) lottery choices, similar to Binswanger (1980). The payoffs for Option A, $2.00 or $1.60, were less variable than the potential payoffs of $3.85 or $0.10 in the "risky" option B. The probabilities were explained using throws of a ten-sided die, and ranged between 1/10 and 10/10(sure win). Holt and Laury (2002) controlled for wealth effects between the high and low real-payoff treatments, by subject being required to give up what they had earned in the first low-payoff task in order to participate in the high-payoff decision. Results from Holt and Laury (2002) showed that most subjects chose the safe option when the probability of the high payoff was small, and then "crossed over" to option B, almost never returning to A. A few more returned in the hypothetical treatment. Once again, the subjects showed increasing degrees of risk-aversion in the high-payoff treatments than the low-payoff treatments.

This result is qualitatively similar to that reported by Kachelmeier and Shehata (1992) and Smith and Walker (1993) in different choice environments. The results indicate that most individuals are risk averse with little variation according to personal characteristics, although wealth has a slight negative effect on risk aversion especially at low pay offs (Holt and Laury, 2002). Distribution of risk aversion was more widely spread at low levels and for hypothetical gambles, suggesting at higher pay offs one is more likely to elicit true risk preferences. The results support the hypothesis of increasing partial risk aversion with increasing payoff levels similar to Bas-Shira *et al*. (1997).

3.15.2. South African research on farmers risk preferences

The first study on risk preferences of South African farmers was done by Lombard and Kassier (1990). Using the interval approach to measuring risk attitudes, they elicited the risk attitudes of 52 farmers in the Western and Southern Cape. The concept of generalised stochastic dominance was used in the interval approach developed by King and Robison (1981) to elicit the risk attitudes of farmers at five different after tax net income levels of –R5000, R15 000, R53 000, R70 000, and R110 000. Risk attitudes were measured using the Arrow Pratt Absolute Risk Aversion coefficient on a sixteen point scale ranging from -0.001 to 0.01 for each of the income levels. A comparison of the empirical measures of risk aversion obtained from studies by Officer and Halter (1968); Halter and Mason (1978); Lin, Dean and Moore (1974) reveals that Arrow-Pratt coefficients, r (·), have ranged from -. 0002 to .0012 for the farmers surveyed.

Lombard and Kassier (1990) found that the degree of intertemporal stability in risk attitudes varied between the specified income levels and there seemed to be a negative relationship between the accuracy of the risk interval on the one hand and the consistency of choice on the other hand. The response to two control questions indicated a varying degree of consistency at each income level. Risk averse, risk seeking and risk indifferent attitudes were observed (Lombard and Kassier, 1990).

Meiring and Oosthuizen (1993) measured 34 irrigation farmers' absolute risk-aversion coefficients by means of the interval approach. The study was carried out in the area of the P.K. le Roux dam (Vanderkloof Dam), Northern Cape, South Africa. Meiring and Oosthuizen (1993) analysed the influence of adjustment of the absolute risk-aversion scale, as well as the width of cumulative distributions on respondents' risk-preferences. The consistency of risk-attitudes was also determined. Results of the elicitation of risk preference by Meiring and Oosthuizen (1993) established that the majority of farmers in Vanderkloof revealed extreme risk-preferences: either risk-seeking or risk-aversion. They further established that, the decision makers who completed the questionnaire at the higher levels of bank balances were significantly more consistent than those who completed the questionnaire at the lower levels. If the width over which the distributions extend, increases, the preferences of a few farmers tends to change from risk-neutral to risk-averse. This study by Meiring and Oosthuizen

(1993) concluded that by propagating the concept of probability distributions for the evaluation of risky alternatives, a better understanding of risk and risk management can be brought about, which will result in easier obtaining of risk measuring results.

The risk preference for irrigation farmers in the Winterton area of South Africa was elicited by Botes, Bosch and Oosthuizen (1994). The aim was to measure the absolute risk aversion coefficients of irrigation farmers in the Winterton area and establish if these were significantly affected by annual income and wealth. A similar methodology was used to that by Meiring and Oosthuizen (1993) to elicit risk preferences. Risk intervals were selected and adjusted for the scale of currency as outlined by Raskin and Cochran (1986). This produced risk intervals in the range of -0.00030 to 0.00170. The study concluded that decision makers became more risk averse when wealth instead of annual income is at stake. Risk aversion coefficients measured at low, medium and high annual income and wealth levels, showed no change when annual income or wealth levels increased and the majority of irrigation farmers had risk neutral annual income and wealth risk preferences (Botes, Bosch and Oosthuizen, 1994). This study is important because adjusting Arrow-Pratt Risk Aversion for the comparison of income and wealth risk preferences is essentially the first attempt in literature to adjust Arrow-Pratt Risk Aversion for the range of data.

A direct elicitation of utility approach was used to measure risk preferences of commercial sugar cane farmers in the UMzimkhulu, Sezela and Eston sugar mill areas of KwaZulu-Natal (Ferrer *et al*., 1997). Arrow- Pratt Absolute Risk Aversion coefficients were elicited and adjusted for both range and scale of the data, to allow both inter and intra study comparisons of risk preferences. A total of 53 farmers surveyed of which 57.2% were risk averse, 29.6% risk neutral and 13.2% risk preferring. Ferrer *et al*. (1997) found that on average the farmers in the study were risk averse although risk preferences varied significantly amongst individuals. Regression analysis further indicated that on average sugar cane farmers are averse to a possible loss in wealth relative to initial wealth and they exhibit increasing absolute risk aversion although at a decreasing rate with increasing gamble range (Ferrer *et al*., 1997).

3.16. Chapter summary

This section commences with an introductory background to risk in agriculture and its effect on people‘s livelihoods. The importance of risk in agricultural economics research is argued due to the fact that risk and uncertainty are quintessential features in agriculture. These terms are closely entwined and central to any decision making framework. The different opinions on the importance of risk and uncertainty to the decision maker and in agricultural production are presented as argued by the various authors. The section proceeds to review studies dealing with the type and sources of risks in agriculture broadly categorized into business and financial risk. These are defined in detail. A review of empirical studies on farmers risk sources globally and in South Africa is presented. The findings suggest that risks and management responses vary across geographical regions and farm types. As a result, risk modeling should be adapted to the unique conditions of the domain being investigated and go beyond price and yield risks. As a minimum requirement, production (including inputs), marketing, and financial considerations must be integrated into a realistic decision making framework (Patrick *et al*., 1985). The agricultural risk management strategies are aimed at mitigating against risk faced by farmers. The literature established that risk management options include 1) reducing the exposure of the farm business to risk, 2) transferring risk to another party; or 3) improving the farmer‘s capacity to bear risk.

A conceptual model for risk preference analysis is outlined as most models of decision making under risk require the knowledge of the decision makers risk preference. Bernoulli models and Expected utility (EU) models are presented and their pros and cons articulated. The definition of risk aversion by Friedman and Savage (1948) in reference of Von Neumann-Morgenstern expected utility function is outlined as is the measures or risk aversion by Arrow (1971) and Pratt (1964). They independently developed equivalent measures of risk preferences that allow for comparisons of interpersonal preferences. These are absolute risk aversion, relative risk aversion, partial risk aversion and the Arrow-Pratt Absolute Risk Aversion coefficient. The case for and how to adjust the ARA for the range and scale of the data is also presented due to the importance of reporting risk preferences in a consistent manner such that studies can easily be compared to one another.

Elicitation procedures are categorised as experimental methods (EM), direct elicitation of utility (DEU) approaches, and econometric methods. The EM and DEU approaches are advanced over the econometric approach in that the researcher can design experiments where many of the features are under the control of the experimenter and suited to the area under study. The section is concluded by a review of the four studies in South Africa that have previously elicited risk preferences. However all these studies have focussed on the risk preferences of large scale commercial farmers.

CHAPTER 4

ADOPTION OF AGRICULTURAL TECHNOLOGY

4.1. Introduction

The focus on investment in agricultural productivity and research in Africa has focussed on the adoption of sustainable approaches such as organic agriculture. Its identification as a developmental pathways aims to improve rural livelihoods. This chapter reviews relevant literature on agricultural technology adoption behaviour and diffusion, presenting studies that analyse agricultural technology adoption and its determinants. It commences with the basic concepts and theoretical foundation of technology adoption delving into the adoption/ diffusion model as studied by several economist, anthropologists, sociologists, educationists and marketers. A critique is given of the factors affecting adoption of agricultural technologies and the findings of various studies with reference to farming are presented. The mode and sequence of agricultural technology adoption is examined as are the barriers to technology adoption as outlined by various authors. Finally the different measurement approaches to technology adoption are examined.

4.2. Basic concepts and theoretical foundation of technology adoption

The term adoption refers to the process an individual passes through since he or she first hears of an innovation (technology) until it starts to be used on a continuous basis (Rogers, 2003; Gatignon and Robertson, 1991). Mahajan and Peterson (1990) define a technology as any idea, object or practice that is perceived as new by the members of a social system. Innovations are classified into product and process innovations. A product innovation is an end product for consumption while a process innovation is an input to a production process (Rogers, 1983). The agricultural technology considered in this study falls in the second category. In this study the terms technology and innovation are used interchangeably. A social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. A social system encompasses individuals, organisations, or agencies and their adoption strategies (Knudson, 1991; Rogers, 1983).

A distinction must be made between the individual adoption by a firm or farmer and the aggregate adoption or diffusion. Feder, Just and Zilberman (1985) defines the level of adoption as the degree or intensity with which a new technology is used when the farmer has complete information about it. Such intensity can be measured as the amount of use of that technology or as whether the farmer uses or not the technology. Adoption is the outcome of a dynamic decision-making process that includes learning about the technology through the collection of information or the experimentation (Feder, Just and Zilberman, 1985).

The term diffusion‘ refers to the level of aggregate adoption of a given technology or innovation within a social system in a specific moment in time. The proportion of adopting individuals or firms is a measure of the degree of spread or diffusion of that technology in that moment (Karshenas and Stoneman, 1995; Feder and Umali, 1993). Most studies on the issue analyse the pattern of the aggregate adoption over time to identify the specific trends in the cycle of the diffusion of the technology. The effect of technological change on the state of this system depends, finally, on the degree to which innovations are transmitted, with technological change being the main contributor to economic growth (Stoneman, 1986) Thus, it is important, from a policy perspective, to understand which factors affect the adoption rate of a particular technology. The economic literature on technological innovation adoption has developed along two different lines to explain why some farmers adopt while others do not. One path uses individual-level discrete choice models (Moreno and Sunding, 2005; Foltz, 2003) while the other uses aggregate models describing the adoption process of a technology and its possible future evolution (Knudson, 1991; Fishelson and Rymon, 1989). Conceptually, the latter are just an aggregation of the former, over individuals and time.

Technologies play an important role in economic development (Caerteling, Di Benedetto, Dorée, Halman and Song, 2011; Wang, Chien and Kao, 2007; and Martins and Marques, 2006). In agriculture, among the most frequently advocated strategies for climate adaptation and economic development is technology research and development (Rosenberg, 1992; Houghton, Jenkins and Ephrams, 1990). There is a strong belief in the ability of technology to continue to provide farmers with the needed strategic and tactical options for handling future environmental problems and uncertainties (Bidabadi and Mashemitabar, 2009; Popp, 2006). Such views are understandable, given many well-documented examples of induced innovation in agriculture, where progress in basic research and technology development has been linked to economic and social stimuli (Hayami and Ruttan, 1985). Induced innovation is one of the foundational economic theories of technical change. First proposed by Hicks (1932), it asserts that changes in relative prices of factors are expected to induce development and implementation of new technology to save relatively more expensive factors. It explains the nature of technical change by justifying impacts of research investments and provides a systematic theoretical basis for productivity growth. Since empirical research on the Induced Innovation Hypothesis (IIH) (Hayami and Ruttan, 1970) began it has been tested in many countries and industries.

Technological change can lead to productivity growth by either expanding the total output or increasing application of the relatively cheap inputs and trimming down use of the more or less expensive inputs. The direction of technological change in agricultural production has been the subject of intense research efforts over the last thirty years (Huffman and Evenson, 1993). This topic is frequently studied in two different ways. One is to consider the effects of investment in research and development on technological change (Alston, Craig and Pardey, 1998; Evenson, 1993; Evenson and Mckinsey, 1991). The other is to explain technological change by testing the induced innovation hypothesis (Baldi and Casati, 2005; Hockmann and Kopsidis, 2005; Clark and Youngblood, 1992; Kawagoe, Otsuka and Hayami, 1986; Binswanger, 1974; Hayami and Ruttan, 1970; Hicks, 1932).

4.3. Factors affecting adoption of agricultural technologies

Technological change has been a major factor shaping agriculture in the last 100 years (Cochrane, 1979; Schultz, 1964). The uptake of new technologies or farming practices has attracted considerable interest over the years. Hence, there is a vast literature on the adoption and diffusion of technologies in agriculture (Feder *et al*., 1985). Nevertheless, the majority of these studies tend to focus on the classic comparison between adopters and non-adopters of a technology (e.g. Dadi, Burton and Ozane, 2004; Burton, Rigby and Young, 2003; DeSouza, Young and Burton, 1999), with very few empirical studies investigating differences between early and late adoption of new technologies in general and organic farming in particular.

In order to understand what causes or constrains the adoption of new technologies, several researchers have examined the influence of various determinants on adoption decisions. Hence, there is a vast literature on technology adoption in agriculture. However this is mainly based on the classic comparison between adopters and non-adopters (e.g. D'Emden *et al*., 2006; Dadi *et al*., 2004; Sheikh, Rehman and Yates, 2003; Feder and Slade, 1984). Compared to the large amount of literature on technology adoption, few empirical studies distinguish between early and late adopters, despite differences among adopter groups over time being well acknowledged in the literature (Feder *et al*., 1985). One of the few examples is a study by Barham, Foltz, Jackson-Smith and Moon (2004). The authors explore agricultural biotechnology adoption of Wisconsin dairy farmers and distinguish among non-adopters, early, late and dis-adopters. Their results show, for example, that attitudes toward the technology and location are linked to early adoption, while farm size and complementary technology are important factors for all adopter groups. Further, Diederen, van Meijl, Wolters and Bijak (2003) considering a range of innovations, investigate differences between innovators, early adopters and laggards utilising Dutch data. The findings of this study indicate that structural and socio-demographic characteristics explain the difference in adoption behaviour between early and later adopters, while information gathering and active involvement in the development of the new technology explain differences between innovators and early adopters.

So far, the only empirical contributions looking at early and late adopters of organic farming are by Best (2008) and Flaten, Lien, Ebbesvik, Koesling and Valle (2006). Flaten *et al*. (2006) compare farm and farmer characteristics, as well as goals and motives of Norwegian early, mid and late adopters of organic farming. In addition to differences in farming practices between early and later adopters, their results reveal changing motives for conversion over time. Best (2008) compares early and late adopters of organic farming in Germany and test the conventionalization hypothesis‖ meaning that organic farming is developing into a modified version of conventional agriculture. His results indicate a development towards more specialized farms, but most farmers still express a high level of environmental concern. Although Best (2008) and Flaten *et al*. (2006) provide good insight into the adoption process over time, both studies are exploratory in nature, and focus on differences between organic farmers, rather than investigating differences in the adoption between the groups.

Many studies that have evaluated the factors affecting adoption of new agricultural technology include Baidu-Forson (1999), Hassan, Kiare, Mugo, Robin and Labosa (1998), Nkonya, Schroeder, and Norman (1997), Adesina and Baidu-Forson (1995), Feder *et al*. (1985) and Shakaya and Flinn (1985). Most of these studies focus on the relation of key variables to the adoption behaviour of farmers. Similarly, there has been a growing body of research interest in the economics of technology adoption, yielding literally hundreds of publications. Of these many studies, some have examined the possible determinants of technology adoption using survey results (example Roberts, English, Larson, Cochran, Goodman, Larkin, Marra, Martin, Shurley and Reeves, 2004; Batte and Arnholt, 2003; Daberkow and McBride, 2003; Arnholt, Batte and Prochaska, 2001), while others have investigated the need for suitable econometric methods to account for the interrelationships among adoption decisions, causing selectivity biases (example Roberts, English and Larson, 2002; Fernandez-Cornejo, Daberk ow andMcBride, 2001; Khanna, 2001; Napier, Robinson and Tucker, 2000; Traore, Landry and Amara, 1998; Dorfman, 1996).

Existing literature shows that adoption of organic farming by farmers is influenced by personal attributes of the farmer, farming systems and resource characteristics, institutional, infrastructural and environmental factors (Padel, 2001; Rigby, Young and Burton, 2001; Jha and Hojjati, 1994). In line with this, attitudes and preferences are important determinants of adoption decisions (De Cock, 2005; De Souza, Young and Burton, 1999; Ajzen and Fishbein, 1977). Personal attributes of the farmers include age, education level, sex. Farming systems and resources constraints comprise cultivated area, family size, availability of appropriate inputs example seed, equipment, machinery and the liquidity position of the farmer. Institutional and infrastructural factors example laws and regulations governing the supply and accessibility of credit, extension advice, training and input markets. Environmental factors give farmers and input suppliers‘incentives to participate in a given new technology subject to expected gains.

4.3.1. The impact of age in technology adoption

Age is a primary latent characteristic in adoption decisions. However there is contention on the direction of the effect of age on adoption. Age was found to positively influence adoption of sorghum in Burkina Faso (Adesina and Baidu-Forson, 1995), and Integrated Pest Management on peanuts in Georgia (McNamara, Wetzstein and Douce, 1999). The effect is thought to stem from accumulated knowledge and experience of farming systems obtained from years of observation and experimenting with various technologies. In addition, since adoption pay-offs occur over a long period of time, while costs occur in the earlier phases, age (time) of the farmer can have a profound effect on technology adoption. Hossain, Alamgir and Croach (1992) revealed that the probability of adoption of new farming practices increased with age among farmers in Bangladesh. Similarly Bembridge (1991) in his study focusing on maize technology transfer in a typical homeland maize-growing area in South Africa established that thirty per cent of producers were over 60 years of age.

Conversely age has 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, 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. Freud, Phillipe and Jacques (1996) in Cote d‘Ivoire found that the farmer‘s age and adoption of modern varieties of cocoa were not related. Similarly, studies on adoption of BT Cotton in South Africa by Gouse, Kirsten and Jenkins (2003), land conservation practices in Niger (Baidu-Forson, 1999), hybrid Cocoa in Ghana (Boahene, Snijders and Folmer, 1999), rice in Guinea (Adesina and Baidu-Forson, 1995), fertilizer in Malawi (Green and Ng'ong'ola, 1993) and established that age was either not significant or was negatively related to adoption.

Older 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, Fuglie, Ingram, Jans and Kascak, 2001; Khanna, 2001). Furthermore, elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt an income –enhancing technology. As a matter of fact, it is expected that the old that do adopt a technology do so at a slow pace because of their tendency to adapt less swiftly to a new phenomenon (Tjornhom, 1995).

4.3.2. The effect of gender on technology adoption

Effective application of agricultural technologies in production has strategic gender implications. The productivity of labour will be altered depending on accessibility of the technology between men and women. In many small-holder farms, technology is mostly at the disposal of men whereas women contribute 70% of agricultural production (Lubwana, 1999). With reference to gender and technology, the questions that arise are whether the technologies are gender neutral or hindering women participation or not addressing a gender concern. Though technologies gender neutral, they often become biased towards one gender during project formulation and implementation. This is because of the disjuncture between the planners and the used of the technology.

Sheng (1989) states that though research has been conducted on various conservation tillage technologies to increase production, many times they have not all been adopted. The social and economic conditions in which the activity is being carried out determine the lack of neutrality in the process of technology selection and adoption. The lack of neutrality is apparent not only from the social and economic perspective, but to a much greater extent, from the perspective of gender in that, no account is taken of who participates in the production process and to what extent. Technology offers women new opportunities to close the gender gap in physical strength. The utilisation of technology in developing human and material resources can be dramatically enhanced when women are included, since they are responsible for 50 - 60% of agricultural production and most domestic tasks (Sheng, 1989). In most African social contexts, women have limited access to resources, especially land and to information and new technologies.

There are several empirical studies that have been conducted on the effect of gender to technology adoption. Doss and Morris (2001) found no significant association between gender and the adoption of improved maize technology among rural farmers in Ghana, although the gender of the household head was important. Phiri, Franzel, Mafongoya, Jere, Katanga, and Phiri (2004) showed that the adoption of improved fallow practices among poor households in Eastern Zambia is gender-neutral. Essa and Nieuwoudt (2001) in KwaZulu-Natal showed that male farmers tend to adopt hybrid seed maize and fertilizer. The argument advanced is that constraints to women adopting technology include socially conditioned inequalities in the access, use and control of resources and credit. They also reported a positive association between the adoption of maize growing and the presence of male decision makers among small scale farmer support programs in South Africa. Similar findings were reported by Semgalawe (1998) on the adoption of soil conservation programmes in Tanzania.

4.3.3. The impact of education and training in technology adoption

Development of the educational level of a population is required if countries have to domestically produce, adapt, transfer and receive new technologies. According to Lyne (1985), improved education services enhance the adoption of new farm technologies in KwaZulu-Natal. Venter, Vink and Viljoen (1993) came to the same conclusion, namely that the low level of educational training is the most limiting factor on technology adoption among small-scale commercial farmers in Venda. Studies that have sought to establish the effect of education on adoption in most cases relate it to years of formal schooling (Feder *et al*., 1985; Tjornhom, 1995). Generally education is thought to create a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Caswell *et al*., 2001) on adoption.

Education is thought to reduce the amount of complexity perceived in a technology thereby increasing technology‘s adoption. Barrett and Moser (2003) in Madagascar, Semgalawe (1998) in Tanzania, Strauss, Bardosa, Thomas, and Gomes (1991) in Brazil, Kebede, Coffin and Gunjal (1990) in Ethiopia and Feder *et al.* (1985) found that education is an important determinant of production efficiency and technology diffusion. 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 adopting appropriate farm practices (Saha, Love and Schwart, 1994a; Lindner, 1987). When technology is new and widely profitable, farmers‘ schooling may increase the probability of adoption as it enhances their ability to acquire, interpret and use information about such technology. Hollaway, Shankar and Rahman (2002) postulate that education can encourage new technology adoption by lowering learning costs or it may discourage adoption since education provides more profitable off-farm employment opportunities and new technologies may reduce the ability of farm operators to substitute their time inputs away from cultivation.

However the level of education required for technology adoption is also dependent on the level and complexity of the given technology. Low levels of education can be accompanied by training on a given technology to improve its adoption and transfer. According to Peres (1997), the programme to develop entrepreneurship abilities in rural youth, PROJOVEM was geared towards small scale farmers in Latin America with low level of education. The programme was implemented in Brazil in the beginning of 1997 with the main aim to prepare rural youngsters to manage small farms in a competitive and sustainable way and thus increase the level of income of their families. This programme also comprises the adoption and correct management of new technologies (Peres, 1997). Training is one of the most critical factors of the technology transfer process. Stroebel (2004) stated that training to enhance the technology transfer and adoption programmes at the sheering sheds in QwaQwa, played an important role in training the small ruminant farmers in the correct use and adoption of medication technologies. This technology does not require high education levels. Nagy, Sanders and Ohm (1988) pointed out that one of the important sections of a support programme for technology adoption is farm management training and demonstration. There are many technologies available that do not require formal or high educational level. In these cases training projects are needed to develop the desire for new technologies and its implementation by the farmers (Abdulai, Owusu and Bakang, 2011; Bucciarelli, Odoardi and Muratore, 2010).

4.3.4 Role of household size in technology Adoption

Family labor is one of the most important inputs to smallholder farm production (Byerlee and Collinson, 1980; Ruthenberg, 1976; Schultz, 1964). Farmers with limited resources often struggle to supply sufficient labor to meet periodic labor demands that arise from seasonal-specific cultivation patterns (Collinson, 2000; Gill, 1991; Delgado and Ranade, 1987). By requiring labor inputs at different times, a management strategy of crop diversification can lessen short term labor scarcities. Nevertheless, peak labor demands often persist and limit agricultural production and associated earnings of the entire farm household. Whereas some technologies save labour for the adopting household, others require additional labour. Labour saving technologies such as a piece of machinery is more likely to be adopted by households that benefit from saving labour. This could be because labour is sparse and local wages are high or more likely because labour market problems make it difficult to hire extra labour. Labour-intensive technologies, on the other hand, are more likely to be taken up if hired labour is abundant and cheap, or if opportunities for household members to seek non-farm employment are artificially depressed. Organic farming is generally labour-intensive, involving more manual labour and less mechanization.

The perceived lower costs of household labour as compared to hired labour are due to the fact that hired labourers have less incentive to work hard than do family labourers, because they are not consumers of the output. This means that the household may have to invest in supervising hired labourers, which can results in even greater costs (Wubeneh and Sanders, 2006). Together, these labour market problems may prevent households from adopting agricultural technologies that are beneficial in terms of yields and prices, but which require additional labour. Besides the fact that rural labour markets often place costs on agricultural households, they are also typically seasonal, with all households requiring labour inputs at the same time. This further emphasizes the benefits of household labour. The periods of high demand and wages often coincide with the planting season when food resources are scarce, farmers without access to household labour will be deterred from investing in new technologies at pla planting time. Family size has been identified as positively associated with the adoption of animal traction in Burkina Faso (Kimseyinga and Kyosti, 1998) and the adoption of new agricultural technologies in Ethiopia (Kebede *et al*., 1990), as larger rural households have relatively more labour resources. Organic farming is a labour intensive technology, implying that households with more people available for family labour are more likely to use the technology. Conversely, Shakaya and Flinn (1985) found that family size did not influence the adoption of rice varieties in Nepal.

4.3.5. The relationship between farm size and technology adoption

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 technology adoption 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 analyzed in many adoption studies (Nkonya *et al*., 1997; Adesina and Baidu-Forson, 1995; Green and Ng'ong'ola, 1993; Shakaya and Flinn, 1985). This is perhaps because farm size can affect and in turn be affected by the other factors influencing adoption. In fact, some technologies are termed scale-dependant‘ because of the great importance of farm size in their adoption (Doss and Morris, 2001; Boahene, *et al*., 1999). Rogers (1983) concluded from adoption research that earlier adopters have larger operations than later adopters. In contrast in most countries, the average farm size of organic farms was smaller than conventional farms (Harris, Lloyd, Hofny-Collins, Barrett, Browne, 1998). This pointed to the importance of small subsistence holdings in the organic sector.

There are two schools of thought concerning the effect of adoption on agricultural technology adoption. The relationships between farm size and intensity or farm size and technology adoption are still debated on the academic arena. Two paradigms address this issue as illustrated in Yesuf and Kohlin (2008): one is Boserupian theory which argues that due to population pressure, small farms lead to intensive use of land through adoption of new technologies; and the second is new-Malthusian group, which argues that population pressure leads to the cultivation of marginal lands, and then degrade the land. The impact of farm size on respect to technology adoption can be positive or negative. The first school of thought argues that small farmers utilize the limited resources more efficiently and adopt new technologies at a faster rate (Allaudin and Tisdell, 1988a; Ahmed, 1981; Barker and Herdt, 1978). Schultz‘s (1964) poor but efficient hypothesis that small farmers in traditional agricultural settings are reasonably efficient in allocating their resources by responding to price incentives‖ can be fairly considered as one of the enduring themes in rural development economics over the past three decades. Although challenged from some fronts (Duflo, 2006; Ray, 2006; Ball and Pounder, 1996) it has been widely accepted by both economists and policy makers (Abler and Sukhatme, 2006; Ruttan, 2003; Nerlove, 1999; Stiglitz, 1989; Hayami and Ruttan, 1985).

The second school of thought argues that land size positively influences adoption as large farmers generate more income which provides a better capital base and enhances risk-bearing ability (Shiyani, Joshi, Askon and Bantilan, 2002; Sarap and Vashit, 1994) and that smaller farms have less incentive to adopt new technologies compared to larger farmers who benefit from economies of scale (Huffman, 1974). It is often hypothesized that small farms could limit adoption due to high fixed costs especially for tractors, tubwells and oxen and tend to adopt more slowly than large farms. Similarly, Latt and Nieuwoudt (1988) found that the adoption was higher on relatively large farms and in more fertile areas in a study in three rural regions in KwaZulu-Natal. Farmers with larger plots were able to sell more produce and they made more use of improved technologies. Swanepoel and Darroch (1991) came to the same conclusion from research done in the same province, as they found that the adoption of new technology packages were higher among farmers who belong to older clubs, have less formal savings, receive more visits from extension officers, have larger farm sizes and a higher rand monetary value on livestock. They concluded that larger farms reduce transaction costs, which increases the economic advantage and incentives of new technologies.

4.3.6. Function of liquidity and income in technology adoption

Past studies (Langyintuo and Mekuria, 2005; Smale, Just and Leathers, 1994; Adesina and Zinnah, 1993) have shown the significant influence of income on the adoption of improved agricultural technologies by smallholder farmers in developing countries. Access to cash which promotes adoption of risky technologies through the relaxation of liquidity constraints as well as boosts the household‘s risk bearing ability (Hardaker, Huirne and Anderson 1997) is hardly available to resource poor farmers for varied reasons (Langyintuo and Lowenberg-DeBoer, 2006). It is argued that the profitability of a scale neutral technology such as improved seed will induce farmers to sell their productive assets (e.g. motorcycles, bicycles, radios, etc.) to generate sufficient cash to purchase the necessary inputs (Feder *et al*., 1985). Primarily due to the disproportionate distribution of productive assets among households within a community, one would expect adoption behaviors to differ across socioeconomic groups.

Farm income may affect adoption positively or negatively depending on its‘relative contribution to household income and/or farm profitability. Farmers with relatively more wealth and liquidity may be better able to finance the adoption of technologies (Essa and Nieuwoudt, 2001) and appropriate farming practices (Strauss *et al.,* 1991). Wealthier farmers are better able to bear risk and, therefore more likely to try new technologies (Doss and Morris 2001). Nassif (1999) in Morocco, Shideed (1999) in Iraq and Kebede *et al.* (1990) in Ethiopia found a positive significant relationship between income and technology adoption. According to Gardner and Rausser (2001), both the rate and extent of diffusion are positively related to changes in the income from the technology. The existence of agricultural income sources could allow farmers to better manage the costs of some technologies such as fertilizer costs, labour and equipment. Iqbal, Ireland and Rodrigo (2005) in Sri Lanka found that farmers who were likely to adopt intercropping are those who rely principally on their own farm enterprise for their income. Non-agricultural incomes on the other hand can reduce risk associated with the trial of new technology.

Langyintuo and Mungoma (2008) showed that the relationship between wealth and technology adoption, using data from households in Zambia proved that within any given farming community, households on the upper part of the wealth continuum are most likely to adopt new technologies because of their secure economic positions. Those on the lower wealth continuum, on the other hand, may be willing to adopt because of their greater desire for upward mobility in the economic group but are unable to invest in new opportunities and therefore lowest in terms of adoption of new techniques. Conversely, Phiri *et al.* (2004) found no barriers preventing low income households from adopting improved fallows in Zambia concluding that improved fallows are a wealth-neutral technology. Given limited off-farm employment opportunities especially in rural agricultural smallholdings, much-needed increases in household income for improving food security must come from gains in agricultural productivity through better technology and more profitable crops.

4.3.7. Role of location in technology adoption

Many of the studies of rural sociologists emphasized the importance of distance in adoption and diffusion behavior. They found that regions that were farther away from a focal point (where a technology is introduced) had a lower diffusion rate in most time periods. Thus, there is emphasis on adoption and diffusion as a geographic phenomenon. Mansfield (1963) viewed adoption as a process of imitation wherein contacts with others led to the spread of technology. However distance remains a major obstacle for adoption of technologies in developing countries.

Much of the social science literature on innovation emphasizes the role of distance and geography in technology adoption (Rogers 2003). Producers in locations farther away from a regional center are likely to adopt technologies later. This pattern is consistent with the findings by Gardner and Rausser (2001) on threshold models where initial learning and the establishment of a new technology may entail significant travel and transport costs, and these costs increase with distance. Diamond‘s (1999) book on the evolution of human societies emphasizes the role of geography in the adoption of agricultural technologies. Geography sets two barriers to adoption: climatic variability and distance.

Diamond argues that there were other geographic barriers to the diffusion of agricultural technologies. For example, the slow evolution of agricultural societies in Australia and Papua New Guinea is explained by their distance from other societies, which prevented diffusion of practices from elsewhere. It is a greater challenge to adopt technologies across different latitudes and varying ecological conditions. The establishment of international research centres that develop production and crop systems for specific conditions is one way to overcome this problem. The measures of location used in past research are varied and typically consist of dummy variables for location represented by the administrative unit or researcher estimates of distance to nearest road (Lapar and Pandley, 1999; Kaliba, Featherstone and Norman, 1997).

Case (1991) argues that ignoring neighbourhood influences not only biases the estimated parameters in standard adoption models, but also sacrifices important policy relevant information. Secondary or adoption in a locality carries forward the momentum generated by the initial investment. The size of this externality constitutes important data for policy makers operating under limited budgets and wishing to maximize returns to extension investment (Hollaway *et al*., 2002). There is prior evidence that village level synergy exists in rice-fish technology adoption in rural Bangladesh. Farmers abounded in the areas where the project was based and introduced (Hollaway *et al*., 2002). The secondary adopters committed increasing amounts of land to the new technology following positive adoption behaviours by their neighbouring farmers within a spatial radius of 2 to 3kms. Mansfield (1963) viewed the diffusion of an innovation as a process of imitation where contact with others leads to the spread of the technology.

According to Koudokpon, Versteeg, Adegbola and Budelman (1995) in South Benin and Atta-Krah and Francis (1987) in Nigeria, several research and development efforts to promote alley cropping and other agro forestry technologies have tended to focus on farmer groups or communities. A community or farmer-group approach to dissemination of information on alley cropping to farmers has advantages if farmers are in close contact with one another or reside in the same area. This allows increasing returns to scale in information dissemination. Secondly, it has economies of scope for extension agencies as they can reach a large number of farmers with different sets of agro forestry technologies. Adesina, Mbila, Nkamleu and Endamana (2000) hypothesized that the proximity of farmers to each other positively influenced the adoption of alley cropping in Cameroon. Adebayo (2009) explored the intricacies of technology adoption in rural based cassava processing enterprises in southwest Nigeria and concluded that the average distance among farmers was not significantly different among adopters and non adopters of the cassava grater. Nweke (2009) indicates that the diffusion of cassava can be described as a self-spreading innovation in African agriculture. He emphasized that the physical presence of the IITA in Nigeria was influential in the diffusion of the Mosaic Resistant TMS Varieties in Nigeria and its adoption among farmers. Such cassava cultivars represent an important contribution to Africa‘s food security, especially among the poor (Nweke, Spencer and Lynam, 2002) because the improved cultivars raised per capita output by 10% continent-wide, benefiting 14 million farmers. Notwithstanding, Nweke *et al*. (2002) show that the low adoption rates of improved technologies remain an obstacle to the fight against hunger in the continent.

4.3.8. Role of risk considerations in technology adoption

Agriculture is by nature a risky activity, and farmers‘ risk attitudes are known to deeply influence their choices, especially when dealing with a new technology (Bocque‘ho and Jacquet, 2010). It is generally understood that risk-averse farmers are reluctant to invest in innovations about which they have little first-hand experience. Binswanger (1980) found that farmers who are risk-averse will seek risk reducing strategies and technologies to adopt in their farming systems. That is why small scale farmers and emerging farmers will implement technologies that do not necessarily give maximum net returns (Dillon 1986). Sanders, Shapiro and Ramaswamy (1996) concluded that farmers who consider adopting new technologies tend to be pessimistic about possible yield gains until they have more information on the results of new technologies. Feder and Umali (1993), Leathers and Smale (1992), Tsur, Sternberg and Hochman (1990), Lindner (1987) and Lindner *et al*. (1982) acknowledge that whereas risk has often been considered to be a major factor reducing the rate of adoption of a new technology, the issue of risk in adoption has rarely been addressed adequately and strong empirical evidence to test the common view about its importance and impact has been rare and scattered. Feder *et al.* (1985) in their review of adoption literature attributed this to the difficulties in observing and measuring risk and uncertainty (Lindner, 1987; Akinola, 1986).

Some attempts to seriously investigate empirically the roles of risk and uncertainty in adoption include studies by Abadi Ghadim (2000), Smale *et al*. (1994), Kebede (1992),

Shapiro, Brorsen and Doster (1992), Marra and Carlson (1987), Byerlee and Hesse de Polanco (1986) and Binswanger, Jha, Balaranaia and Sillers (1980). Even fewer studies of risk and adoption have used direct interview techniques to investigate the effect of farmers‘ risk attitudes and perception of riskiness of enterprises on their allocative decisions (Abadi-Ghadim, 2000; Huirne, Harsh, Dijkhuizen and Bezemer, 1997; Smale *et al*., 1994; Lindner and Gibbs, 1990; Binswanger, 1980). However, with the exception of Abadi-Ghadim (2000) these studies have generally had low explanatory power.
Shapiro *et al.* (1992) showed that higher levels of adoption of double cropping were associated with higher levels of risk aversion. These findings differed from Brink and Mc Carl (1978) who found an opposite relationship for a similar sample of Corn Belt farmers and Marra and Carlson (1990) on the adoption of double cropping of Wheat/Soyabeans. Shapiro *et al*. (1992) argued that these contradictory results could be explained by noting that the sample of farmers displayed a wide range of risk preferences. They suggested that this may be related to Young‘s (1979) contention that risk preferences differ by situation and level of risk.

Kebede (1992) found that the adoption of new technologies by Ethiopian farmers was significantly positively related to their degree of risk aversion. Smale *et al*. (1994) established that Malawian maize growers‘ perceptions of the relative riskiness of new seed varieties influenced the probability of their adoption and intensity of cultivation. Smale‘s study provided strong empirical evidence to support the primarily economic character of the adoption decision and also highlighted the importance of risk in the decision process. Risk aversion tended to reduce adoption, and to a greater extent as relative riskiness and scale increased.

Binswanger *et al*. (1980) elicited the risk preferences of a sample of Indian farmers using several elicitation techniques, one of which included gambling questions with real monetary pay-offs. These methods measured farmers‘ levels of risk aversion, which were then used in regression analyses of farmers‘ adoption decisions. Statistical significance tests showed mixed results, and their findings were inconclusive with regards to risk aversion. Byerlee and Hesse de Polanco (1986) analyzed farm survey data from Mexico to investigate the reasons for stepwise adoption of components of packages of practices. Their regression model showed that adoption of each innovation was explained primarily by its profitability and riskiness. Marra and Carlson (1987) provided an empirical test of some of Just and Zilberman‘s theoretical results using farm-level data on adoption of double-cropped wheat/soybeans. They found evidence to support the fact that risk preference is likely to be limiting factors in the farm size adoption relationship.

4.3.9. Role of land tenure in technology adoption

Land rights are the backbone of a land tenure system i.e. the system of rules, rights, institutions and processes, under which land is held, managed, used and transacted (Cotula, 2006). Land rights include ownership and a range of other land holding and use rights which may coexist over the same plot of land (Hodgson, 2004). These rights may be held by individuals, by groups, or by the State. They may be based on national legislation, on customary law or a combination of both. Studies done by Hazell and Lutz (1999), Feder and Feeny (1991), Lutz and Daly (1991),Harrison (1990), Feder and Noronha (1987), Abalu (1977) have demonstrated that the rights that farmers have over natural resources can be important in determining whether they take a short- or long-term perspective in managing resources. For example, farmers who feel that their tenure is insecure, with or without formal rights are less likely to be interested in conserving resources or in making investments that improve the long-term productivity of resources. Therefore stronger land rights and presence of land title are often associated with an increased likelihood of adoption and investment in new agricultural technologies.

Fenske (2011) and Besley (1995) argue that this is far from universal and there are often divergent effects on different types of investments within the same site. Moreover, some of the results themselves, though statistically significant, would hardly qualify as important because of very low marginal impacts. According to Place (2009) and Brasselle, Gaspart and Platteau (2002), although there are strong theoretical reasons why more complete land rights are expected to enhance agricultural technology investment, empirically this link has been found to be weak. Several reasons have already been identified for this, including adequate incentives in African tenure systems, thin credit markets, endogenous tenure, failures of titling programs, and empirical difficulties

Community rights over land may discourage investment because the community fears negative externalities from investments made (Besley, 1995). This was one of the reasons the system of open fields was inefficient. Collective management inhibited the adoption of new crops and new techniques by requiring consensus (Pannell, Marshall, Barr, Curtis, Vanclay and Wilkinson, 2006). In many indigenous African systems of tenure, investment is expressly forbidden by certain tenancy contracts and is taken as a challenge to the authority of the grantor. In the case of strangers, successful innovation and investment can lead to hostility from local inhabitants (Chauveau, 2002). Similar powers taken by the state lead to analogous results. When land is ―owned‖ by the state, existing tenure arrangements may not give security to the holder, and the state can block endogenous institutional change (Hagos and Holden, 2006). While many indigenous institutions forbid holders of secondary rights from making permanent improvements, other institutional arrangements have emerged expressly for the purpose of facilitating investment, as with sharecropping in the case of Ghanian cocoa (Abdulai, Owusu and Goetz, 2008).

On the other hand, investment incentives may be sufficient even if indigenous tenure is insecure. If individuals are altruistic towards other members of the community, they may not be discouraged by the possibility that land will revert to the larger group. Similarly, if output is shared, the rest of the community should encourage investment by its individual members (Besley, 1995). In the case of tenancy contracts, the threat of eviction can be used to elicit greater effort from the tenant (Banerjee and Ghatak, 2004). Because time horizons vary greatly across types of investment, insecurity may not matter for many of these (Gebremedhin and Swinton, 2003). All else equal, we should see that the impact of insecurity on tree planting and irrigation will be more substantial than on the use of fertilizers and other inputs (Holden and Yohannes, 2002). Investment in agriculture competes with investment in capital goods, which are recoverable in the event of eviction, and with non-agricultural assets. Even given insecurity, returns in agriculture may still be higher (Hayes, Roth and Zepeda, 1997).

4.3.10. The importance of extension services in technology adoption

Studies on the effect of extension education on agricultural technology adoption include (Mariam and Galaty, 1993; Longo and Juliano, 1990). Understanding the impact of extension agencies on the adoption and diffusion of environmentally beneficial technologies is particularly important given the declining status of extension. Vanclay and Lawrence (1994) state that the entire extension apparatus in developed and developing countries is in a state dilemma due to the gradual replacement of traditional public extension services with private extension (Guerin and Guerin ,1994; Umali and Schwartz, 1994). One root of the problem is the Iongstanding relationship between extension services and the classic adoption/diffusion model (Stephenson, 2003). Both have been based on a shared set of assumptions that were highly effective at promoting the adoption of productivity-enhancing technologies but have proven inadequate to diffusing more ecologically sensitive practices. The classical diffusion model initially fostered a linear approach to the diffusion of innovations in which researchers generate knowledge which extension workers convey to producers (Roling, 1993). This approach generally provides technologies in a one size fits all fashion, with little regard to the non-technical factors that affect the adoption of innovations (Davidson and Ahmad, 2003; Adhikarya, 1996). In addition, the lack of a feedback loop tends to favor innovations generated by research institutions, largely ignoring innovations developed on-farm (Davidson and Ahmad, 2003). This approach has been largely discarded throughout the world and is widely regarded today as naıve and counterproductive.

A more participatory approach to agricultural extension emerged in the United States as well as the developing world. The power structure of partnerships among development agencies, experts, and farmers was addressed, leading to fundamental changes in the system. Through this participatory approach, a new innovation came to be viewed not simply as a new technology delivered to a target group, but as a new practice developed through exchanges of information among stakeholders (Norman and Marlon, 2000). The fundamental reasoning was that researchers could work directly with farmers to address their specific concerns. Farmers were seen more as partners who possess valued knowledge. The participatory approach allows new innovations to be continually and more easily adapted to new contexts and needs, and guides research through a stronger feedback loop (Buhler, Morse, Arthur, Bolton and Mann, 2002).

Miller, Mariola and Hansen (2008) examined the roles of extension agents on agricultural technology adoption by smallholder farmers in Costa Rica. Miller suggested that a model more appropriate to the adoption of agricultural technologies in a developing country setting should take into account institutional factors, including the mode of interaction between farmers and extension agencies. However results from this study found that EARTH University extension agents had achieved more success in promoting certain technologies, such as biodigestors and worm compost, than others such as traditional compost and agro-ecotourism. The authors concluded that simply entering a community and conducting extension outreach there will not spur the community‘s farmers to adopt en masse. On the other hand, Schuck, Nganje and Yantio (2002) examined the extent to which extension education can promote adoption of cropping systems by smallholder farmers in Cameroon. The choice of cropping system included slash and burn, multiple crops or mono-cropping. Results indicated that higher visitation rates by extension personnel reduce the likelihood of farmers choosing slash and burn agriculture.

4.3.11. The impact of social capital and cooperatives in technology adoption

Social capital refers to features of social organization, such as trust, norms and networks that can improve the efficiency of society, facilitating co-ordinating actions (Portes, 1998). Likewise, the World Bank states defined broadly, social capital encompasses the formal and informal rules that enable coordinated action and goal achievement (World Bank 2000). Parthasarathy and Chopde (2000) define social capital as the ability to develop and use various kinds of social networks – and the resources that become available thereof and is central in understanding how farm households, and the farming community in general, adopt and benefit from improved agricultural technologies. Studies have shown the importance of collective action for the successful uptake of technologies for which cooperation is a prerequisite. However the importance of collective action and the use of social capital in information flows regarding new technology options and adoption procedures, and the actual ways in which communities enhance their collective welfare as a consequence of individual farm level growth, is something about which little is known (Parthasarathy and Chopde, 2000). The authors claim that social capital in terms of increased ability and willingness to co-operate and work together for achieving common goals, and, sustaining and developing norms and networks for collective action - is crucial for successful uptake, diffusion, and impact of innovations. According to Narayan (1997) while cooperatives advised farmers of the need to incorporate pigeon pea in their crop rotations, and its sustainability capabilities, farmers also obtained knowledge of sustainable practices from older farmers in the community of Vidharbha and Marathwada regions of Maharashtra in India. Legitimacy for trying out the new option seems to have come from community elders who were critical of the new input intensive practices and advocated a return to older practices in achieving sustainability. The authors conclude that social capital is crucial in facilitating adoption, and overcoming constraints of lack of financial, human and natural capital. Collective action actually provides the means to adopt and benefit from agricultural innovations, generate economic and human capital, and make the development process sustainable (Grootaert, 1997).

Amelia, Scott, Bryan, Jinxia and Jikun (2008) analyzed traditional technologies, household level technologies and community level technologies among farmers in Northern China. The study established that the while levels of adoption of water saving technology in northern China increased due to increasing water scarcity, the extent of adoption was quite low. The authors concluded that While they did not have a definitive answer why the adoption of these technologies are higher than other types, it appears that the most successful technologies have been those that are highly divisible, low cost and do not require collective action or large fixed investments.

4.3.12. Role of livestock ownership in technology adoption

The use of compost incorporating manure is part of an organic agriculture system that emphasizes maximum reliance on renewable farm and other local resources. Compost is an organic fertilizer that has the advantage that it improves soil structure and aeration, increases the soil‘s water-holding capacity and stimulates healthy root development (Twarog, 2006). Thus, both stubble tillage and compost may be appealing options for enhancing productivity with resource-poor farmers, especially in developing countries. Escalating prices and production and consumption have been cited as among the factors limiting the use of inorganic fertilizers in Africa (Kassie, Yesuf and Köhlin, 2008; Dercon and Christiaensen, 2007). As a result traditionally, rural farmers have continued to be inclined to organic methods of production due to their low income and hence inability to afford inorganic fertilizers. Thus, given the aforementioned challenges to inorganic fertilizer adoption, a key policy intervention for sustainable agriculture is to encourage adoption of farming technologies that rely, to a greater extent, on renewable farm and other local resources. Organic farming practices, such as the use of compost, tillage and livestock manure application are among such technologies. The water retention characteristics of these technologies (Twarog, 2006) make them especially appealing in water-deficient farming areas.

In addition to reducing natural risks, organic farming practices enable poor farmers to minimize the financial risk of buying chemical fertilizer on credit and given that compost, tillage and manure are readily available, hence alleviate the prevailing problem of late delivery of chemical fertilizer (Hailu and Edwards, 2006). Manure is a major component for organic fertilisation. The main source of manure is from livestock. These include cattle, sheep and goats. Chicken manure is also commonly used in rural areas directly or as liquid fertiliser. There exists ample evidence to show that use of compost, tillage and manure can result in higher and/or comparable yields compared to chemical fertilizer (Sasakawa-Global 2008, 2004; Kassie *et al*., 2008; Edwards, Asmelash, Araya and Tewolde, 2007; Hailu and Edwards, 2006; Mesfine, Abebe and Al-Tawaha, 2005; Hemmat and Taki, 2001). This implies that these organic farming technologies can create a win-win situation, where farmers are able to reduce direct production costs, improve environmental benefits, and, at the same time, increase their crop yields.

Despite considerable empirical research and attention directed to the issues of technology adoption, a consensus has not been reached regarding the social and economic conditions that lead farmers to conserve soil. The above literature review shows mixed results on the factors that affect technology adoption and diffusion behaviour in agriculture. It does however suggest that the adoption of certified organic farming could vary across the households and that factors such as the farmer‘s age, gender, education level, household size, proportion of area planted, proportion of income from farming, input cost per hectare, location of households and the farmer‘s risk attitude should be considered in the local analysis. Chicken ownership was considered because of its significance as a source of manure in the study area.

4.4. Mode and sequence of agricultural technology adoption

In explaining the mode and sequence of agricultural technology adoption, two approaches are common in agricultural adoption literature. The first approach emphasizes the adoption of the whole package while the second approach deals with sequential adoption. Feder and Umali (1993) explored the adoption of agricultural innovations and indicated that most agricultural technologies introduced in the last three decades, particularly the high yielding varieties (HYVs) are in fact a package of interrelated technologies. Accordingly, one major focus in the literature in recent years has been the investigation of the decision-making process characterizing choice of the optimal combinations of the components of a technological package over time (Leathers and Smale, 1991).

One of the first models dealing with a technological package was developed by Feder (1982) incorporating technological complementarities and adoption under uncertainty. The study examines a case where farmers face the choice between a traditional technology (for example, a traditional crop variety) and two innovations-a divisible, scale-neutral technology (for example, a modern variety) and a lumpy technology subject to decreasing costs with respect to farm size(example the tube well). The two innovations are interrelated because potential output is higher if both technologies are adopted than when only one is adopted. Furthermore, the adoption of the lumpy technology influences the perceived risks associated with the divisible technology. Given a perceived output risk associated with the divisible technology and farmer risk aversion, farmers maximize their expected utility through the dichotomous choice of whether or not to adopt the lumpy technology and the choice of the proportion of land to be allocated to as well as the intensity of use of, the divisible technology.

Nweke (2009) indicates that until the early 1980s, Ghana‘s food policy favoured cereals because widely-believed myths about cassava discouraged the government from investing in measures to diffuse the TMS varieties to farmers. Interest in the mosaic-resistant cassava varieties was awakened by a severe drought in 1982 and 1983 when cassava survived the drought and helped people cope with food insecurity. In 1993, sixteen years after the release of the TMS varieties in Nigeria, the Government of Ghana released three TMS varieties to farmers resulting in its diffusion and adoption among farmers in the Eastern, Greater Accra, and Volta regions, where farmers prepare *gari* for sale in urban centers. The 16-year delay in Ghana illustrates the need for political leadership in promoting the adoption of new technology from neighbouring countries (Nweke, 2009).

Though new technologies are usually promoted in a package, the response of farmers is often to adopt one or more components and gradually add more components rather than adopting the whole package immediately. Sequential or stepwise adoption of parts of a technological package has been observed in a variety of settings (Leathers and Smale, 1991). The whole package may only be adopted over the period of several years. Previous research has offered a number of theoretical models to explain this adoption process. According to Feder *et al.* (1985), the conventional explanations for the sequential adoption process are lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentive associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labor shortage, chaotic supply of complementary inputs (such as see, chemicals, and water), and inappropriate transportation infrastructure.

A now old literature on green revolution technology adoption from the 1970‘s and 1980‘s analyzed package technologies, and identified sequential adoption patterns in which farmers adopted parts of the package before adopting the whole package (Leathers and Smale, 1991; Byerlee and Hesse de Polanco, 1986). These works were primarily empirical, and argued that fixed costs, credit constraints, risk, uncertainty, and learning all contributed to a sequential adoption pattern. Leathers and Smale (1991) attempted to explain sequential adoption even when farmers are risk neutral and unconstrained in their expenditures using a dynamic Bayesian model. The model demonstrates that in order to learn more about the innovation, the farmer may choose to adopt a component of the package rather than the complete package. Moreover, while early adopters may adopt only parts of a package, later adopters, whose confidence has been raised by the positive experience of their neighbors, may adopt the whole package.

Arega and Hassan (2008) measured the technical, allocative and economic efficiencies of farmers within and outside the Extension Package Program (EPP) in high and low potential agro-ecological zones in Eastern Ethiopia and concluded that in view of the significant positive interactions among components of agricultural technology packages, adoption of the whole technology package is argued to be more profitable than adopting a component or some. Nweke (1974) noted that the relative high growth rate in food grain production achieved by Ghana in 1960-1975 was made possible through the adoption of tractor mechanisation. Farmers were incentivised with tax and credit subsidies to import and own tractors. However, this increase was as a result of area expansion rather than productivity.

4.5. Induced innovation hypothesis and agricultural development

The hypothesis of induced innovation as first proposed by Hicks (1932) and later articulated by Hayami and Ruttan in the early 1970s, is a dynamic process that has earned wide recognition as a predominant economic theory of agricultural development. The most fundamental insight of this hypothesis is that investment in innovation of new technology is the function of change in resource endowment and the price of the resources that enters into the agricultural production function. This has spawned a conceptual infrastructure that addresses the broader issues of how farmers and public institutions determine priorities for agricultural production (Koppol, 1995).

According to this hypothesis, societies develop technologies that facilitate the substitution of relatively abundant factors of production for relatively scarce factors in the economy. It has been substantiated through establishing a correlation between a measure of factor scarcity and an indicator of the direction of technical change (Hayami and Ruttan, 1985). For example, the constraints imposed on agricultural development by an inelastic supply of land have, in countries such as Japan, Taiwan, Korea, and several south Asian countries, been offset by the development of high-yielding crop varieties designed to facilitate the substitution of fertilizer for land. Similarly, the constraints imposed by an inelastic supply of labour, in countries such as the United States, Canada, and Australia, have been offset by technical advances leading to the substitution of mechanical power for labour.

In Ghana, Nweke (2009) stated that the severe drought of 1882 and 1983 contributed to the adoption of the Mosaic Resistant TMS cassava variety. The Green Revolution of the 1940s to the late 70s in Latin America and Asia on the other hand was in response to food security concerns and involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers (Hazell 2009; Gaud 1968). Ndhleve *et al*. (2011) noted that the phenomenal growth witnessed in Asia and Latin America in the 1970s was linked to the Green Revolution. The call for a New Green revolution in Africa‖ is partly driven by the food crisis trap that threaten the continent that is a result of among other factors population growth outstripping agricultural productivity, changes in consumer patterns, nature‘s curtailment and political neglect, low levels of technology (Ndhleve *et al*., 2011).

In recent years the hypothesis of induced innovation has emerged as a basis for understanding potential future agricultural adaptation to climate variability and change (Gitay, Brown, Easterling and Jallow, 2001; Easterling 1996). Beddington (2011) warns that the global food system will experience an unprecedented confluence of pressures over the next 40 years. On the demand side, global population size will increase to eight billion by 2030 and on the production side, competition for land, water and energy will intensify, while the effects of climate change will become increasingly apparent. The need to reduce greenhouse gas emissions and adapt to a changing climate will become imperative. Over this period globalisation will continue, exposing the food system to novel economic and political pressures (Beddington, 2011). Any one of these drivers of change‘would present substantial challenges to food security.
Increasing the productivity of smallholders through appropriate application of good practices and improved technologies should be a priority for developing countries wishing to achieve food security. The United Nation (2010) emphasized the need to increase the growth rate of agricultural productivity in developing countries through promoting the development, dissemination and transfer of appropriate, affordable and sustainable agricultural technology while supporting agricultural research and

innovation, extension services and agricultural education in developing countries. Beddington (2011) alludes to the need to increase productivity while simultaneously conserving the natural resource base upon which future productivity increases depend.

The New African Green Revolution is currently being advanced by AGRA and the Consultative Group on International Agricultural Research (CGIAR) in order to ensure the progress made in addressing poverty and food security over the past decade are not reversed (Delgado, 2008). This challenge is made more difficult by climate change, which is expected to have significant impacts on agriculture and food production patterns, and the fact that African governments have cut back on expenditure devoted to agricultural technology adoption, development and transfer by as much as 37% from 1971 to 1991. (Ndhleve *et al*., 2011) resulting in a slowdown in productivity growth compared to previous decades. It is therefore necessary to substantially increase investments in international and national public agricultural research and development, strengthening, in particular, the Consultative Group on International Agricultural Research (CGIAR) and the national agricultural research systems. Ruane and Sonnino (2011) argue that technologies must be appropriate, accessible and adapted to the local needs of poor farmers. Preference should be given to technologies promising win–win combinations of enhancing productivity and conserving natural resources.

The CGIAR has been investing heavily in Africa over the years. In 2003, it allocated 45% of its funds, equivalent to US$180 million, to agricultural research and technology adoption projects in Sub-Saharan Africa, up from 43% the previous year (CGIAR, 2003). The New African Green Revolution‖ focuses on research and innovation of agricultural technologies that will spur economic growth through agricultural production. These include a technology package for agriculture involving the use of external inputs, massive agricultural infrastructure and high yielding seeds varieties. The emphasis is also in ensuring response to the environmental consequences. All this has been induced by the food security crisis bedeviling the continent.

4.6. Barriers to agricultural technology adoption

The adoption of new technologies in agriculture in developing countries has attracted much attention from scientists; since agriculture is an important sector in those countries and new technologies seem to offer opportunities to alleviate poverty. But the introduction of many new technologies has met with only partial success as measured by observed rates of adoption (Feder *et al*., 1985). One of the new technologies toward sustainable development is organic farming which is considered to offer more sustainable alternative to conventional agricultural production (Mader, Fliebach, DuBois, Gunst, Fried and Niggli, 2002) and has experienced considerable growth since the 1980s in many regions of the world, but the conversion to organic farming is connected with changes in farm management techniques, cognitive and psychological barriers which may pose as a challenge for some farmers (Darnhofer, Schneeberger and Freyer, 2005; Schneeberger, Darnhofer and Eder, 2002; Schneider, 2001; Hadatsch, Kratochvil, Vabitsch, Freyer, Götz, 2000).

Harris *et al*. (1998) and Lampkin (1990) have argued earlier that adoption of organic farming is not an easy option for farmers as it carries with it several barriers. These barriers could be technical, economic, social, cultural or legal (Dubgaard and Holst, 1994). Fairweather (1999) also concluded that dealing with issues of technical and economic viability of organic production more comprehensively would require farmers to overcome major obstacle for conventional producers frequently confront and could result in higher rates of conversion. Padel and Lampkin (1994) argued that conversion to organic production may be hampered by:

1. Perceptions (the image of organic farmers and the size of the market).
2. Access to technical and financial information.
3. Institutional barriers (problems in getting loans and certification constraints).
4. Social barriers (particularly in tight-knit communities).

In two studies from Switzerland and the United States, farmers mentioned the professional challenge in organic conversion, rather than problems with conventional systems (Duram, 1999; Maurer, 1997). McEachern and Willock (2000) identified naturalness, market demand and policy factors as important for the conversion decision to organic farming. Worries about weeds and other technical problems were major reasons preventing interested farmers in New Zealand from going ahead with the conversion to organic farming. According to Schneeberger *et al*. (2002), Austrian cash-crop producers hesitated to adopt organic production due to problems with weeds, diseases and insects, and additional labor requirements. Non-organic farmers also listed yield reductions, higher weed and pest infestations and more disease damage on crops as problems associated with the conversion process (Niemeyer and Lombard, 2003). One technical problem for non-organic farmers in New York was their preference of pest and disease resistant crop varieties as compared to natural seeds (Buttel and Gillespie 1988).

The certification issue is another challenge facing organic movements, especially with regards to developing countries. According to Reynolds (2004), onerous and expensive certification requirements create significant barriers to entry of poor Southern producers and encourage organic production and price premiums to be concentrated in the hands of large corporate producers. Reynolds (2004) suggests that shifting certification costs downstream and empowering local producers to fullfil monitoring tasks should reduce barriers for small-scale producers. Austrian farmers did not adopt organic practices for the following reasons: there were no compensation payments for organics and the willingness to forego net income for benefits of environmentally friendly farming was not there (Darnhofer *et al*., 2005). Loibl (1999) showed that the principal reasons given for not converting to organic farming were mainly economical, such as the lack of appropriate marketing outlets and additional requirements for labor.

Large-scale and non-organic farmers in South Africa considered fewer marketing opportunities, no premium prices and the lack of subsidies as economic factors keeping them from adopting organic practices (Niemeyer and Lombard, 2003). Also, issues related to the financial viability of organic production systems were identified as barriers for conversion to organic farming. In particular, the studies identified uncertainty over the future level of premiums (Kirner, 1999; FiBL, 1997) perception of a limited future demand for organic products (Padel and Lampkin, 1994), higher labor demands of organic systems (Kirner, 1999; Maurer, 1997), access to more market outlets (Lohr and Salomonsson, 2000; Vogel and Hess, 1996; Padel and Lampkin, 1994) and the additional investments required complying with the standards.

Furthermore, a lack of information (Kirner, 1999; Padel and Lampkin, 1994) particularly on technical issues such as alternative strategies for weed, pest and disease control (Fair-weather, 1999; Padel and Lampkin, 1994) and confusion with regards to the standards was frequently mentioned with other institutional barriers, including a lack in government's commitment (Lohr and Salomonsson, 2000; Michelsen and Soegaard, 1999; Padel, Lampkin and Foster, 1999; Padel and Lampkin, 1994).

4.7 Approaches for analysing technology adoption and diffusion

Several analytical approaches have been developed to analyse adoption and diffusion of agricultural innovations. Some are more suited and applied to adoption decisions while others model diffusion better. This section provides a review of the various analytical models developed and used to study adoption and diffusion of agricultural technologies. Non parametric approaches discussed include count data methods (Isgin, Bilgic, Forster and Batte, 2008; Lohr and Park, 2002), the use of index numbers (Kiani, Iqbal and Javed, 2008; Ehui and Jabbar, 2002) and Data envelopment analysis (DEA) (Cisilinio and Madau, 2007; Seiford and Thrall, 1990; Charnes, Cooper and Rhodes, 1978; Farrell, 1957). Others methods discussed include basic statistics (OECD, 2000; Klepper *et al.,* 1977) and participatory approaches (Hanson *et al*., 2004). Econometric techniques on the other hand have become increasingly sophisticated in ways that could not have been imagined 20 years ago (Doss, 2006). Many of the econometric approaches work to compensate for the fact that researchers are generally using cross-sectional data to address issues that are inherently dynamic. A non exhaustive discussion on the different econometric approaches is presented in 4.7.2.

4.7.1. Non parametric approaches

Lohr and Park (2002) outlined a model to describe the effects of farm level and regional variables on alternative insect management technology choice within the context of organic farming. In terms of econometric specification, they reject the Poisson model in favour of the Negative Binomial. They found that full time farming does not influence

the number of adoptions whereas years of experience and level of education are positively related.
More recently Isgin *et al*. (2008) examined the number of precision farming technologies adopted by farmers using count data methods. Using survey data of 491 farmers, they employ are Poisson and Negative Binomial count data models. Isgin *et al*. (2008) expect education to be positively related to the number of technologies adopted whereas age or other variables measuring experience do suggest a lower number of adoptions. This argument is based on the premise that there is a reduced time period over which a new technology will be rewarded. Also farmers with greater experience with existing technologies farmers may be willing to continue their reliance on existing methods and as such there may be a status quo bias. This can also be thought of as a consequence of risk aversion.

Kiani *et al*. (2008) applied the Tornqvist-Theil index (TTI) approach to measure total factor productivity (TFP) using outputs and inputs for 24 fields and horticulture crops in Pakistan. The results indicate that agricultural research expenses, number of tractors, and tubewells have positive and significant impact on TFP in the crops sub-sector. Empirical evidence showed attractive marginal rates of return to investments in agricultural research in Punjab. The study concluded that investment in agricultural research has resulted in attractive returns and recommended that supporting and further strengthening research and extension system of the province should be continued. Ehui and Jabbar (2002) argue that superlative-index based total factor productivity measures are a more appropriate technique for assessing the performance of agricultural production technologies and systems. This was based on three case studies from sub-Saharan Africa in which this approach was applied are reviewed.

Data envelopment analysis (DEA) or non-parametric frontier estimation dates back to Farrell (1957). It was operationalized by Charnes *et al*. (1978) and an overview of the method with applications can be found in Seiford and Thrall (1990). No particular production function is assumed. Instead, productivity is defined as the ratio of a linear combination of outputs over a linear combination of inputs. The main advantage of DEA is the absence of functional form or behavioral assumptions. The underlying technology is entirely unspecified and allowed to vary across firms. Cisilinio and

Madau (2007) used the Data envelopment analysis to estimate difference in efficiency and productivity between organic and conventional olive producers. Results reveal that the two groups are quite similar and that, even if organic farms still produce a lower economic value, they better compensate productive factors, especially in terms of Labour Force. Organic olive-growing farms were more able in using their disposable resources and the higher efficiency permits them to compensate the lower productivity with respect to the conventional farms. Hanson *et al*. (2004) used a series of focus groups during 2001 and 2002 to explore the risks faced by organic farmers, how they are managed them and needs for risk management assistance. Contamination of organic production from genetically modified organisms was seen as a major risk as well as inadequate crop insurance. Klepper *et al.* (1977) used basic statistics to establish the economic performance and energy intensiveness of organic and conventional farms in the Corn Belt. The results of from the preliminary study suggest that organic farming warrants more intensive research.

OECD (2000) also used basic statistics to examine the effects of prevailing agricultural support policies on the relative profitability of intensive conventional and extensive biological or organic farming practices, and provide some indications of their effects on the environment and on the demand for labour. The study found that the shift to organic farming is, on the contrary, based on pre-existing economies of scope in the form of crop rotation. The additional private costs associated with organic farming bring advantages for the community as it benefits consumers interested in finding what they see as healthy produce but also the general public, who enjoy a better environment. A more balanced system of price support and a factor-price structure more favourable to labour would better foster economies of scope, and hence encourage organic farming.

4.7.2. Econometric approaches

Econometric models, in particular the logit, probit, tobit and multinomial logit models, have been widely used to determine the composition of explanatory variables influencing the adoption process of new technologies by farmers (Shields, Rauniyar and Goode, 1993; Jansen, 1992). Literature suggests that the farm, farmer and institutional factors drive farmers to adopt new technologies (De Francesco, Gatto, Runge and Trestini, 2008; Rehman, McKemey, Yates, Cooke, Garforth, Tranter, Park, and Dorward, 2007; Hattam, 2006). Factors such as the financial and socio-economical impacts of new technologies, effects of new technologies on the risk of the farm, available resources, and technology transfer programmes also have an effect on the decision of the farmer to adopt new technologies (Feder *et al.*, 1985). When the objective is to identify the socio-economic variables that influence both adoption and intensity of adoption, the probit and the tobit models are preferred (Nichola and Sanders, 1996; Adesina and Zinnah, 1993; McDonald and Moffit, 1980). Different approaches towards adoption models that were used in the past are described by Nichola (1994). There are many econometric studies dealing with economic and environmental aspects of conversion to more sustainable farming systems such as organic farming. It is clear that the majority of the reviewed econometric studies are oriented towards supporting policy making (Feder *et al*., 1985).

A study by Workneh and Parikh (1999) used probit and ordered probit to examine both the significance of the impact of farmers' perception in adoption decisions of new technology and how perceptions are influenced by the decision to adopt new technology. The probit approach is used to analyse the adoption decision, while farmer perceptions are modelled using the ordered probit methodology since there is an ordering to the categories associated with the dependent variable (Calatrava and Gonzales, 2008; De Cock, 2005; Albisu and Laajimi, 1998). The ordered probit model assumes that there are cut off points which define the relationship between the observed and the unobserved dependent variables (Verbeek, 2008; Pindyck and Rubinfield, 1981). Belknap and Saupe (1988) used maximum likelihood to estimate a probit model relating variables to the probability that a farm operator used conservation tillage. Farmers were defined as having adopted conservation tillage if conservation tillage was used on part of the farm. Independent variables were classified as being the physical characteristics of the farm, farm business characteristics and human resources characteristics. Unlike Rahm and Huffman (1984) human capital variables were included in the adoption model to approximate psychological cost of adoption, attitudes and management objectives. Other authors that have used this methodology include Isin, Cukur and Armagan (2007) and Hattam and Holloway (2004) for the estimation of conversion to organic certification and to establish the factors affecting the adoption of the organic dried fig agriculture system in Turkey respectively.

Sinja, Karugia, Mwangi, Baltenweck and Romney (2004) investigated farmers‘ perception of technology and its impact on adoption of legume forages in central Kenya highlands by estimating the ordered probit model to assess relative importance of each attribute to the farmer. Lohr and Salomonsson (2000) focused on analysing the factors that determine whether a subsidy is required to motivate organic conversion by using a utility difference model with Swedish data. From these results Lohr and Salomonsson concluded that services rather than subsidies may be used to encourage conversion to organic agriculture. Pietola and Oude-Lansink (2001) focused on analysing the factors determining the choice between conventional and organic farming technology in Finland using a Bellman equation. The choice probabilities were estimated in a closed form by an endogenous Probit- type switching model using Maximum Likelihood Estimation (MLE).

Logistic regression was used by van Vuuren, Larue and Ketchaba (1995) to determine the impact tenant, contract and land characteristics have on adoption of farm practices that enhance productivity and environmental husbandry on rented land. The logit model was also successfully used by Parra and Calatrava (2005) to identify factors related to the adoption of organic farming in Spanish olive orchards. Rigby and Young used logit model to establish why some agricultural producers abandon organic production systems. Wynn, Crabtree and Potts (2001) aimed to model the entry decisions of farmers and the speed of entry to Environmentally Sensitive Areas (ESA) in Scotland. A multinomial logit model was used for modelling entry decisions and a duration analysis was made to quantify the relative speed at which the farmers joined the ESA scheme. They concluded that the logit and duration models were reasonably successful in explaining the probability and speed of entry to the scheme respectively.

Using discriminant analysis, Thompson (1996) identified and ranked the partial effects of the variables that distinguish lessors and lessees in KwaZulu-Natal. The results showed that the most important variable distinguishing lessors from lessees was farm size followed by liquidity. On the other hand, Cooper (1997) made an attempt to estimate the minimum incentive payments a farmer would require in order to adopt more environmentally friendly best management practices (BMPs), using contingent valuation method (CVM). Other studies have analysed agricultural technology farming adoption and its determinants using various models and methodological approaches. These empirical modelling studies show the importance of incentives and agricultural policy. They provide an understanding of the factors influencing a certain dependent variable example the factors influencing the conversion to more sustainable farming systems and the effect of different policies on the decision making of farmers. The ordered probit model has been applied in this study because of its suitability in modeling categorical dependent variables. It is an especially useful and informative approach to understand the farmers decision on their organic farming status represented by fully-adopts agricultural technology, partially-adopts agricultural technology and do not adopt agriclutral technology.

4.8. Chapter summary

This section looks at the adoption of agricultural technology by smallholder farmers. Technologies play an important role in economic development and technological change has been a major factor shaping agriculture in the last 100 years. There is a strong belief in the ability of agricultural technology to continue to provide farmers with the needed strategic and tactical options to address food security while addressing environmental concerns. The literature on innovation is diverse and has developed its own vocabulary. In this chapter the basic concepts and theoretical foundation for technology adoption and diffusion is explored with the definition by Rogers (2003) and other authors referred to. A distinction is made between individual and aggregate adoption. The induced innovation as outlined by Hicks (1932) is examined and it has been tested in many countries and industries. The categorization of adopters into innovators, early adopters, early majority, late majority and laggards are illustrated and the cumulative adoption is described as an S-shaped curve resulting from the fact that few farmers adopt the new technology in the early stages of the diffusion process and the essential differences among farmers can explain this phenomenon.

It explains the basic concepts and theoretical foundatiobn of technology adoption by smallholder farmers. It further describes the factors affecting the adoption of technology by these farmers. The mode and sequence of agricultural technology adoption is thouroughly explained and it continues to clarify induced innovation and agricultural development. Moreover, the study asses the barriers to agricultural technology and discusses the approaches to analysing technology adoption. A non-exhaustive selection of empirical research in trying to understand the determinants of farmer‘s decisions to adopt to agricultural technologies are reviewed. The review reveals that adoption by farmers is influenced by personal attributes of the farmer, farming systems and resource characteristics, institutional, infrastructure and environmental factors, attitudes and opinions. In explaining the mode and sequence of agricultural technology adoption two approaches are common in literature: the adoption of the whole package or sequential adoption. Various arguments are given for the different approaches to adoption. The barriers to adoption of organic farming are explored and highlighted as (i) perceptions; (ii) access to technical and financial information; (iii) institutional barriers; and (iv) social barriers. Finally the approaches of analyzing technology adoption and diffusion are examined which the analysis revealing that econometric models, in particular the logit, probit, tobit and multinomial logit models, have been widely used to determine the composition of explanatory variables influencing the adoption process of new technologies by farmers.

CHAPTER 5

METHODOLOGY

5.1. Introduction

This chapter describes the research methodology for data collection and analysis for the study. A description of the background of the study area in the former Ciskeis' homelands with the following sub- sections: the geographical location, history of the former homeland, demographics, natural resource base, agricultural potential and land use patterns in the area. Information on the sampling framework is presented and data methods and instruments used to obtain socio- economic, demographic, and institutional and household is described. The methodology of eliciting risk preference of sample farmers is also described using the ordered probit model. The chapter concludes by giving the empirical specifications and estimation procedures for the model.

5.2. Study area

The former Ciskei homelands are represented by the study areas of Melani village, Battlefield village and Binfield village (near Alice town) all situated in the Amatole District municipality under Nkonkobe municipality. Figure 5.1 graphically show the former homelands of the Ciskei. The Amatole District Municipality is named after the legendary Amatole Mountains (Eastern Cape Tourism Board, 2011). Amatole is a diverse district Municipality in the province. It contains the popular Metropolitan in the country, the Buffalo City Metropolitan, which includes East London, King Williams Town and Mdantsane. Two thirds of the district is made up of the former homelands areas. The Amatole Mountains that lie north- west of King Williams Town give the district its name. The well-watered coastal strip gives way to the former Transkei Hillls (ECDC, 2008b). The district has a moderate Human Development Index of 0.52. This district has over 1,635,433 inhabitants (Community Survey, 2007), and a moderately of 78 people per square kilometre. The population is mainly African with some whites and coloured. Amatole District Municipality has the second highest economy in the province. The private sector is dominated by manufacturing in the areas of motor industry, food processing, textiles and clothing

Figure 5.1 Map of the former Ciskei homelands of the Eastern Cape

The following paragraph and subsections below describe the study areas in terms of geographical location, history of the former homelands, demographics, natural resources base, agricultural potential and land use.

5.2.1. Geographical study area

The Amatole District Municipality occupies the central portion of the Eastern Cape Province(see figure 5.2. below), boarded by the Eastern Cape districts Cacadu, Chris Hani and OR Tambo, respectively to the west, north and east. The district extends over 23,577.11 km squared and includes several local municipalities and one Metropolitan (Buffalo City, Amahlathi, Nxaba, Nkonkobe, Nqushwa, Great Kei Municipality, Mquma and Mbashe Local Municipality), incorporating 21 former magisterial districts. Amatole District Municipality includes the former administrative areas of the Eastern Cape, namely former Transkei and Ciskei homeland areas and former cape provincial areas. According to the Amatole District municipality Integrated Development Plan (2011), Amatole district is classified as a category C2 municipality, indicating a largely rural character and low urbanisation rate, as well as limited municipal staff and budget capacity. Mbhashe, Mquma and Nqushwa are classified as B4 (rural mainly subsistence), and Great Kei, Amahlathi, Nkonkobe and Nxhaba as B3 (small towns, agricultural) municipalities, reflecting limited institutional capacity and areas characterised by small centres, limited Small Medium Micro Entreprises (SMMEs) and market opportunities, dependence on public support and LED activities that are principally at the level of the small project (Amatole District Municipality Integrated development Plan, 2011). Buffalo city Municipality is the category B1(secondary city) municipality in the province, reflecting relatively large budgets and staff, as well developed formal business sector and enterprises that have access to market supplied business services (Amatole District Municipality Integrated development Plan, 2011). The study will be conducted in the rural, urban and peri-urban areas of Amatole District Municipality. These are Kwezana, Tshatshu peri-urban areas around Alice Town and the rural area of Cata.

Figure 5.2 Map of the Eastern Cape Province

5.2.2. History of the former homelands of Ciskei

The former homelands were set up by the South African government prior independence for Xhosa- speaking people (ECDC, 2012). The former Ciskei was a Bantustan in the south east of South Africa covered an area of 2,970 square miles, most entirely surrounded by what was then the Cape Province, and possessed a small coastline along the shore of the Indian Ocean. Under South Africa's policy of apartheid, land was set aside for black people in self- governing territories. The former Ciskei was designated as one of two homelands or Bantustan for Xhosa speaking people. Xhosa speaker were resettled there and to former Transkei, the other Xhosa homeland. The former Ciskei had a succession of capitals during its existence. Originally, Zwelitsha served as the capital with the view that Alice would become the long- term national capital. However, it was Bisho now spelled Bhisho that became the capital until former Ciskei reintegration into South Africa.

At the end of the nineteenth century, the area between the Fish and Kei rivers had been set aside for the Bantu and was known as the former Ciskei (Cameroon, 1986). The Europeans gave the name former Ciskei to the area to distinguish it from the former Transkei, the area north of Kei. In 1961 former Ciskei became a separate administrative region and in 1972 was declared a self governing under the rule of chief Justice Mbandla and then Lennox Sebe. In 1978 it became a single- party state under the rule of Lennox Sebe and in 1981 it became fourth homeland to be declared independent by the South African government and its residents lost their South African citizenship. However, there were no border- controls between South Africa and former Ciskei. In common with other Bantustans its independence was not recognised by the international community.

5.2.3. Demographics

The population of Amatole District is unevenly distributed among seven municipalities and metropolitan city. The number of households is 458,582 (community survey, 2007). According to the Amatole District Municipality Integrated development plan (2011), the majority of its population reside within the Buffalo City Municipality (42.8%), followed by Mnquma LM (16.4%) and Mbhashe LM (16.1%). The two local municipalities with the smallest percentages of the Amatole are Nxuba (1.5%) and Great Kei (2.9%). The population density within the Amatole District municipality has steadily decreased since 2002. While the population density was 70.4 people per square kilometre in 2002, it decreased to 69.2 people per square kilometre in 2009(Amatole District Municipality Integrated Development Plan, 2011).

5.2.4. Natural resources

The natural environment of Amatole district Municipality is similarly diverse, including moist mountainous, well-watered coastal and semi- arid Karoo, thornveld, succulent and thick areas. The district includes part of the wild coast and is home to Cwebe and

Dwesa Nature reserves, and extends inland to include mountainous areas, centred on the Amatole mountain range. Amatole is the most diverse district municipality in the Eastern Cape. Two- thirds of the district is equally diverse. The climate is moderate for most of the year, but with hot periods from December to February. Although the area receives rainfall throughout the year, it is primarily a summer rainfall region, with the months of June and July being the driest and coldest. The mean annual precipitation varies from 1000mm along the coast to 700mm inland above Butterworth and 1200mm in the Amatole District is considerably dryer, with less than 500 mm per annum, than the Eastern side, which has rainfall as high as 1000 mm per annum along the coast.

5.2.5. Agricultural potential and land use

Agriculture in most part of Amatole district Municipality has not yet developed beyond smallholder farming because of constraints facing agricultural areas. The prospects of agriculture currently look dim because of the lack of inputs, resources and a lack of interest from the youth. The communal farming areas are characterised by low technical input, low cost, low yield enterprises with poor infrastructure and support services. The agricultural enterprises are very limited in their potential to increase the contribution to the Gross Domestic Product of the area due to a number of constraints. The Amatole region is characterised by diverse land use and ownership linked to natural resources as well as past political systems and boundaries. Areas of the homelands are mainly communally owned with high population densities. These exist alongside privately owned commercial farmland with much higher population densities and very different agri- enterprises.

Commercial agriculture is characterised but private ownership, larger more viable farming units, higher levels of technical input and expertise, higher cost structures, higher yields and access to better infrastructure and support systems.

5.3. Melani village

5.3.1. History of Melani village

The village is named after Melani Vela who, together with his followers fought on the side of the colonist in the last centuary and in 1866, was granted the land on which the village is situated (see figure 5.3 below). At that time 19 families were granted residential sites and 19 fields (each of 8 acres) were surveyed and issued as Quitrent land. After the group settled in Melani, other people moved into the village especially after the 1940s. From the 1960s onwards this situation changed a great deal with land scarcity increasing as people settled in the village (Manona, 2005). According to De Wet (1987), in 1963 further land shortages resulted from the implementation of the betterment scheme which decreased the amount of land available to the people. In the late 1960s increasing shortages were experienced in Melani as many landless people from white owned farms in the neighbouring districts sought and found residential land in the village. These were destitute people who had been evicted from farms or who were not satisfied with farm working or living conditions where they were before. Currently, the village population is still growing and people from outside were getting residential sites in Melani.

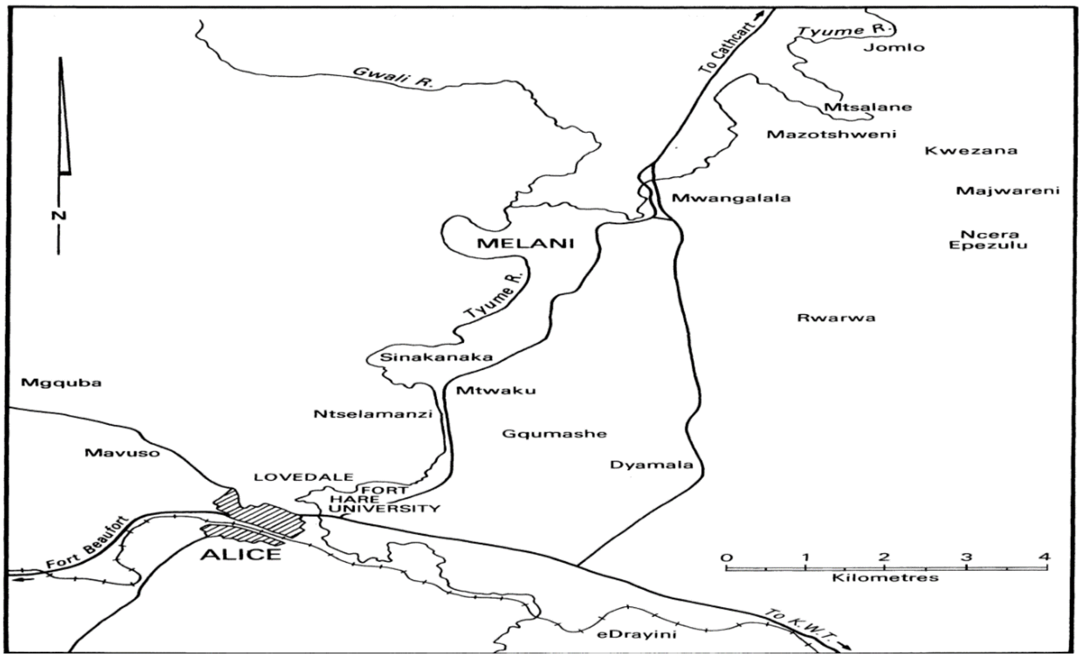

Figure 5.3 Map of Melani village

5.3.2. Agriculture and land use

Agriculture in the study area consists of crop production and stock farming under dryland conditions and under irrigation in a small government- sponsored project. A small percentage of the village residents have access to arable land. Studies conducted by Monona (1997), showed that 19 percent of the households in the area do not have access to any land, where else the other 30 percent had access to Quitrent fields of about 8 percent one morgen-plots.

5.3.3. Battle Dan irrigation scheme

In Melani there is an irrigation scheme named Battle-Dan irrigation scheme which consists of 35 ha of land. This scheme started in the 1960s when a small holding which belong to the white trader was incorporated into the village was then divided into 16 plots which were taken up by residents. These plots are located in an area that is closer to a dam. In 1974 the plot holders were motivated by an extension officer to use the local dam for irrigation. That was when they took the initiative to establish battle-Dan irrigation scheme. Some of the members pointed out that the scheme functioned fairly successfully for two years and they were able to produce a wide range of vegetables. Thereafter they were not able to access a suitable market for their produce, and they started using the land for dry land cultivation.

After 1994 the department of agriculture had a mandate to revitalised irrigation schemes and thus made a provision for irrigation facilities to the scheme. The scheme is currently producing citrus fruits, mainly oranges of which they have a strategic partner who buys from them at a certain price in bulk and sell it to the market. When they have excess produce they sell to local markets including Fruits and Veg market in Alice. The scheme has about 32 members who are actively involved in the production and has created about 19 jobs for permanent works and 10 temporary works who are mostly actively involved during picking periods.

5.4 Sampling Procedure

The selected sample comprised irrigation farmers who are involved in the production of crops, these farmers will be categorised into homestead food gardeners, smallholder irrigation farmers, and or smallholder irrigation schemes in the Amatole District Municipality. Open-ended interviews with community leaders and focus groups were used to gather information on the ideal location to carry out research because of the farming activities taking place in the area. In some cases farmers are sparsely populated. Against the foregoing background, a sample of 101 farming households was drawn from three places in the former Ciskei “homeland” of South Africa, including the Melani, Battlestan and Binfield of the Nkonkobe municipality in the Eastern Cape Province. These three villages were randomly selected from the Nkonkobe Municipality.

A total of 63 homestead food garderners and 38 smallholder farmers from each of the two production activities (homestead food gardeners and smallholder irrigation farmers) were randomly selected from the farming population of Melani, Battlestan and Binfield village. There was no specific number of farming households per location because the villages generally share the same geographical and institutional setup (Amatole district municipality Integrated Development Plan, 2011).

5.5 Data collection methods

Primary data was collected via interviews using questionnaires and situational analysis. The field work will commence with a situational analysis of the study area to acquire the general information of the Total farming population Random selection Sample institutional set-up of the area. Finally, detailed information required in the study was gathered using a structured questionnaire. A situational analysis was employed in the study to assess the local situation which helped to identify the sample population, designing of the questionnaires and feasibility of the study. The method will involve an observation of the settlement set-up of the study area.

Both qualitative and quantitative data were principally collected through questionnaires. A single-visit household survey using structured questionnaires which will cover a wide range of issues, including demographic information, risk sources, risk information, and adoption of new agricultural technology within concise a broad definition will be employed. Although Bourque and Fielder (2002) assert that questionnaires are used to collect data from people who complete the questionnaires themselves, the enumerator in this study will use the questionnaires to carry out the interviews with farmers. With the help of three enumerators, a total of 101questionnaires were used to collect data from the sample population. Unlike in a posted questionnaire, this interview process ensures direct communication with respondents. In this case, there is clarity whenever a question posed to the interview is not clear. Information from illiterate respondents is also captured using this method. An interview provides the platform to gain cooperation, hence there is minimal loss of information (Ormrod, Leedy, 2004). The method also ensures avoidance of spoilt or lost questionnaires. Timely response is also achieved using this method.

The data to be captured using questionnaires was utilised for different levels of analysis. Firstly, the data were used to describe the demographic and socio-economic characteristics of the study area. Secondly, the data was used to determine how different factors influence each other. In this regard ordered probit analysis and binary logistic regression was employed to identify variables fitted into the final model for determining the risk preferences of smallholder irrigation farmers. In the latter case (logistic model), four key production variables constituting the definition of adoption of technology were identified and each made a response variable. These variables are: education and training, household size, farm income and land tenure. Lastly, the data was used to find major sources of risk of smallholder irrigation farmers and their implication for new agricultural technology adoption. To find out key constraints affecting smallholder irrigation farmers, a review of the models and variable specifications was done.

Table 5.1: Model variables applied in the analyses

Variables	Unit	Type of Variable	Expected sign +/-
Risk	Farmers' risk attitude	Categorical	+/-
Age	Actual in years	Continuous	+/-
Sex	Sex of the respondent 0 =female; 1= male	categorical	+/-
Household Size	Actual number	Continuous	+/-
Group	Group which respondent belong to 0= homestead food gardener; 1= smallholder farmer	Categorical	+/-
Level Of Education (Leveledu)	Attended formal schooling or not 0 = attended school; 1= did not attend school	Categorical	+
Access to credit	Source of credit 0= other ;1=bank	Categorical	+
Land size (Sizeplot)	Actual size in hectares	Continuous	+/-
Land tenure (tenuresystem)	Type of tenure system, 1=own land ; 0=otherwise	Categorical	+/-
Occupation (Occu)	Employment status apart from farming 0=employed; 1= unemployed	Categorical	+/-
Years of tenure (yrsoftnr)	Number of years in farming	Continuous	+
Livestock damage crops	Farmers perceive it as a risk 0=no risk; 1= riskiness	Categorical	+/-
Financial security (Finscurty)	Farmers financial security 0= no; 1=yes	Categorical	+/-

Information on crop production (infocrp)	Information about producing crops 0=no; 1=yes	Categorical	+/-
Information on markets (Infomrkts)	Information about alternative markets 0=no; 1=yes	Categorical	+/-
Ploughing method (plghmmthd)	Method used for ploughing crops 0=hand tools; 1=own tractor	Categorical	+/-

Source: Obi, 2013

5.6 Variable specification and definition

The variables examined in the study are presented in Table 4.1. Previous research has shown that market access is strongly influenced by such factors as the physical conditions of the infrastructure, access to production and marketing equipment, and the way the marketing functions are regulated (Killick, Kydd and Poulton, 2000; IFAD, 2003).

(i) **Age:** This variable is expressed as the actual age of the household head in years. Previous studies, including Bembridge (1984), have established that this variable is a key determinant of behavioural patterns of household and community members. Younger farmers are expected to be less willing to take risks than older farmers who are perceived to have acquired experience of farming and resources. Therefore, it is hypothesized that a higher age is negatively related to risk. This is supported by an observation by Mushunje, Belete and Fraser (2003) that older farmers are likely to have more resources at their disposal, which may make them more likely to adopt to technologies more readily than younger farmers, despite being less aggressive to seek out more profitable markets. In that case, age may be related to the measure risk either positively or negatively.

(ii) **Sex:** This variable is articulated as the sex of the respondent. Studies have revealed that the productivity of labour will be altered depending on accessibility of the technology between men and women. In many smallholder farms, technology is mostly at the disposal of men whereas women contribute seventy percent of agricultural production (Lubwana, 1999). According to Doss and Morris (2001) there is no significant association between gender and technology adoption of improved maize technology among farmers in Ghana. In other words sex may or may not have any effect on farmers willingness to take risks.

(iii) **Household size:** Increase in household size might increase the dependency ratio, which in turn affects savings and investment. Conversely, a larger household may mean increased labour availability, which enhances farm production under the kind of labour-intensive farming systems that prevail in communal agriculture. In turn, increased production increases the chances of market access due to larger economies of scale. Therefore, it is possible for either positive or negative relationships to exist between risk preference and household size.

(iv) **Group:** Studies have revealed that smallholder farmers as opposed to homestead food gardeners tend to be risk takers. Homestead food garderners tend to secure food only for household consume, that is they are only concerned about food security and are only concerned about thus have no aim of profit maximisation where else smallholder are profit driven and tend to take risks to improve their produce and there is a possibility of either negative or positive relations between risk preferences and group.

(v) **Education level:** Studies conducted in several developing countries have confirmed the importance of education in the decision-making process with implications for the socio-economic development and human capital production (Schultz, 1964; Bembridge, 1984; Mushunje, 2005). For the agricultural sector, earlier studies equally established that education plays an important role in the adoption or otherwise of improved practices in traditional agriculture

(Bembridge, 1984). The absence of education is therefore expected to have a negative influence on these processes. In the light of that, it can be hypothesized that there is a positive correlation between education and risk preference.

(vi) **Years of tenure:** This variable measures the number of years a farmer has been engaged in farming. It can be hypothesized that the lesser the number of years the farmer is involved in farming, the higher the probability of being technically constrained because certain farming techniques require that the farmer possesses some degree of experience. Thus, there is a positive correlation between risk preference and farming experience.

(vii) **Access to Loans and/or credit:** This variable measures whether farmers had access to institutional finance for the facilitation of production. Foltz (2005) developed a model that links credit access with agricultural profitability and investment in Tunisia. The findings show that credit constraint negatively affects farm profitability. As Reardon, Kelly, Crawford, Jayne, Savadogo and Clay (1996) have noted, farm profitability depends on availability of markets. It can therefore be hypothesized that preference is positively correlated to access to production loans and/or credit.

(viii) **Land size:** This variable refers to the size of land in hectares. Increase in land size may enhance production if the land is effectively utilized. At the same time, land may be available but not being effectively utilized. Effective utilization will entail application of appropriate farm practices that will lead to higher physical output than otherwise would be the case. In the absence of more direct means of assessing effectiveness, this can only be inferred from the results. Intuitively, one can expect higher output if there is effective utilization of available land, and lower output otherwise. It is also reasonable to expect that the more physical output a farmer produces, the more surplus is marketed. Therefore, it is hypothesized that there is either a positive or a negative correlation between risk preference and land size.

(ix) **Occupation:** This variable measures whether the farmer is receiving off-farm income. Off-farm income can help diminish on-farm technical constraints since the farm has alternative capital inputs. Farmers who lack off-farm income are less likely to adopt to new agricultural technologies than those who have. This is also supported by Mashatola and Darroch (2003). Thus, it can be hypothesized that there is a positive correlation between off-farm income and risk preferences.

(x) **Financial security:** This variable defines whether or not the farmers have sources and security for credit.

(xi) **Information on crop production:** This variable explains whether or not farmer have acquired information on the effective crop production.

(xii) **Information on markets:** This variable explains whether or not farmers have received information on available markets for their produce.

(xiii) **Ploughing method:** This variable measure the method which is employed to plough crops.

(xiv) **Water rate**: The variable measures the amount which is paid for water by the farmers.

(xv) **Irrigation system:** This variable measures the method which is used to irrigate crops.

5.7. Data analysis model

5.7.1. The probit model

This section presents the background to the probit model as well as the mathematical representation of the model. The probit model is used to identify the determinants of farmers' decision to take risk.

5.7.1.1. Introduction and application of the model

Multiple response models are used when the number of alternatives that can be chosen is more than two. They are developed to describe the probability of each of the possible outcomes as a function of personal or alternative specific characteristics (Verbeek, 2008). Ordered response models are applied where there exists an ordered or logical ordering of the alternatives. In this case it is assumed that there exists an underlying latent variable that drives the choice between the alternatives (Verbeek. 2008). The results in this case will be sensitive to the way in which the alternatives are numbered. The modelling methodology used to establish the determinants of the farmers risk preference status is the ordered probit model.

The ordered probit is suitable for modelling with a categorical dependent variable (in this study the risk preference status). Multivariate modelling is an especially useful and informative approach to understanding the farmer‘s decision on their risk preference status. This is because multiple factors contribute to their decision on whether to take risk or not. Ordered probit is especially appropriate in this study because like Ordinary Least Square (OLS) it identifies the statistical significant relationships between the explanatory variables and the dependent variable. BUT unlike the OLS regression, ordered probit discerns unequal differences between ordinal categories in the dependent variable (McKelvey and Zavonia, 1975; Greene, 2003).

5.7.1.2. Mathematical representation of the ordered probit model

In this study, the dependent variable of the risk preference status was placed in two ordered categories in the survey. An ordered probit model is used to determine the factors that influence a farmer‘s riskiness. Based on the review of literature, the model is estimated as follows:

(1) farmers' riskiness = *f* (age, sex*, education, household size, land tenure, location, risk attitudes, type of plot, tenure system, ploughing method, irrigation system, financial security, livestock damage crops, uncertainty in climate, source of water, water rate, paying water*)

The farmer's decision on their risk preferences is unobserved and is denoted by the latent variable si*. The latent equation below models how si* varies with personal characteristics and is represented as:

An Ordered Probit model was used to meet the objective. The model is shown as follows:

$y_i^* = \beta' x_i + \varepsilon_i = i, \qquad \varepsilon \sim N[0,1]$ ---(5.1)

$y_i = 0$ if $y_i^* \leq \mu 0$

$y_i = 1$ if $y_i^* \leq \mu 1$

$y_i = 2$ if $y_i^* \leq \mu 2$

Where:

y_i^* *is* the observed counterpart of y_i^* ,

β is the vector of coefficients to be estimated,

x_i is the matrix of independent variables,

μ_j *is* the distance variable and

ε_i is the error term.

The variance of error term is assumed to be 1.00 (Greene, 2000).

The ordinal variable y_i is defined to take a value of j if y_i^* falls in the j *th* category:

$y = j$ *if* $\xi_{j-} < y^* < \xi_{j1}$ $j = 1, \ldots,$

J where ξ *' s* are unknown threshold parameters that must be estimated along with β assuming $\xi_{-1} = -\infty$, $\xi_0 = 0$ *and* $\xi_j = \infty$.

The probability of obtaining an observation with $y = j$ is equal to $Pr\,ob(y = j) = F(\xi_j - \beta' x) - F(\xi_{j-1} - \beta' x)$

where *F* is the cumulative standard normal distribution function.

The effect of the independent variable on the probability of the *j* th level is given by:∂ $Pr\,ob(y = j) / \partial x = \beta\,[f(\xi_{j-1} - \beta' x) - f(\xi_j - \beta' x)]$
where *f* is the standard normal density function (Tansel, 2002). The following model was estimated by using maximum likelihood method to have consistent and efficient parameter estimates.

5.7.2. Multinomial logistic regression model

The multinomial logistic regression model was used to test the different levels of risks, namely no risk, minor risk and severe risk as perceived by farmers in the area.

Multinomial logistic regression can be used to predict a dependent variable, based on continuous and/or categorical independent variables, where the dependent variable takes more than two forms (Hill, Griffiths and Judge, 2001). Furthermore, it is used to determine the percent of variance in the dependent variable explained by the independent variables and to rank the relative importance of independent variables. Logistic regression does not assume linear relationship between the dependent variable and independent variables, but requires that the independent variables be linearly related to the logit of the dependent variable (Gujarati, 1992). Pundo and Fraser (2006) explained that the model allows for the interpretation of the logit weights for the variables in the same way as in linear regression.

The model has been chosen because it allows one to analyse data where participants are faced with more than two choices. In this study, smallholder farmers are faced with three choices, which are; no risk, minor risk and severe risk. Firstly, the farmers are assumed to decide whether they perceive a certain issue as minor risk, severe risk and/or no risk.

5.7.2.1 Mathematical representation of the model

As such, the utility maximizing function can be given as:

$\text{Max } U = U(C_k, R_{fk}, R_{ik}; H_u)$ .... (5.2)

Where: Max U denotes the maximum utility that can be attained from agricultural production.

C_k represents the sex*, education, household size, land tenure, location, risk attitudes, type of plot, tenure system, ploughing method, irrigation system, financial security, livestock damage crops, uncertainty in climate, source of water, water rate, paying water…*

From the utility maximizing function, it can be seen that households make decisions to produce, consume and market, subject to risk factors. It follows that if the costs that are associated with using a particular channel are greater than the benefits, households will be discouraged from using it, shifting to another option that maximizes their utility.

O' Sullivan, Sheffrin and Perez (2006) pointed out that it is difficult to measure utility directly; therefore, it is assumed that households make participation choices depending on the option that maximizes their utility. Thus, decisions to participate in either formal or informal markets or even not participating signify the direction, which maximizes utility. With the given assumption, multinomial regression was used to relate the decisions to participate in formal markets, informal markets or not participating and the factors that influence these choices.

A typical logistic regression model, which was used is of the form:

$$\text{Logit}(P_i) = \ln(P_i / 1 - P_i) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n + U_t \quad \text{(5.3)}$$

Where: $\ln(P_i / 1 - P_i)$ = logit for market participation choices

P_i = denotes the mean

$1\text{-}P_i$ = the variance

β = coefficient

X represents covariates

U_t = error term

5.7.2.2 Justification of the econometric model

Multinomial logistic regression model is useful in analysing data where the researcher is interested in finding the likelihood of a certain event occurring. In other words, using data from relevant independent variables, multinomial logistic regression is used to predict the probability (p) of occurrence, not necessarily getting a numerical value for a dependent variable (Gujarati, 1992). Dougherty (1992) explained that the procedure for formulating a multinomial logistic regression model is the same as for a binary logistic regression. Whereas in binary logistic regression, the dependent variable has two categories, in multinomial logistic regression, it has more than two categories. Thus, multinomial logistic regression is an extension of binary logistic regression.

According to Mohammed and Ortmann (2005), several methods can be used to explain the relationship between dependent and independent variables. Such methods include linear regression models, probit analysis, log-linear regression and discriminant analysis. However, multinomial logistic regression has been chosen because it has more advantages, especially when dealing with qualitative dependent variables.

Linear regression model (also known as Ordinary least squares regression (OLS) is the most widely used modelling method for data analysis and has been successfully applied in most studies (Montshwe, 2006). However, Gujarati (1992) pointed out that the method is useful in analysing data with a quantitative (numerical) dependent variable but has a tendency of creating problems if the dependent variable is qualitative (categorical), as in this study. Amongst other problems, the OLS cannot be used in this study because it can violate the fact that the probability has to lie between 0 and 1, if there are no restrictions on the values of the independent variables. On the other hand, multinomial logistic regression guarantees that probabilities estimated from the logit model will always lie within the logical bounds of 0 and 1 (Gujarati, 1992). In addition, OLS is not practical because it assumes that the rate of change of probability per unit change in the value of the explanatory variable is constant. With logit models, probability does not increase by a constant amount but approaches 0 at a slower rate as the value of an explanatory variable gets smaller.

When compared to log-linear regression and discriminant analysis, logistic regression proves to be more useful. Log-linear regression requires that all independent variables be categorical and discriminant analysis requires them all to be numerical, but logistic regression can be used when there is a mixture of numerical and categorical independent variables (Dougherty, 1992). In addition, discriminant analysis assumes multivariate normality, and this limits its usage because the assumption may be violated (Klecka, 1980). According to Gujarati (1992), probit analysis gives the same results as the logistic model. In this study, the logistic model is preferred because of its comparative mathematical simplicity and fewer assumptions in theory. Moreover, logistic regression analysis is more statistically robust in practice, and is easier to use and understand than other methods.

5.8 Chapter summary

This section explains the methodology used to conduct this study. It starts by introducing the study area which is the former Ciskei in the Eastern Cape Province. Rural Eastern Cape Province where the study was conducted has high concentration of people who are relatively poor and population resides in communal areas of the former Ciskei homelands. The study continues to explain the different villages, and areas wherein the research was conducted. Giving a historical overview of the areas, the demographics thereof, natural resources, agriculture and land use within that area. It further explains the sampling procedure, data collection methods, variable specifications and the chapter is concluded with data analysis model. Questionnaires were used to collect data from 101 smallholder farmers and the econometric models probit and multinomial models were methods used for analysis were outlined in the text. The researcher decided to iterate with alternative functional forms due to the fact that no study with the exact same problem context exists and the researcher is still trying to explain the apparent incongruity of the failure to transform despite positive and favourable policy and investment environment at the national and provincial level.

CHAPTER 6

RESULTS AND DISCUSSION

6.1. Introduction

This chapter presents research findings. The chapter begins with the presentation of summary statistics of the demographic and socio-economic characteristics of the smallholder farmers. As the chapter proceeds, the results of the analyses of the survey data on Risk preferences of the smallholder farmers are thoroughly discussed. The data collected for this chapter were derived from interviews with the heads of the household drawn from for the two farmer groups in the study area. Quantitative and qualitative approaches were used to gather and evaluate the data in order to gain deeper understanding of farmers' management decisions and perceptions on risk. Quantitative variables were expressed as averages, whereas the gender and literacy dummy variables were reported as frequencies and percentages. The probit being an important determinant for the farmers decision to take risk. Multinomial logistic regression model was used to test the different levels of risk, namely, no risk, minor risk and severe risk as perceived by farmers. The results for the determinants of risk preferences are analysed and discussed.

6.2. Description of demographic factors

6.2.1. Description of Household Size

Table 6.1 represents the total number of the respondents in the study area was 101, that is, 63 were homestead food gardeners and 38 smallholder irrigators. The mean household size for homestead food gardeners was found to be 4 family members and 5 members for smallholder irrigators. The median for the two groups was found to be the same which is 5 and the maximum number of homestead food gardeners' household members is 13 and the minimum being 1 and for smallholder irrigators the maximum is 10 members and a minimum of 2 members. The household size is a proxy for family labour which is one of the most important inputs to smallholder farm production. The availability of family labour especially during peak labour demand is important for households that have adopted new agricultural technology that is labour intensive. On the other hand large family sizes also put pressure on household food demands and hence has implications for the adoption of agricultural technologies that have a bearing on food security and/or commercialization for income sources.

Table 6.1 Household size of respondents

	Smallholder n= 38	Homestead n=63	Overall
Mean	5	4	5
Median	5	4	5
Maximum	13	10	13
Minimum	1	2	1

6.2.2. Description of Household by Sex

Figure 6.1 Shows both results of homestead food gardeners and smallholder irrigators males dominate in homestead food gardens represented by 63%, whereas females dominated in smallholder irrigators with 52%.This may be attributed to loss of jobs through retrenchment policies, retirement and high unemployment rate especially in the formal sector that requires more educated skilled labour. Secondly, over 90% farm plots on irrigation schemes and dry land were allocated to men due to bias of the African culture and norms which deny women legal rights to own such crucial agricultural resource (Kodua- agyekum, 2009).

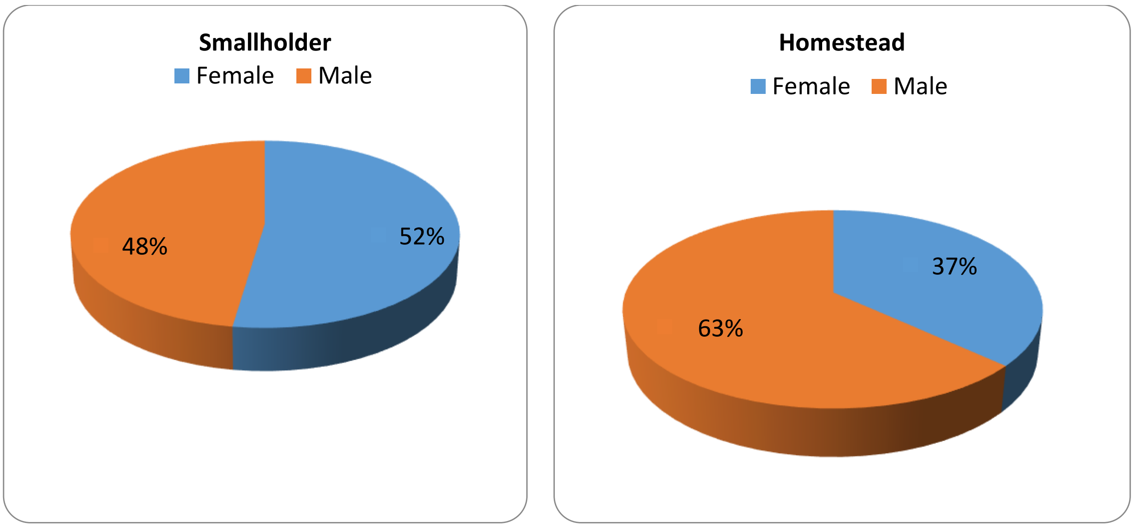

Figure 6.1 Sex distributions of the respondents, Survey data, 2013

6.2.3 Description of household by Age

Figure 6.2 shows that the homestead food gardeners have the youngest individuals involved in farming who are around 20- 29 years and also the oldest age between 81 and above. Furthermore, the results indicate that the age distribution from 70-79 is similar between the two groups. Kirsten and Jerkins (2003) and Adesina and Baidu-Forson (1999) established that age was either significant or was negatively related to adoption. Older farmers, because of investing several years in a particular practice, may not want to jeopardise it by trying out a completely new method. Farmers' perception that technology development and subsequent benefits, require a lot of time to realise, can reduce their interest in the new technology because of their advanced age, and the possibility of not living to enjoy it

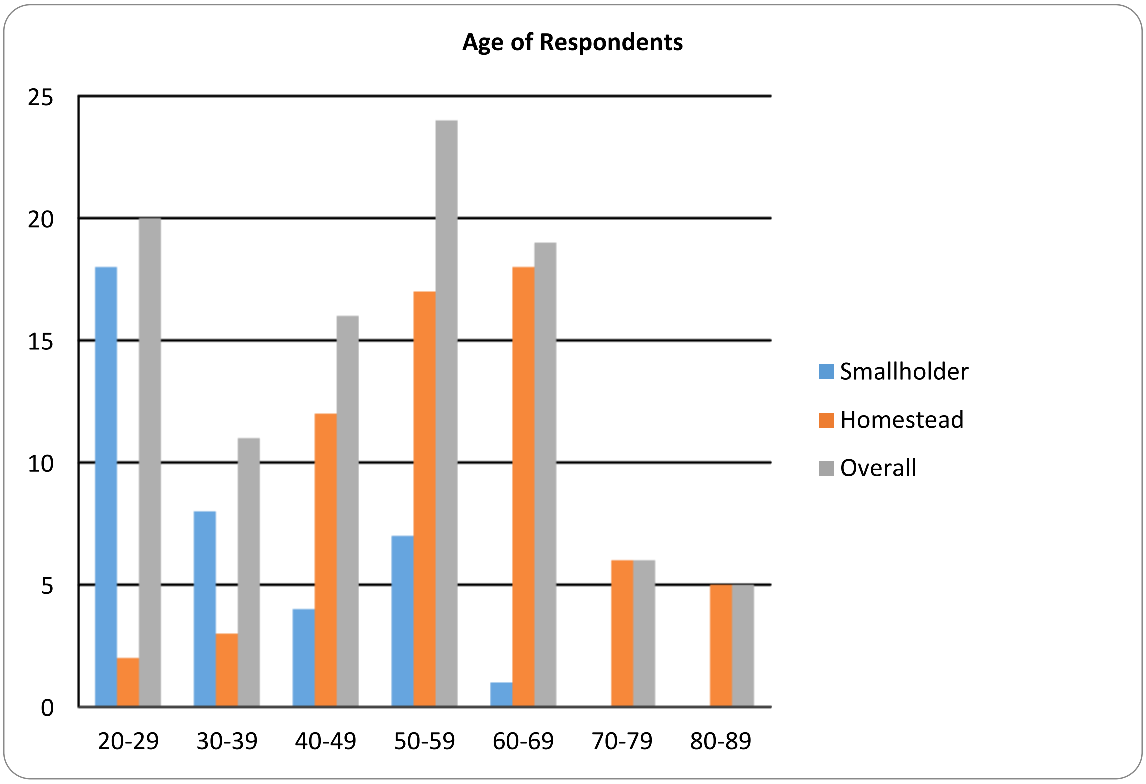

Figure 6.2 Age of household respondents, survey data 2013

6.2.4. Definition of Household by Education

The level of education was divided into two segments which are Formal education and no formal education. This is one of the important characteristics because the higher the educational level the easier for the respondents to adopt and use modern technology since they understand technology better. Moreover the flow of agriculture information from one stakeholder to another is easier. Figure 5.3 below clearly indicates the education system received by farmers in the study. 90% homestead food farmers have received formal education, wherelse 3 % of smallholder irrigation farmers have never received formal education. A large percentage of smallholder irrigation farmers in the area seems to have received formal education, hence the 97%. In both homestead food gardening and smallholder irrigation farming a large percentage has received formal education.

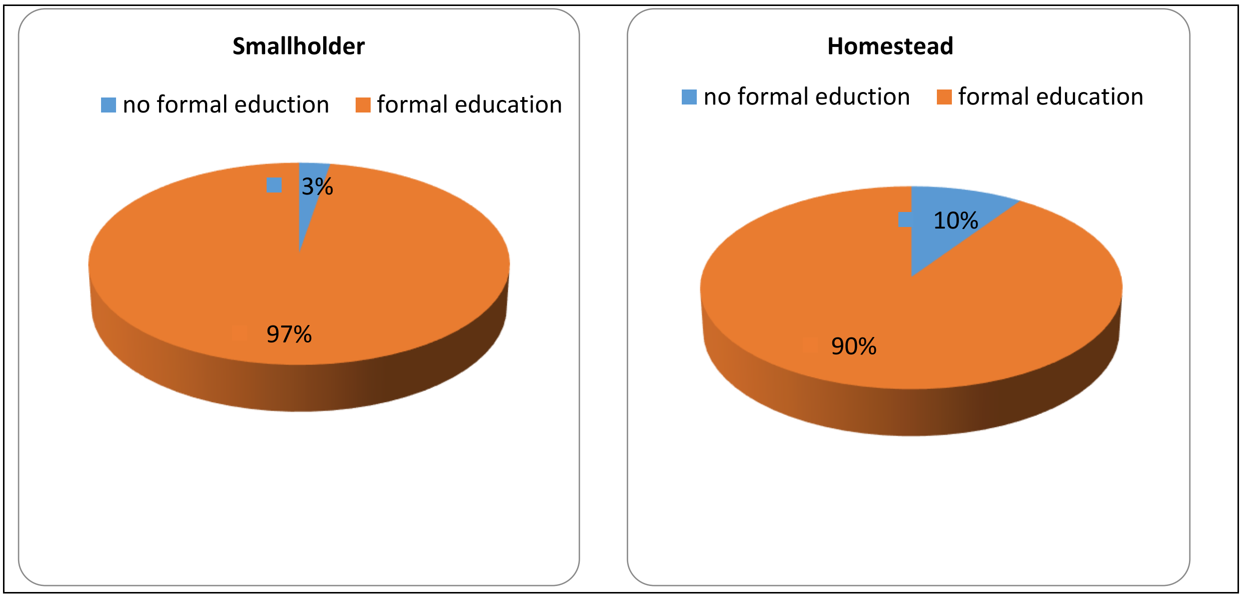

Figure 6.3: Education level of the respondents, survey data, 2013

6.2.5. Explanation of household by Occupation

In this study the occupation category of the respondents is divided into retired, unemployed and self-employed. The respondents have got more retired respondents of about 7 % and 57% of the respondents are self-employed. About 21% of the respondents are employed elsewhere and hence have non farming income. Occupation of the respondents is very crucial since income they earn helps the respondents to achieve household food security. To some degree, income is also used to purchase food, clothes and other (Muregerera, 2003).

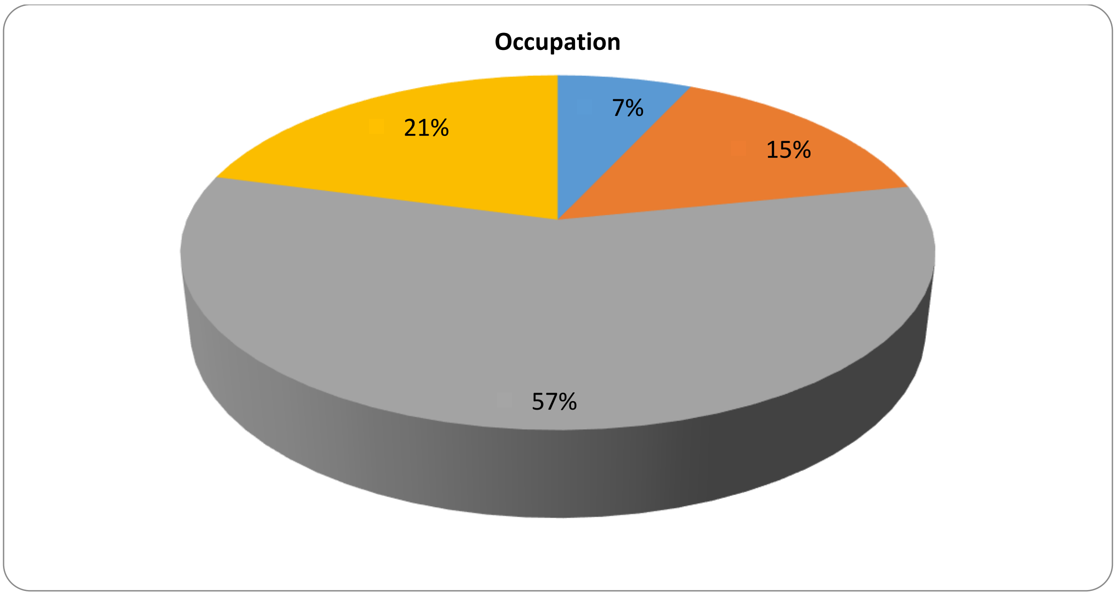

Figure 6.4 Occupation of the respondents, survey data, 2013

6.2.6. Description of household by Income

From the figure below clearly indicates that both smallholders and homestead food gardeners are earning slightly above R1500, this could be because some of the respondents are pensioners, who are eligible to the pension funds, and others may be having other sources of income, and a very low percentage of the farmers are earning above R1500. Both smallholders and homestead food gardeners have the same income of about R500. Access to cash which promotes adoption of risky technologies through the relaxation of liquidity constraints as well as boosts the household's risk bearing ability is hardly available to resource poor farmers for varied reasons (Langyintuo and lowenberg, 2006). Farm income may affect adoption negatively or positively depending on its contribution to household income and farm profitability. Farmers with more wealth and liquidity maybe better able to finance the adoption of new technologies and farming practices (Essa and Nieuwoudt, 2001).

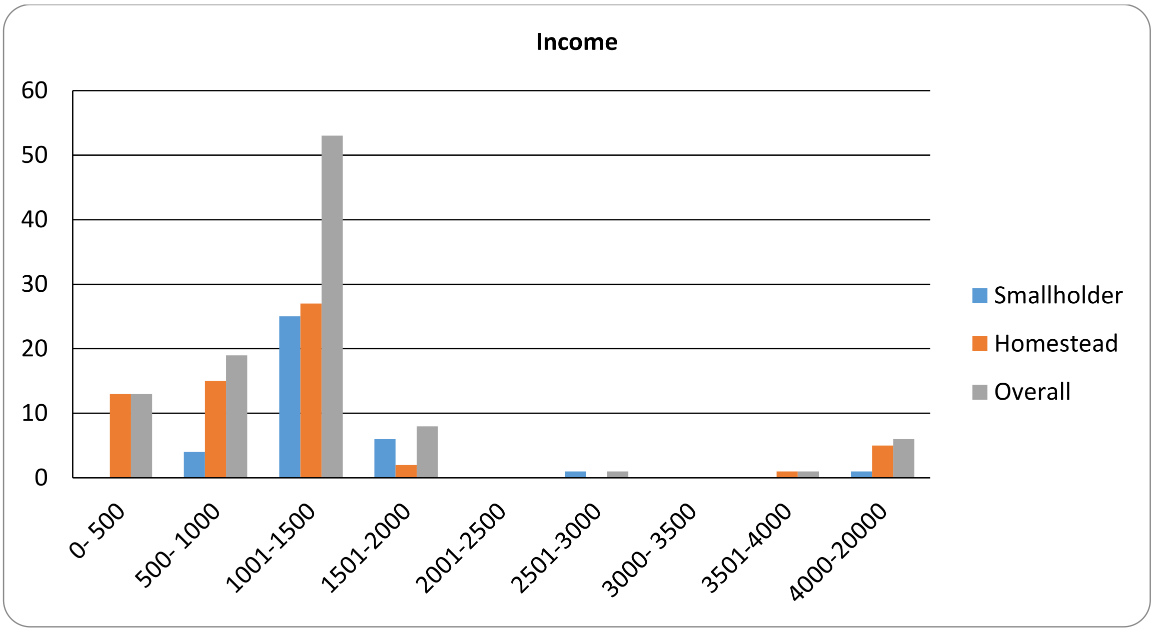

Figure 6.5 Income of respondents, survey data, 2013

6.3. Land use

6.3.1. Number of years farming

A vast majority of homestead food gardeners have been farming for over 16 years as compared to the smallholder's irrigation farmers whose majority of farmers have been farming between 6 to 10 years. Moreover the homestead food gardeners seems to have been in farming for more years as seen in figure 6.7 where smallholder farmers have been farming for not more than 10 years. The number of years in farming is very important in depicting the experience that a farmer has and also in determining whether or not a farmer can easily adopt to new agricultural technology.

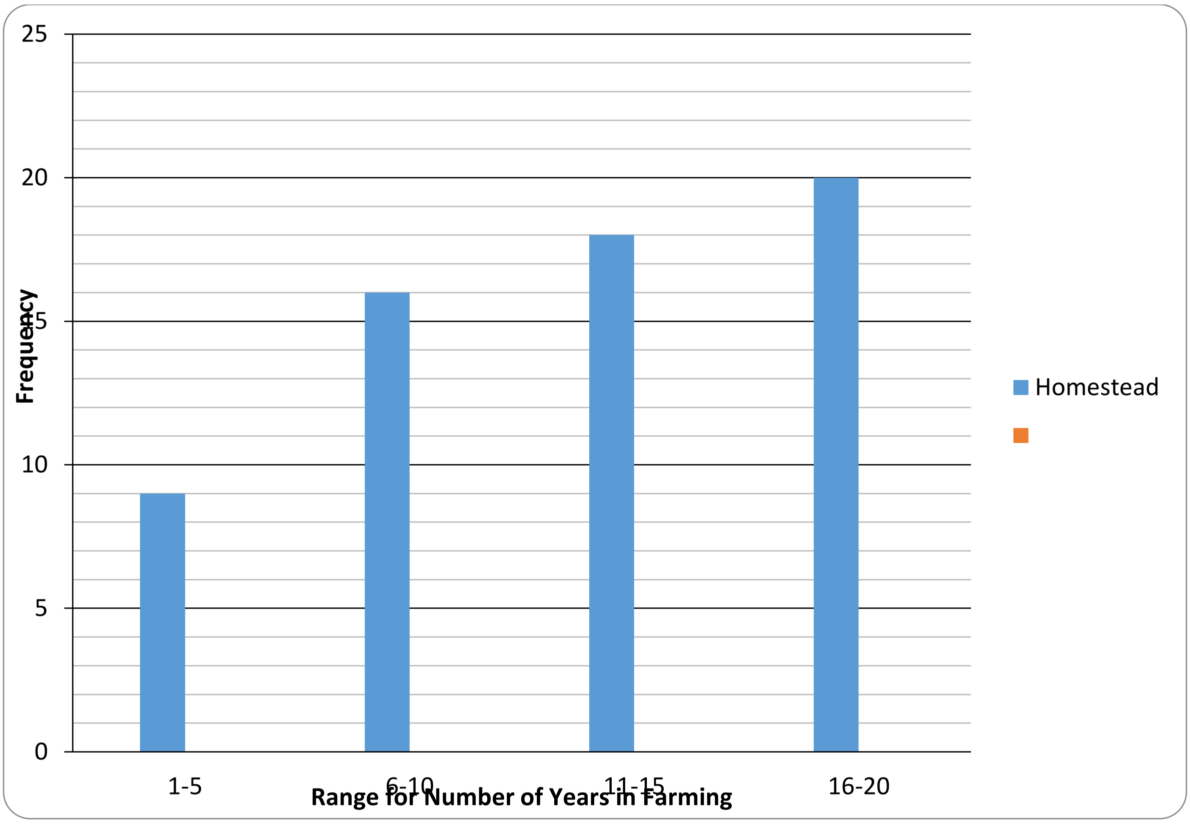

Figure 6.6 Number of year in farming, survey data, 2013

6.3.2. Land tenure system used by the farmers

The figure below illustrates the type of tenure system used by the farmers in the study area. About half of the farmers in the study area have their own land making it easier for them to continue with their farming activities and also the willingness to take risk. However a slightly lower percentage of about 40 % are using communal lands and this is has a negative impact on the willingness to take risks and the adoption of new agricultural technology. If farmers perceive their tenure as secure, they have an incentive to invest in land improvements and maintain existing improvements to increase productivity. However, policies such as the land reform process play a role in finding solutions for problems associated with limited access to land.

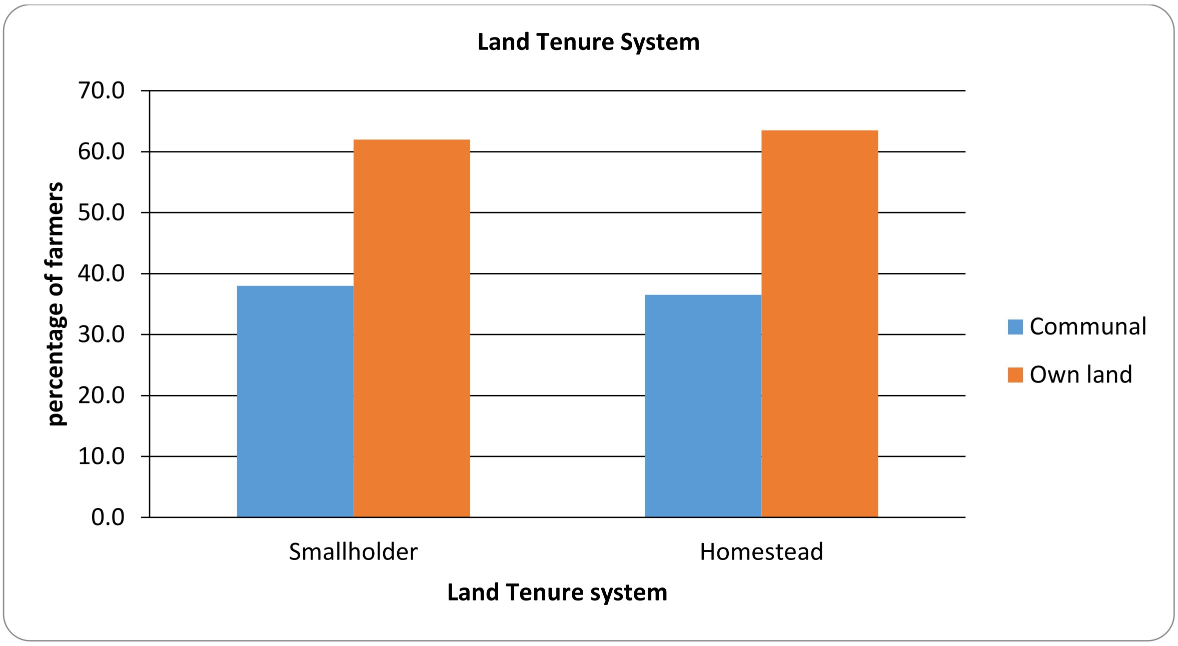

Figure 6.7 Land tenure system of the respondents, survey data, 2013

6.3.3. Land Size

The size of land a farmer owns is usually associated with the amount of produce the farmers will produce even though it's not always the case since most farmers might not utilise all the land that they have been allocated (Muchingura, 2007). Najafi (2003) also goes on to say that land size is also an important aspect when it comes to the food security of household and thus the bigger the land the bigger the production. The average land size obtained in the sample is 1.5 ha there is a difference of about a hectare between the two groups on the land sizes and they ranged from 0.25 to 10 ha.

Table 6.2: Size of land utilised by respondents

	Smallholder n=38	Homestead n=63
Mean	2.27	0.25
Std. Deviation	1.48	1.73
Minimum	0.25	4
Maximum	8	10

6.4 Water use

6.4.1. Source of water

The main sources of water in the former Ciskei homelands of the Eastern Cape are dams, rivers, taps and boreholes. A high percentage of farmers in the area are using water from the dams as most of them are surrounded by dams, however they do not have water rights. Only 4% of the farmers use water from borehole and 155 uses water from taps which are communal taps.

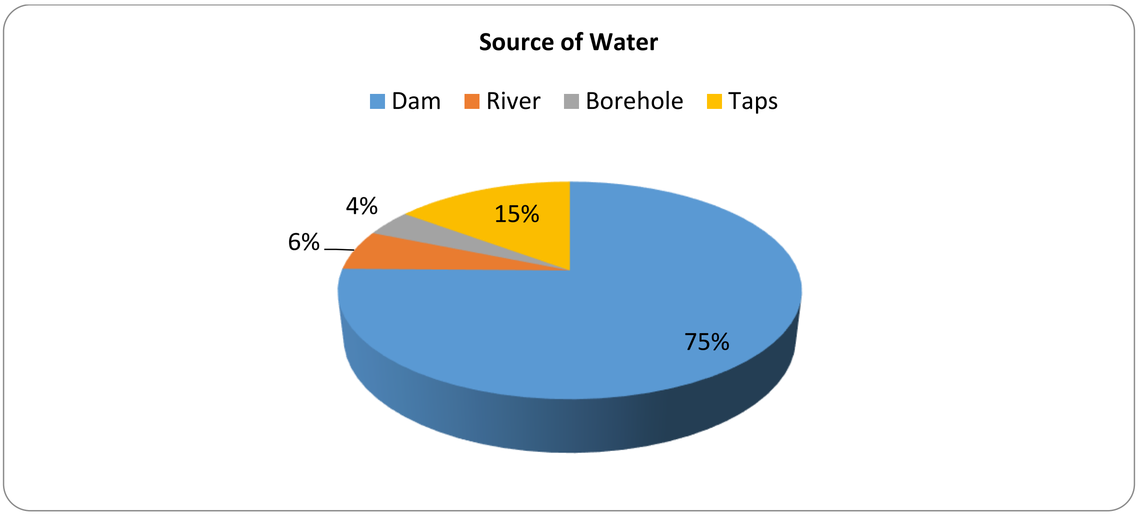

Figure 6.8 Sources of water used by the respondents, survey data, 2013

6.4.2. Type of irrigation system

The most commonly used method of irrigation are water cans which are used mostly by homestead food gardeners,38% of the farmers uses sprinklers which are mainly used by smallholder irrigation farmers. Other irrigation systems include drip irrigation systems and pivots which are also used in the area. This is illustrated in figure 6.9 below

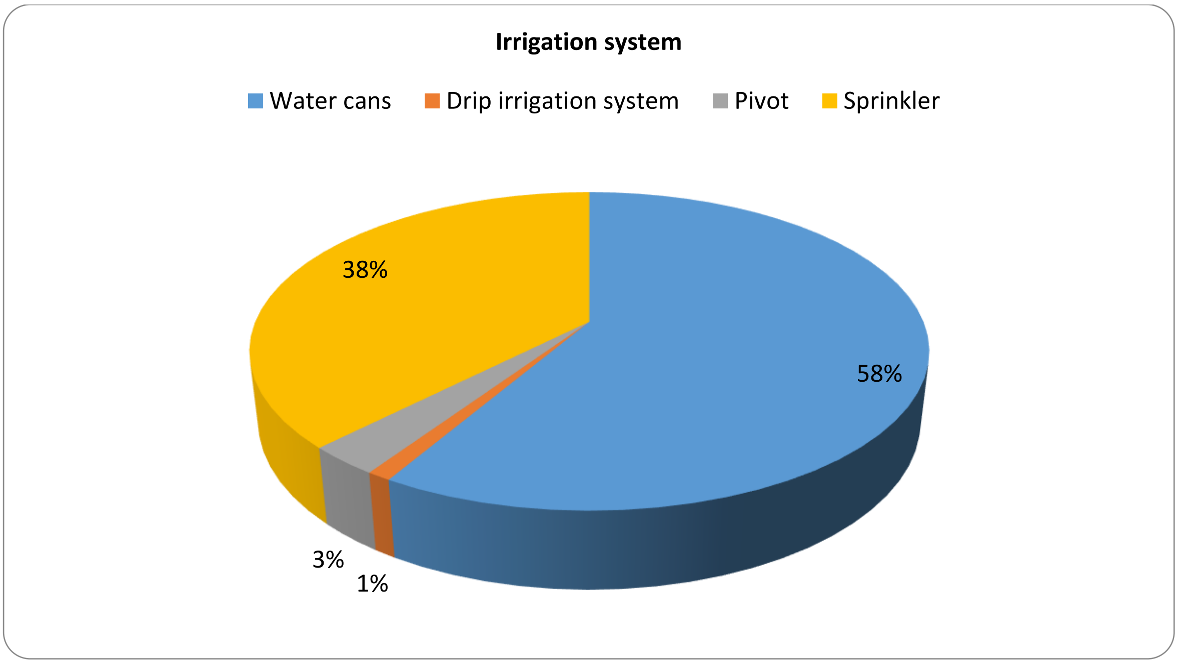

Figure 6.9 type of irrigation system of the respondents, survey data, 2013

6.5. Livelihood strategies

6.5.1. Cash borrowed

Table 5.3 below reflects the amount of money borrowed both smallholder farmers and homestead food gardeners. Over 70 % of the farmers have borrowed money between R1 and R500. Atleast 1% of the respondents have borrowed money from R2501 and R2000; this could be influenced by the fact that most of the farmers are self-employed.

Table 6.3: The amount of money borrowed

Amount Borrowed	Frequency	Percentage
1- 500	78	77.2
5001-1000	11	10.9
1001-1500	4	4
1501-2000	1	1
2001-2500	7	6.9

6.5.2. Purpose of credit

Although farmers may have access to informal credit, they have a number of issues they are using it for. This study has discovered that many of the farmers in Ciskei borrow money for the main purpose of family suppose and this is reflected by the 70% in the graph below.

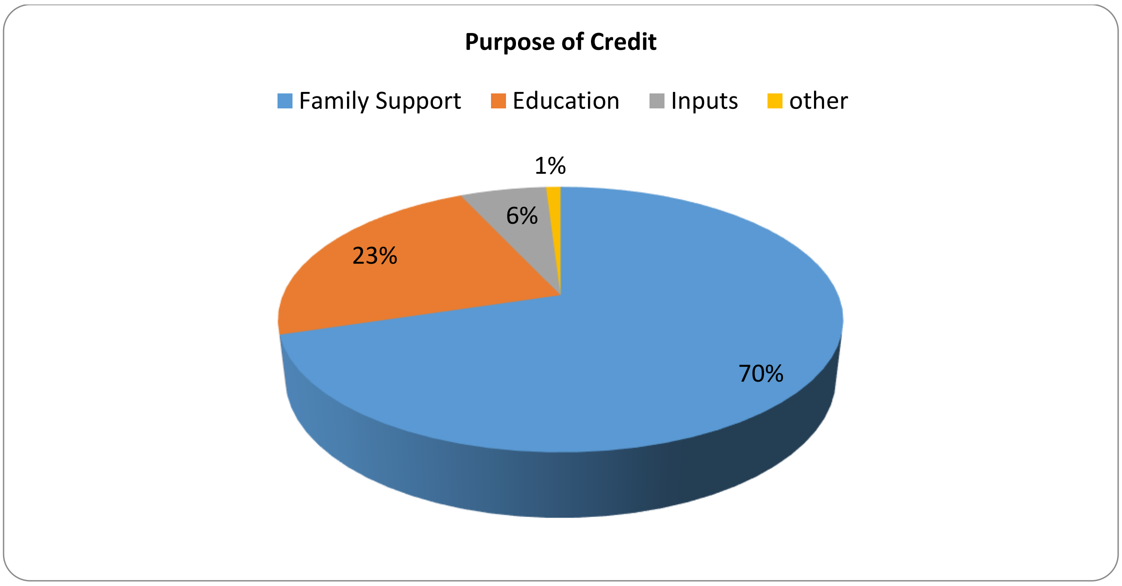

Figure 6.10 Main purposes for credit, survey data, 2013

6.5.3. Source of credit

For smallholder farmers access to credit is vital to any production, especially for commercial purposes. This both credit to obtain assets over a longer period and production credit cyclical basis (May and Carter, 2009).Both homestead food gardeners and smallholder farmers outsource their credit from lenders and just a small percentage of these farmers get their loans from banks. This can have a negative impact on risk and the adoption of new agricultural technology.

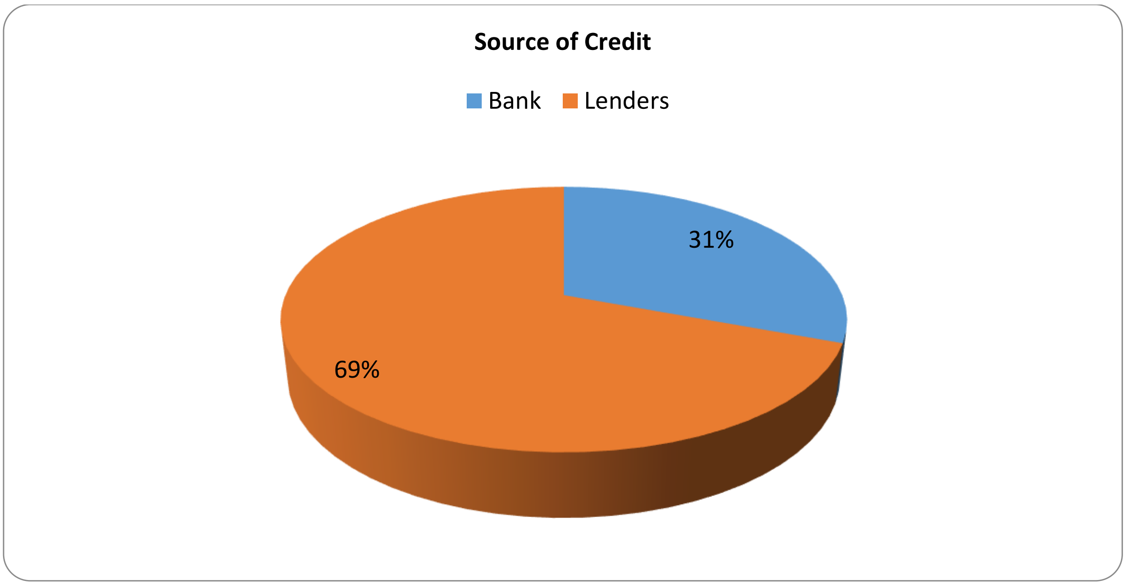

Figure 6.11 Sources of credit, survey data, 2013

6.5.4. Financial security

Figure 5.12 below illustrate whether or not farmers in the study area have financial security or not. Over 70 percent of the respondents do not have financial security, making it difficult for them to access credit and thus more risk averse and less willing to adopt to new agricultural technology.

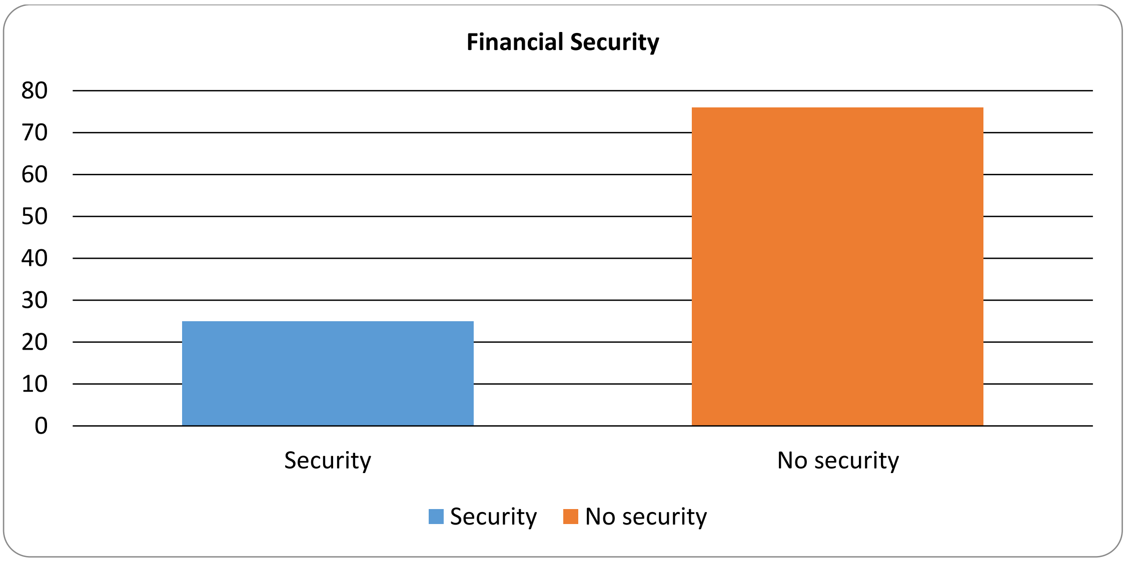

Figure 6.12 Financial securities of the respondents, survey data, 2013

6.6. Empirical Analysis

6.6.1. Determinants of risk: Probit results

The probit model successfully estimated the significant variables associated with the farmers' risk perception. The following variables were found to be significant determinants in the farmers decision to take risk in the study area: sex, age, occupation, type of plot, size of plot(land), tenure system, years in tenure, source of water (water accessibility), water rate and irrigation system. A positive and significant relationship between risk and sex depict that male farmers are at lower risk aversion as compared to their female counterparts, however studies by kisaka- lwayo (2005) did not observe any gender differences in risk propensity towards 'contextual' decisions and concluded that gender stereotype may not reflect male and female attitudes toward risks. Experiments have shown that context matters in relation to gender differences and risk attitudes (Schubert et al., 1999).

Age is significant indicating that older farmers tend to be more willing to take risk. While this is not consistent with findings in most extension studies, in the study area, the average age of the farmers is over 49 years. Similar findings have been recorded by Matungul (2001). Farming in the study area and many rural areas of South Africa is undertaken by older farmers as the younger members of the household migrate to urban areas in search for jobs. Farming in many instances is also considered as an alternative option to retirement from wage employment. A similar relationship between risk and the age of the farmer was found by Hossain *et al.* (1992) who revealed that the probability of taking risk increased with age among farmers in Bangladesh. Similarly in China, Feng and Chenqi (2010) established in their study on Sustainable Agricultural Technologies (SAT) that the adoption of SAT is higher among older farmers than younger farmers. This is probably due to previous knowledge gained as these were earlier technologies introduced in Northern China and hence farmers had more experience in using them.

Occupation i.e. non-farm income is significant and this is due to the fact that farmers who have other income apart from the farm are more willing to take risk or are less risk averse. This is supported by studies by Kisaka-Lwayo (2005) in Kwazulu-Natal where income was found to be negatively correlated to risk aversion. Type and size of plot were found to be significant to risk due to the fact that farmers tend take risk when there is enough resources available for them and thus if there is enough land available they adopt to new technologies. However cultivating more land could be a risk coping strategy for the risk averse, but as most of the farmers in the study area resource poor, more land means more resources to be allocated to farming and hence this may tend to create less willingness to take risk.

The tenure system (land tenure) security of the farmers is statistically significant. This implies when farmers have security of land tenure the tendency to risk is higher. The farmer‘s perception of tenure security was assessed by the rights the household can exercise on his/her own cropland by building structures. However it should be noted that in the study area, land ownership is customary and farmers have permission to occupy. A study undertaken by Smucker, White and Bannister (2000) on land tenure and the adoption of agricultural technology in Haiti found that formal title is not necessarily more secure than informal arrangements. Informal arrangements based on traditional social capital resources assure affordable and flexible access to land for most people. The perceived stability of access to land via stability of personal and social relationships is a more important determinant of technology adoption than mode of access.

The years of tenure are significant because the more experienced farmers are more willing to take risk as compared to less experienced farmers as they seem to have more knowledge farming. Water rate and source of water are significant and positively related to risk because of the availability of water in the study area as the area is surrounded by rivers and dams, although they may need water rights and good irrigation systems.

Information on crop production is positive and significant and this indicates that farmers in the study area have indigenous knowledge on crop production and may also receive it from the extension officers.

Risk preferences could be explained by individual psychological factors and it may be important to estimate individual risk preferences or identify factors that affect the individual's capacity to bear risk or consider their risk environment.

Table 6.4 Socio- economic statistics variables, Eastern Cape

Variable	Std. error	Z	Significance
HHSIZE	**0.024**	**-0.470**	**0.638**
SEX	**0.112**	**3.127**	**0.002****
AGE	**0.004**	**-3.510**	**0.000*****
LEVELEDU	**0.160**	**0.664**	**0.507**
OCCU	**0.119**	**-5.117**	**0.000*****
TYPEPLOT	**.135**	**-6.303**	**0.000*****
SIZEPLOT	**.037**	**-10.046**	**0.000*****
TENURESYSTEM	**.102**	**-5.805**	**0.000*****
YRSOFTNR	**.008**	**-19.445**	**0.000*****
SOURCEH2O	**.119**	**3.932**	**0.000*****
H2ORATE	**.016**	**-6.289**	**0.000*****
H20PAYING	**.732**	**6.023**	**0.000*****
IRRIGATIONSYSTEM	**.135**	**-5.841**	**0.000*****
FINCLSCURTY	**.092**	**-0.082**	**0.935**
CLMTUNCRTN	**.093**	**-.0204**	**0.838**
INFOCRP	**.111**	**4.105**	**0.000*****
INFOMRKTS	**.105**	**-3.339**	**0.001****
PLGHNGMTHD	**.125**	**-4.413**	**0.000*****
INTERCEPT	**.394**	**0.543**	**0.587**
Goodness- of-Fit			
	Chi-Square	**df**	**Sig.**
Pearson	**5.084E+037**	**77**	**.000**

Source: results from SPSS version 21, where, ***, ** represents statistical significance at 10% and 5% respectively.

6.6.2. Determinants of Risk preferences: Multinomial results

There is a positive and significant relationship between household size and farmers who perceive farming as severe risk. This finding supports the interpretation that a larger family size implies higher subsistence consumption needs and aversion to risk. Hollaway *et al*. (2002) had a similar result and interpreted it as a confirmation that higher subsistence pressure leads to greater adoption of new agricultural technology aimed at improving food access among households. Feinermann and Finkelshtain (1996) found that larger family size leads to more cautious and conservative behaviour, while Dillon and Scandizzo (1978) found that farmers with larger households were less risk averse. The potential to meet peak labour demand also highlights the importance of the availability of family labour.

Water rate is significant and positively related to risk. This could be because farmers who perceive farming as severe risk are mostly residing in areas which are far from rivers and dams and are unable to easily access water. Irrigation system is also positively and significant to farmers who perceive farming as risky, these is because most of these farmers do not have sufficient and efficient irrigation systems for a good production.

Table 6.5 Risk attitudes of farmers in the Eastern Cape Province of South Africa

VARIABLE	Minor risk			Severe risk		
	B	**Std. error**	**Significance**	**B**	**Std. error**	**Significance**
INTERCEPT	**-3.015**	**2.089**	**0.149**	**2.093**	**2.380**	**0.379**
HHSIZE	**0.083**	**0.149**	**0.580**	**-0.340**	**0.182**	**0.061***
SEX	**-.012**	**0.641**	**0.986**	**0.470**	**0.739**	**0.525**
AGE	**0.039**	**0.023**	**.0094**	**-0.016**	**0.027**	**0.542**
LEVELEDU	**0.984**	**0.959**	**0.305**	**1.600**	**1.331**	**0.229**
SURCEH2O	**0.388**	**0.672**	**0.564**	**-0.422**	**0.807**	**0.601**
H2ORATE	**0.027**	**0.022**	**0.221**	**0.083**	**0.026**	**0.002****
IRRIGATION SYSTEM	**-0.208**	**0.709**	**0.769**	**-2.428**	**1.043**	**0.020***
FINCLSCURTY	**-0.733**	**0.681**	**0.282**	**-1.207**	**0.799**	**0.131**
INFOMRKTS	**-0.131**	**0.630**	**0.835**	**-0.781**	**0.689**	**0.257**

Goodness-of-Fit

	Chi-Square	**df**	**Sig.**
Pearson	**188.877**	**182**	**0.348**
Deviance	**166.019**	**182**	**0.796**

Source: results from SPSS version 21, where, ***, ** represents statistical significance at 10% and 5% respectively

6.7. Chapter Summary

The chapter concludes the main theme of the study which is to ellicit risk preferences of smallholder irrigation farmers. Thus, the analysis of the adoption of new agricultural technology and its relationship to risk taking decision by smallholder farmers in the study area. Further analysis is presented in this chapter and the assessment of risk perception of smallholder irrigation farmers. The generated information in this chapter is thought to be useful to identify the risk preference patterns and attitudes that determine the transition from homestead food gardening to smallholder irrigation farming in the Eastern Cape province of South Africa.

In summary smallholder farmers risk preferences is dependent on a number of factors, such as age, income, occupation, water rate, irrigation systems etc. hence this also has an effect on the adoption of new agricultural technology. They are also different farming systems that the farmers use and they have access to land, although they is limited access to inputs such as seeds, fertilisers and pesticides. Both groups are willing to take risks. The probit model successfully estimated the significant variables associated with the farmer‘s adoption decisions and these are: age, sex, tenure system, years of tenure and water rate. The multinomial logit also proved the significance of water rate, irrigation system and the importance of household size in decision making. The study also found that older farmers tend to be adopters supporting findings by (Feng, Chenqi, 2010).

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CHAPTER 7

RISK AND RISK MANAGEMENT BY SMALLHOLDER FARMERS

7.1. Introduction

The chapter presents the results of farmers‘ risk classification of the smallholder farmers in the Eastern Cape Province and compares these to results from similar studies in India, Philippines, Zambia, Ethiopia and Cote d‘ Ivoire. The perceived sources of risks are ranked and the main sources of risks identified. The traditional risk management strategies used by the farmers are discussed. The results of principal components analysis are presented along with extracted principal components (PCs) that explained most of the variation. The relationship between the farmer‘s perception of risk sources and farm and farmer characteristics are also explained.

7.2. Risk aversion classification

The responses of the sample farmers are explored and presented in Table 7.1 below for each farmer category. The table presents the distribution of risk aversion preferences for each prospect for the household food gardeners and smallholder farmers, and the number of valid cases analysed for the sample. The distribution of responses was spread across all classes of risk aversion for the pooled data. It can be noted that on average, the majority of the respondents revealed their preference for prospects representing intermediate and moderate risk aversion alternatives across the three farmer groups. Table 7.1 further shows that household food gardeners were the most risk averse being classified as extremely risk averse at 20.4%, compared to smallholder farmers certified at 7.3% and 4.2%. This may explain why they have not adopted new agricultural technology being introduced in the area since 2000. On the other hand, the household food gardeners were the least risk averse, being classified as neutral to risk preferring at 9.1% compared to 7.3% smallholder farmers. These results conform to *a priori* expectations regarding the risk preference patterns of smallholder farmers.

Table 7.1 Distribution of smallholder farmers according to risk preference patterns

	Risk aversion classification					
Farmer group	**Extreme**	**Severe**	**Intermediate**	**Moderate**	**Slight to neutral**	**Neutral to preferring**
Homestead food gardeners (n=63)	7.3	5.5	30.9	40	7.3	9.1
Smallholder farmers (n=38)	4.2	8.3	44.8	29.2	5.2	7.3

Source: field data

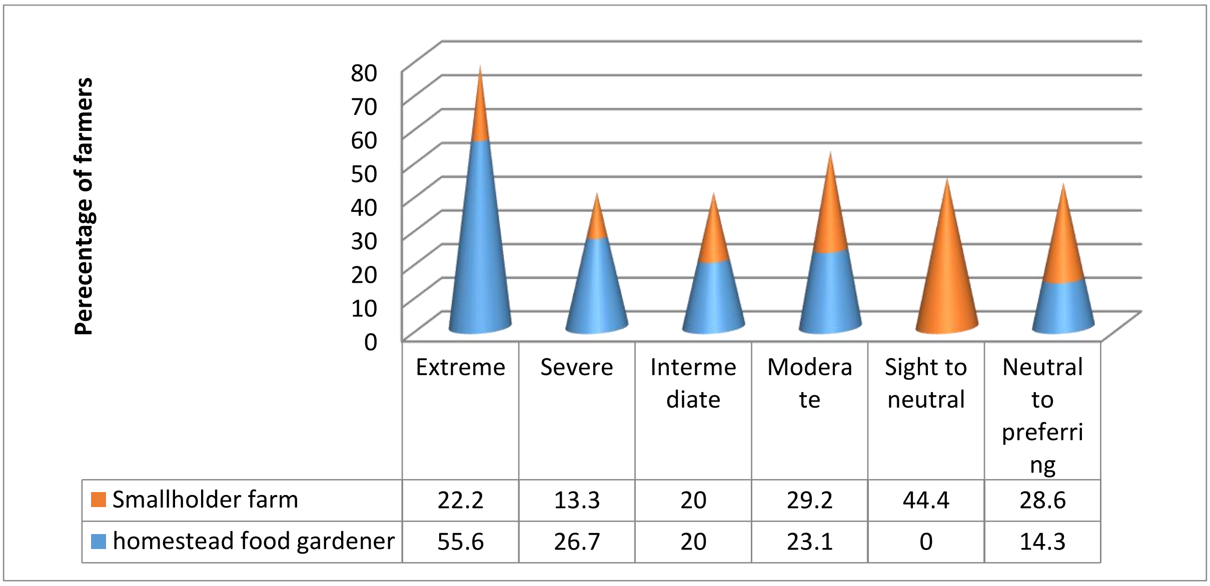

Figure 7.1: Frequency distribution within risk aversion classes across the farmer groups

According to Figure 7.1, the homestead food gardeners constituted 55.6% of respondents within the extreme risk aversion class compared to 22.2% smallholder farmers. This is a confirmation of previous findings in these studies that explains the non-adoption of new agricultural technology by the household food gardeners. In the risk neutral to preferring category, the smallholder farmers constitute only 14.3%.

Table 7.2 below compares the results from this study, which applied the general experimental method, with similar studies using the same methodology for farming communities in the Côte d'Ivoire (Kouamé, 2010), Ethiopia (Yesuf, 2007), Zambia (Wik and Holden, 1998), Philippines (Sillers, 1980) and India (Binswanger, 1980). To facilitate comparisons among the experiments and to give a sense of the experimental pay-offs in terms of local incomes, all pay-offs were expressed in experiment- specific daily or monthly wage units following Wik and Holden (1998). This is equivalent to the monthly wage received by an unskilled agricultural labourer in the study areas in question. These results are shown together with our results from the South African study. According to Table 7.2, comparing the results from this study to the Ethiopian, Zambian, Côte d'Ivoire and Indian experiments, it is found that the proportion of farmers falling in the extreme to severe risk category is higher in the Ethiopian experiment, but lower in the Zambian, Côte d'Ivoire and Indian cases. These results suggest that farm households in South Africa particularly the KwaZulu-Natal province are less risk averse than in Ethiopia, Zambia and Côte d'Ivoire but are much more risk averse than in India and Philippines. The table also reveals that the findings of the South African study are in tandem with findings of the studies done in India, Philippines, Zambia and Côte d'Ivoire, where the majority of the respondents are classified as intermediate to moderate risk aversion (Table 7.2).

Table 7.2 Percentage distribution of revealed risk preferences in five experimental studies

Games	Extreme to severe risk aversion	Intermediate to moderate risk aversion	Risk-neutral to risk preferring	Number of responses
India (Binswanger, 1980)				
50 rupee	8.4	82.2	9.4	107
500 rupee	16.5	82.6	0.9	115
Philippines (Sillers, 1980)				
50peso	10.2	73.5	16.3	49
500peso	8.1	77.6	14.3	49
Zambia (Wik and Holden, 1998)				
1000kw	29.1	46.4	24.5	423
10000kw	36.7	52.5	11	137
Ethiopia (Yesuf, 2007)				
5bir	45.4	33.6	21	262
15bir	55.7	27.5	16.8	262
Côte d'Ivoire (Kouamé, 2010)				
1000FCFA	32.8	53.9	13.3	362
5000FCFA	46.1	45.9	8	362
*South Africa, KZN (Lwayo, 2011)				
400Rands	16.5	70.0	11.5	196

Source: Lwayo, 2011

7.3. Estimation OLS model for risk aversion and socio-economic characteristics

Table 7.3 gives the estimated regression results for the determinants of Partial Risk Aversion (PRA).

Table 7.3 Parameter estimates for the Ordinary Least Square for Partial Risk Aversion

	Homestead food gardeners			Smallholder farmers			Pooled (n= 196)		
	B	**Std Error**	***P*- value**	**B**	**Std Error**	***P*- value**	**B**	**Std Error**	***P*- value**
Constant	-6.422	2.358	.016	-5.904	5.339	.319	-0.642	2.136	0.765
Years of schooling	.067	.075	.382	-0.445	0.202	.079*	-0.043	0.78	0.590
Age(years)	.060	.026	.032**	0.171	0.054	.025**	0.069	0.26	0.013**
Gender (0=male)	1.857	.808	.036**	-0.247	1.819	.897	0.267	0.785	0.736
Land size(hectares)	.293	.662	.665	1.492	1.988	.487	-0.881	0.617	0.162
Proportion of income from farming (rands)	1.817	.488	.002*	-5.137	3.230	.173	0.472	0.592	0.430
Source of information	2.672	1.145	.488	.034**	6.784	2.276	0.501	1.137	0.662
Literacy	2.319	.570	.001***	7.999	1.633	004***	1.741	0.655	0.011***
Household size	-.034	.060	.575	-0.302	0.225	.238	-0.144	.0070	0.045**
Off farm income	.000	.000	.044**	-0.003	0.001	111	0.000	0.000	0.068*
Savings (1=yes)	-1.586	.702	.039**	2.081	1.054	105	0.616	0.692	0.379
Adjusted R_2	0.606			0.146					
ANOVA	0.003			0.086					

The theoretical expectations of the models are broadly confirmed. The following variables were statistically significant for the household food gardeners: Years of schooling, age of the farmers, gender of the farmer, proportion of income from farming, source of agricultural information, literacy levels, off farm income and savings by the household. A positive sign in the OLS model is an indication of lower risk aversion. The age of the farmers is positive and statistically significant at 5% level of probability for homestead food gardeners and smallholder farmers as well as the pooled data. This implies that older farmers in the study area are more likely to take risks than the younger farmers. This is demonstrated by the fact that the average age of the respondents in the study area was over 50 years. This result supports findings by Hossain *et al.* (1992).

The estimated coefficient for gender is positive and statistically significant at 5 % level of probability for the homestead food gardeners, implying that women were more likely to take risks than their male counterparts. It should be noted that homestead food gardeners have the highest proportion of income from farming (62%), an indication that their adoption of new agricultural technology is contributing to increased farm and overall household income.

The main source of agricultural information in the study area is from fellow farmers. This variable was found to be positive and statistically significant at 5%level of probability for the homestead food gardeners. Farmer-to-farmer information exchange has the propensity to reduce the degree of risk aversion of the farmers. The estimated coefficient of household size is negative for the non-organic crop farmers. This finding supports the interpretation that a larger family size implies higher subsistence consumption needs and aversion to risk. The statistically significant positive estimated coefficient for literacy at 1% level of probability for the Homestead food gardeners and pooled data indicates that farmers with higher levels of literacy are relatively more willing to take risk (Miyata, 2003). Education and literacy are important for these farmers as the procedure for being certified requires that each farmer understands the certification requirements, and the farming and basic record keeping procedures that must be followed in order to be certified. The Ciskei area has generally low farmer education levels with years of schooling averaging 4.8 and 4.1 for the homestead food gardeners and smallholder farmers, respectively. Household size was significant for the pooled data. The negative coefficient for the homestead food gardeners and smallholder farmers suggests that whereas a large family size is an indication of increased labour force from the household, it has a negative effect on risk aversion. A large family means more people to feed which increases the level of vulnerability of the household. Off farm income is found to be positive and statistically significant at 5% level of probability for homestead food gardeners and is considered a risk management strategy. The regression results obtained using the partial risk aversion shows that there are more than just the observed explanatory variables that are reported here that explain the risk aversion of smallholder farmers. Risk preference could be better explained by individual psychological factors that were not readily observable for the sample farmers. However the results above point up the socio-economic variables that impact of the farmer‘s risk aversion.

7.4 Factors affecting choices of risk management strategies

This section presents the results of the farmers‘ sources of risk. These are ranked from 1-20 in order of priority based on the score of the likert scale. The section also presents the extracted principal components that explain most of the variation. Socioeconomic factors having a significant effect on the various sources of risk are analysed and presented below. The section concludes by presenting the results of the risk management strategies used by the farmers.

7.4.1. Farmers' perception of risk sources

A total of 20 sources of risk were presented to respondents in the survey. Farmers were asked to identify the sources of risk that they have experienced and express how significant they considered each source to be of risk in terms of its potential impact on their farming activity. Each source of risk was scored on a 3-point Likert scale from 1 (no impact) to 3 (high impact) to. In doing this, farmers selected and ranked the different sources of risk from the less important to the most important. The identified risk sources and their ranking in order of importance are presented in Table 7.4.

The homestead food gardeners farmers cited in order of priority, uncertain climate (mean 2.96), lack of cash and credit to finance inputs (mean 2.78) and tractor unavailability when needed (mean 2.76). These risk sources have a direct bearing on adoption of new agricultural technology. Climatic conditions are beyond the farmers‘ control, and the top ranking probably reflects the farmers‘ concerns about the effects of recent drought in the former Ciskei homelands. These impacts negatively on crop yield. Due to communal land ownership and strict conditions for credit, farmers have limited options to obtain production credit from financial institutions. Among the sampled farmers only 21 farmers were able to access credit. Farmers in the study area lack collateral that is acceptable to banks. For example, banks required title deeds as proof of land ownership but the majority of black farmers in South Africa and especially in the former homelands still lacked this vital documentation. Tractor unavailability can be attributed to the fact that there is one tractor that has been allocated to the members of the irrigation scheme. The tractor is leased out at a rental fees. This poses a challenge during the land preparation phase when the demand for its services is at peak.

Similarly, smallholder farmers also ranked tractor not being available when needed (mean 2.89) and uncertain climate (mean 2.83) as identified sources of risk. The risk of delays in payment for products sent to pack house (mean 2.89) are attributed to various factors, among them the contractual obligation the agent has with the retailer which has a bearing on the duration of payment. Payment is only made to the farmer once the supply has been forwarded to the retailer and there is confirmation of the quantity of produce that has been rejected. The process flow delays payments to farmers. Non-organic farmers also cited uncertain climate (mean 2.82), livestock damage to crops (mean 2.80) and lack of cash and credit to finance farm inputs (mean 2.78). The livestock damage is a result of lack of fencing around the crops planted.

It is evident from the rankings in Table 7.4 that some of the sources of risk were common across the farmer groups. These include the uncertain climate and lack of cash and credit to finance inputs. All the farmer groups ranked cannot find labour lowest at a mean of 1.73 and 1.76 for homestead food gardeners and smallholder farmers respectively. This is a clear indication that labour is not a constraining factor in the study are and is relatively available. Similarly the smallholder farmers also ranked cannot access more crop land at a mean of 1.98. Lack of access to land was not identified as a major risk as land in the study area is readily available. The South African Government has made great strides through land reform programmes to ensure access to land for small emerging black farmers. The land reform programme remains a priority for the Government. The country's land reform programme has three pillars: (i) restitution, which seeks to restore land ownership or compensate those forced off land during white rule;

(ii) redistribution, of mainly agricultural land, to redress the discriminatory colonial and apartheid policies by providing the disadvantaged and poor with access to land; (iii) land tenure reform, which seeks to secure tenure for all South Africans, especially the more vulnerable, such as farm labourer tenants. The customary land system through the permission to occupy remains the basic system of land allocation.

Table 7.4: Identification of risk sources and rank

	Homestead food gardeners			Smallholder farmers		
Constraint	**Mean**	**Standard deviation**	**Rank**	**Mean**	**Standard deviation**	**Rank**
Livestock damage crops	2.56	.744	7	2.82	.488	4
Uncertain climate	2.96	.189	1	2.83	.409	3
Uncertain prices for products sold to packhouse	2.21	.793	13	2.13	.591	16
Uncertain prices for products sold to other markets	1.94	.811	17	2.02	.595	18
More work than the family can handle	2.58	.599	6	2.32	.688	12
Lack of cash and credit to finance inputs	2.78	.567	2	2.58	.615	6
Lack of information about producing organic crops	2.02	.687	15	2.20	.632	14
Lack of information about alternative markets	2.38	.623	10	2.29	.602	13
Lack of proper storage facilities	2.56	.660	7	2.46	.543	9
Lack of affordable transport for products	2.72	.492	4	2.42	.560	11
Lack of telephones to negotiate sales	2.69	.509	5	2.55	.633	8
Inputs not available at affordable prices	2.52	.642	9	2.80	.447	5
Tractor is not available when I need it	2.76	.501	3	2.89	.416	1

Note: mean score 1 (no problem) to 3 (severe problem) and Rank is in ascending order; 1 means most important and 20 least important

7.4.2. Principal component analysis of farmers' perceived sources of risk

The number of components was obtained by the Kaiser-Guttman rule. Table 7.5 below represents the Eigen value proportions of variance for selecting the optimal number of components. The correlation matrix shows that all of the estimated correlation coefficients between the sources of risk scores are less than 0.7 as articulated by Kim and Mueller (1994). Kim and Mueller (1994) state that the correlation coefficients are fairly robust with respect to ordinal distortions in measurements and such distortions can be restricted if; (i) PCA is used to find general dimensions of the variables in the data and (ii) the underlying correlation among the variables are less than 0.7.

Seven principal components (PCs) that explained 66.13% of the variance in the original scores were extracted from the covariance matrix using STATA 11 as reported in Table 7.5 below. Koutsoyiannis (1987) suggests retaining PCs that meet Kaiser's criterion: have Eigen values of one or above, have estimated component coefficients greater than 0.3, and can be meaningfully interpreted. The Eigen values for the seven PCs are all above one. Varimax rotation did not improve the interpretation of these PCs and the reported PCs are thus unrotated as explained in Norusis (2008). According to the factor loadings in Table 7.5, the factors 1 to 7 can best be described as 'financial and incentives index', 'input-output index', 'crop production index', ' labour bottleneck index', 'lack of production information index', 'lack of market opportunity index' and 'input availability index' respectively.

Principal Components 1: Financial and incentive index

The first principal component (PC1) explained 18.37% of the variance in the explanatory variables with all six estimated coefficients above 0.3 being positive. ‘Financial and incentive index’ = **(0.3281) ‘**uncertain prices for products sold to packhouse’ + **(0.3690) ‘**uncertain prices for products sold to other markets’ + **(0.3307)** ‘cannot find labour to hire’ + **(0.3734)** ‘lack of bargaining power over product prices at the packhouse’ + **(0.3706)** ‘lack of information about consumer preferences for our organic products’ + **(0.3594)** ‘packhouse does not reward me fully for my own product’. This index suggests that respondents who were concerned with uncertain prices for the formal and informal market options are also faced with the risk of labour unavailability as well as lack of bargaining power. These farmers are also concerned about the lack of information on consumer preferences and the ability of the pack house to give farmers incentives for production. According to Hough, Thompson, Strickland III and Gable (2008), buyers have a stronger competitive advantage when they can exercise bargaining leverage over price, quality, service or other terms of sale. This component seems to capture risks associated with financial or farmer liquidity and incentives.

Table 7.5 Estimated principal components for the sources of risk variables

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Proportion	**18.37**	**12.74**	**8.94**	**7.66**	**7.43**	**5.77**	**5.21**
Eigen Values	**3.6748**	**2.5483**	**1.7874**	**1.5325**	**1.4866**	**1.1538**	**1.0417**
Sources of risk	**Factor Loadings**						
Livestock damage crops	0.1100	-0.1156	**0.3452**	0.2196	0.2857	-0.0013	-0.2347
Uncertain climate	0.0757	0.0462	0.0187	-0.2487	**-0.4786**	-0.1421	0.2498
Uncertain prices for products sold to pack house	**0.3281**	-0.0683	-0.0500	0.0549	**-0.3858**	-0.0258	0.2812
Uncertain prices for products sold to other markets	**0.3690**	-0.1476	-0.0176	-0.0476	-0.0498	0.1235	-0.1389
More work than the family can handle	0.1083	0.0648	0.2948	**0.5425**	0.0253	0.1286	-0.0136
Lack of cash and credit to finance inputs	0.0279	**0.3881**	**0.3753**	-0.0694	0.1017	0.1417	0.0874
Lack of information about organic farming	0.1746	-0.0545	-0.0123	0.0754	**0.3494**	-0.1293	0.1272
Lack of information about alternative markets	0.2371	0.0901	0.1686	0.1849	0.0141	**0.5791**	-0.1677
Lack of proper storage facilities	-0.0776	**0.3881**	-0.2332	-0.0969	0.2711	-0.1649	-0.0234
Lack of affordable transport for products	0.0498	0.1455	**-0.4236**	0.2461	0.2707	0.1866	0.2077
Lack of telephones to negotiate sales	0.2397	-0.1594	0.0795	-0.2056	0.2309	**0.3997**	0.2935
Inputs not available at affordable prices	0.0256	0.2961	**0.4164**	0.1253	-0.1322	0.1380	**0.3008**
Tractor is not available when I need it	0.0195	0.2949	0.0251	-0.2040	0.2671	-0.2627	**0.4099**
Cannot find manure to purchase	0.0410	**0.4545**	-0.0444	0.0499	-0.2645	0.1226	-0.2108
Cannot find labour to hire	**0.3307**	-0.0497	0.2221	0.0955	-0.0049	**-0.3651**	-0.1058
Cannot access more cropland	0.1567	0.1187	0.2744	**-0.5214**	0.1259	0.0288	-0.1877
Delays in payment for products sent to pack-house	0.1748	**0.4314**	-0.1998	0.2250	-0.1263	-0.0296	-0.2235
Lack of bargaining power over product prices at the pack-house	**0.3734**	0.0006	-0.0859	-0.1015	0.0098	-0.1224	-0.2903
Lack of information about consumer preferences for our organic products	**0.3706**	0.0829	-0.0977	-0.0456	0.1177	**-0.3165**	-0.0481
Pack-house does not reward me fully for my own product	**0.3594**	-0.0640	-0.1541	0.1723	-0.0063	0.0119	**0.3410**

Principal Component 2: Input-output index

The second principal component (PC2) accounted for 12.74% of the variance in the explanatory variables.

'Input-output index' **= (0.3881) '**lack of cash and credit to finance inputs' + (**0.3881) '**lack of proper storage facilities' + **(0.4545) '**cannot find manure to purchase' + (**0.4314) '**delays in payment for products sent to pack house'.

The index shows that Homestead food gardeners and smallholder farmers, who rank lack of cash and credit to finance inputs as a source of risk, are also concerned with the lack of proper storage facilities to store their crops. These farmers also experience challenges to purchase manure for farming, and delays in payment for products that have been sent to the pack house. This component could be interpreted as reflecting input-output risk. Lack of liquidity may remain a risk in the short and medium-term as the rural farmers do not have collateral required by the financial institution for access to credit. Land is commonly used as collateral however, for these farmers; the system is characterized by indigenous communal land tenure, which commercial banks do not accept as collateral.

Principal Component 3: Crop production index

The third principal component (PC3) accounted for 8.94% of the variation.

'Crop production index' = **(0.3452) '**livestock damage crops' **+ (0.3753) '**lack of cash and credit to finance inputs' **- 0.4236 '**lack of affordable transport for products' + (**0.4164)** 'inputs not available at affordable prices'.

The index shows that farmers who strongly perceive livestock damage to crops as a major source of risk are also concerned about inputs not being available at affordable prices. Across the three farmer groups, lack of cash and credit to finance inputs was identified as a source of risk. However, these farmers did not perceive lack of affordable transport for products as a major risk. The latter can be attributed to the fact that the produce is collected at the farm gate and transport costs are limited to produce sold in the local market or surrounding farms. This dimension reflects a crop production risk.

<u>Principal Component 4: Labour bottleneck index</u>

The fourth component (PC4) explained 7.66% of the variance in the explanatory variables and implies a labour biottleneck risk.

'Labour bottleneck index' **= (0.5425) '**more work than the family can handle' **(0.5214) '**cannot access more cropland'.

More work than the household can handle was identified as a major risk. However lack of crop land was not perceived as a risk. The latter is due to the fact that land in the area is not a constraining factor and expansion of cropland is possible upon request to the local headman. On the other hand, farming is a labour intensive technology and would require more labour than conventional farming however the returns may be higher if farmers access the niche markets as is currently the case with the homestead food gardeners and smallholder farmers who are supplying an up market food retail store in Eastern Cape Province. The labour bottlenecks experience could also be attributed to increasing disability and ailments due to HIV/AIDS and outmigration of the youth. Parallel development especially in the mining and commercial sectors also raises agricultural labour costs.

<u>Principal Component 5: Production information index</u>

The fifth principal component (PC5) displays a variation of 7.43% in the farmers' rankings, and captures a lack of production information risk.

'Production Information index'= **-** (**0.4786) '**uncertain climate' **–** (**0.3858)** 'uncertain prices for products sold to packhouse' **+ (0.3494)** 'lack of information about producing organic crops'.

This risk is closely linked to weak support for extension services and advice to enable smallholder farmers to produce more food and reap greater benefits from their organic farming and harvest. The South Africa Government is in the process of revitalizing extension services to ensure access to information and improved agricultural practices among smallholder farmers especially in rural areas. Farm extension and rural advisory services occupy a strategic position in the agricultural production cycle. They link farmers to information about appropriate farming practices, when and what to plant, and how to use new technologies like seeds and soil management techniques developed by researchers. Extension service providers also pass on feedback from farmers to policy makers and help to ensure that government policies are effectively meeting the needs of farmers.

Principal Component 6: Market opportunity index

The sixth principal component is a lack of information about alternative markets risk and accounted for 5.77% of the variation in the farmers' scores for the sources of risk.

'Market information index' **= (0.5791) '**lack of information about alternative markets' **+ (0.3997)** 'lack of telephones to negotiate sales'c **(0.3651) '**cannot find labour to hire' **- (0.3165)** 'lack of information about consumer preferences for our organic products'.

What both —established and emerging black smallholders have in common though is that they farm mainly to add to household food security. Surplus production has remained rare in this rural context. Moreover, the accidental but limited excess farming output is usually sold in local markets (within the village or a nearby makeshift open/roadside market). Raising the general level of well-being of society is positively correlated with the rise and growth of markets. One implication of this hypothesis for smallholder farmers is that in order for them to raise the efficiency of their productive activities, they need to integrate into a system of market relations. The potential or real benefits of developing markets for smallholders are directly relevant to South Africa's second economy project because its primary goal is to craft a mix of strategies to uplift targeted underdeveloped regions (The Presidency 2008, 2007).

Principal Component 7: Input availability index

Finally the seventh principal component is an input availability risk and accounts for 5.21% of the variation.

'Input availability and incentive index' **= (0.3008) '**inputs not available at affordable price's **+ (0.4099) '**tractor is not available when I need it' **+ (0.3410) '**packhouse does not reward me fully for my own product'.

The farmers perceived lack of inputs at affordable prices, tractor not available when needed and little or no reward from the pack house as major risk sources. Lack of access to inputs and incentives is a deterrent to the development and growth of smallholder farming. According to the Southern African Trust (2009), Malawi is a great example of how government intervention prioritized smallholder farmers to overcome chronic hunger and achieve national food security. The government introduced a new agricultural growth policy focused on giving subsidized inputs to smallholder farmers. The subsidies have led to a significant boost in production to the extent that Malawi has been exporting surplus staple grains to countries facing a deficit within the Southern Africa region.

7.4.3. Relationship between perceptions of risk sources against farm and farmer socioeconomic characteristics

Relationships between the farmer's perceptions of sources of risk and the farm and farmer socioeconomic variables were determined using multiple regressions, the results of which are shown in Table 7.6. For each of the independent variables, the table depicts the partial regression coefficients and the levels of significance for the two-tailed t-tests. The goodness-of-fit of the models is indicated by adjusted R2. 221
In the regression analyses, multicollinearity among the independent variables was not found to be a problem (i.e. no variables have been omitted): Correlations were low, and nonlinear principal components analysis drawing on the work of (Gifi, 1990) for socioeconomic variables did not show strong relationships. The variance inflation factors as defined by (Hair, Anderson, Tatham and Black, 2006) had all values around 1. As shown in Table 7.6, the equations for 'Financial and Incentive', 'Input-output' and 'Labour bottlenecks' are statistically significant at a 1%, 1% and 5% level of significance respectively. The equations for 'crop production' and 'Input availability' are significant at less than 20%. All Durbin-Watson statistics for the six regression models ranged from 1.5 to 2.5, suggesting that autocorrelation is not a problem for these models (Table 7.6). The goodness of fit is fairly low as is the case for discrete choice models (Verbeek 2008).

Table 7.6: Results of multiple regressions for sources of risk against socio-economic variables

Independent Variables	Description of variable	Financial and Incentive	Input-output	Crop production	Labour bottlenecks	Production information	Market opportunity	Input availability
Constant		-1.35**	-0.362	-0.674	-1.202*	0.291	-0.638	0.1
Age	years	-0.004	0.008	-0.009	0.017**	-0.001	0.007	-0.01
Gender	male=0	-0.321	0.626***	0.52**	-0.127	-0.019	0.024	-0.194
Education	years	-0.013	0.065***	0.002	-0.046*	0.022	0.02	-0.026
Location	1=Battlefield ;2=Binfield ; 3=Melani 4=Numgwane	0.243***	-0.114*	0.074	0.073	-0.049	0.004	0.18**
Land Size	hectares	0.101	-0.084	0.086	-0.208**	-0.028	-0.079	-0.115
Information	hours	0.089***	-0.051***	0.021	0.03	-0.05**	-0.007	-0.008
Household size	number	0.032	0.029	0.028	-0.007	0.02	-0.012	-0.017
Household Income	rands/year	0.045	0.005	0.013	-0.004	-0.001	0.035	-0.008
Risk taking	1= less likely to take risk 2= More likely to take risk	0.05	-0.135	0.057	0.191*	0.064	0.002	0.117
Adj R2	0.223***		0.188***	0.048	0.12**	0.003	-0.070	0.028*
Durbin Watson statistics	1.464		1.785	1.632	1.642	2.147	2477	1.779

An analysis of the socio economic factors identified the following variables to have a significant effect on the various sources of risk: age, gender, education, location, information access and risk taking ability (table 7.6). Older farmers were concerned about the availability of labour while female farmers considered input-output risk and crop production risks as significant and relevant. Farmers residing in the areas of Battlefield and Binfield sub-wards were more concerned about financial and incentive risk as well as input availability. These farmers have limited access to financial resources and incentives for production while farmers residing in the pioneer organic area of Melani considered input-output risk as less relevant. Farmers with access to information perceived input output risk and crop production risks as less relevant but financial and incentive risk are significant and more relevant. Farmers who were more likely to take risk perceived labour bottleneck risks as much less relevant.

7.4.4. Risk management strategies used by farmers

The production, financial, market and institutional risks, along with a farmer‘s attitude toward risk, have a major impact on the choice of risk management strategies and tools (Shapiro *et al*., 1993). Risk sources cause adversity in yield, prices and production units (Anderson *et al*., 1985). Each or any combination of the outcomes of the risk sources may lead to low or declining farm income. There are several strategies that farm operators can use to reduce the farm exposure to risks. The strategies can be classified into modern and traditional risk management tools (Harwood *et al*., 1999). The modern instruments include crop insurance, forward contract and futures, among others (Goodwood and Ker, 1998). In the absence of modern risk management tools especially among rural smallholder farmers, farmers can rely on some traditional strategies to deal with risk. This section summarizes the most important traditional risk management strategies used by the surveyed farmers in Eastern Cape Province. These are crop diversification, precautionary savings and participating in social network.

Diversification is a frequently used risk management strategy that involves participating in more than one activity. The motivation for diversifying is based on the idea that returns from various enterprises do not move up and down in lockstep, so that when one activity has low returns, other activities would likely have higher returns. The extent to which a farmer uses on-farm diversification as a risk management strategy was measured using the Enterprise Diversification Index (EDI) also referred to as the Herfindahl Index (DH). Enterprise diversification is a self-insuring strategy used by farmers to protect against risk (Bradshaw, 2004).

The proportion of farmers using different risk management strategies are presented in Table 7.7. The overall Herfindahl index of crop diversification is estimated at 0.61 which indicates that the cropping system is relatively diverse (Table 7.7). These results confirm previous findings by Rahman (2009) who obtained an estimated DH of 0.49-0.69 among smallholder farmers in three regions in Bangladesh. As shown in Table 7.7, non-organic farmers practiced more crop diversification with a DH index of 0.23 compared to organic farmers with a DH index of 0.72. These results are consistent with previous findings in this study measuring farmers risk attitudes and p that established that smallholder farmers in the study area tend to diversify due to their risk averse nature and that smallholder farmers are more risk averse than homestead food gardeners.

Table 7.7 Risk management strategies used by the different farmer groups

Risk Management Strategy	Homestead food gardeners	Smallholder farmers
Enterprise diversification index (DH)	0.7220	0.8962
Practice crop diversification (% of respondents)	69.1	81.2
Savings (% of respondents) Savings bank account	60.9	48.9
Current level of savings[6] (% of respondents) less than R500 R501 – R1000 R1001 – R5000 More than 5000	 27.27 45.45 21.21 6.07	 37.84 29.73 29.73 2.70
Social networks (% of respondents) Membership of EFO Others (burial clubs, *stockvel*[7])	 100 33	 100 25

Precautionary saving occurs in response to risk and uncertainty (Feigenbaum, 2011). The smallholder farmers' precautionary motive was to delay/minimise consumption and save in the current period due to their lack of crop insurance markets. According to Cunha, Heckman and Navarro (2005) the quantitative significance of precautionary saving depends on how much risk consumers face. Whereas 60.9% of the Homestead food gardenerers had savings bank accounts, only 48.9% smallholder farmers had bank accounts. The current level of saving in the study area was low with savings ranging from less than R500 to over R5000 per month. The level of savings was low across all groups. Among the homestead food gardeners group, most of the respondents (45.45%) saved between R1000-R5001 whereas most of the partially-certified farmers (37.84%) saved less than R500 per month. Most of the non-organic farmers (41.18%) saved between R501-R1000 per month. Across all groups, however the level of saving greater than R5000 was minimal.

The farmers also engage in social networks as a risk sharing strategy. There were two main categories of social networks that the farmers engaged in. These are farmers association and other social networks most notably burial clubs and *stockvels*. The farmers association is used as a vehicle by the homestead food gardeners to gain access to markets for their produce while the burial clubs and *stockvels* are sources of access to credit and/or loans. In the latter instance, farmers do not have to produce collateral. The burial clubs and *stockvels* are common in most rural areas and are a source of mitigating liquidity and financial risk where possible.

7.5. Chapter summary

The results of the risk aversion classification show that the distribution of responses was spread across all classes of risk aversion for the pooled data. It can be noted that the majority of the respondents revealed their preference for prospects representing intermediate and moderate risk aversion alternatives across the farmer groups and on average. These results conform to *a priori* expectations where smallholder farmers are expected to be more risk averse than homestead food gardeners. A comparison of the findings of this study against similar studies showed that the findings of the South African study are in tandem with findings of the studies conducted in India, Philippines, Zambia and Côte d'Ivoire where the majority of the respondents were classified as intermediate to moderate risk aversion.

In general price, production and financial risks were perceived as the most important sources of risk. These were identified across the farmer groups as: uncertain climate, lack of cash and credit to finance inputs; tractor is not available when needed, delays in payment for products sent to pack house and livestock damage to crops. Seven principal components (PCs) that explained 66.13% of the variance in the original scores were extracted namely: the 'financial and incentives index', 'input-output index', 'crop production index', 'labour bottleneck index', 'lack of production information index', 'lack of market opportunity index', and 'input availability index'.

An analysis of the socio-economic factors identified the following variables to have a significant effect on the various sources of risk: age, gender, education, location, and information access and risk-taking ability. Older farmers were concerned about the availability of labour while female farmers considered input-output risk and crop production risks as significant and relevant. Farmers residing in the areas of Binfield and Battlefield sub-wards were more concerned about financial and incentive risk as well as input availability. These farmers have limited access to financial resources and incentives for production while farmers residing in the pioneer areas of Melani considered input-output risk as less relevant. Farmers with access to information perceived input output risk and crop production risks as less relevant but financial and incentive risk are significant and more relevant. Farmers who were more likely to take risk perceived labour bottleneck risks as much less relevant.

The most important traditional risk management strategies used by the surveyed farmers in rural Eastern Cape are identified as crop diversification, precautionary savings and participating in social network. Enterprise diversification is a self-insuring strategy used by farmers to protect against risk (Bradshaw, 2004). According to Cunha, Heckman and Navarro (2005) the quantitative significance of precautionary saving depends on how much risk consumers face. There were two main categories of social networks that the farmers engaged in. These are farmers association and most notably burial clubs and *stockvels*. The findings are consistent with economic theory which postulates that in the absence of insurance markets, poor farm households tend to be risk averse and are reluctant to participate in farm investment decisions that are uncertain or involve high risk.

CHAPTER 8

SUMMARY, CONCLUSION AND RECOMMENDATION

8.1. Introduction

This thesis is structured in eight (8) chapters that address the introduction and background to the study, literature review that covers the state of agriculture globally and in South Africa, agricultural technology adoption, risk and risk management, methodology, results and discussions and culminates in the summary and recommendations. The chapter begins with a summary of the introduction focusing mainly on the background, problem statement, research objectives and significance of the study. The summary on the state of agriculture underlines the global perspective with reference to the food and agricultural crisis and the response to this crisis. The summary on agricultural technology adoption in South Africa is also presented covering different adoption related issues. Further to this, an overview of risk and risk management is presented. The methodology has been summarized with regard to the study area, sampling procedure, data collection methods and instruments, variable specification and models for data analysis. The summary on the presentation of the results constitutes the determinants of technology adoption among smallholder farmers, risk and risk management by smallholder farmers. This culminates into recommendations that address the policy implications and areas for further research

8.2. Summary

The summary contextualizes the study by highlighting the state of agriculture, agricultural technology adoption, risk and risk management. Furthermore, it also gives an overview of the methodology used in the study and the results. The results highlight the outcome of analysis for the various models. These establish the determinants of risk and risk management by smallholder farmers and homestead food gardeners. The recommendation of the study outlines the policy implications and areas for further studies.

8.2.1. The state of agriculture

The World Bank (2010) noted that food and nutritional security remain an issue of major global concern especially in developing countries. The global food and agricultural crisis which resulted in a sharp rise in food prices in 2007- 2008 further exacerbated the situation of the vulnerable and drew attention to the imperative to examine alternative food production questions. Because this global food crisis was widely attributed to the failure of food supply to meet rising demand, it prompted a number of high profile international initiatives to expand the global supply of food as well as its availability to poorer countries where chronic underinvestment in the agricultural sector has continued (FAO 2009b).

IFAD (2009a) has identified smallholder agriculture as the key to local and global food security and the engine for development and economic growth for most developing countries. Dano (2009) argues for a truly *green* revolution‖ in Africa, based on traditional and local knowledge, integrating smallholder‘s expertise and needs and taking into account regional diversities. Organic agriculture has been identified as one of the sustainable approaches to farming which offers insights towards a paradigm shift in food and nutritional security (Byerlee and Alex, 2005). The UNEP-UNCTAD, (2007) indicates that organic agriculture offers developing countries a wide range of economic, environmental, social and cultural benefits.

The global markets for organic products have also grown rapidly over the past two decades (Sahota, 2011). Currently 32.2 million ha are being managed organically worldwide by more than 1.2 million producers (Willer and Klicher, 2009). In Africa, South Africa has the third largest area (50,000ha) under organic farming (Willer and Klicher, 2009). Organic production is particularly well-suited for smallholder farmers, who comprise the majority of the world's poor. It builds on and keeps alive their rich heritage of traditional knowledge and traditional land races. It has also been observed to strengthen communities and give youth incentive to keep farming, thus reducing rural-urban migration. In rural South Africa, Aliber *et al.* (2009) reported that the majority of smallholder farmers ‘goals are predominantly cultivating food crops for home consumption with less emphasis on generating farm incomes. Smallholders ‘less emphasis on farming as business may influence farmer‘s decision to cultivate small-plot with minimal investment leading to low productivity and marketable surplus (Padilla-Fernandez and Nuthall, 2001; Maskey, Lawler and Batey, 2010). According to Aliber *et al.* (2009), smallholder farmers'output in South Africa contribute negligibly to the nation agricultural GDP although they are still regarded important for sustainable food security and self-employment among rural resource-poor households.

Despite the positive contributions to increased food security and employment, smallholder agriculture is faced with numerous challenges resulting from social, political, economic and environmental factors (Ortmann and King, 2010). According to Obi (2011), subsistence farmers, especially in the former independent homelands of South Africa, are locked in low productive traditional technologies. Like most rural farmers in Sub Saharan Africa, smallholder farmers in South Africa are faced with challenges such as lack of access to factors of production (mainly land and water), lack of access to credit, and limited technology accessibility and applicability (Spio, 1997). Poor rural farmers are also faced with high transaction costs associated with input/output markets and lack market information which may be as a result of poor infrastructures (Ortmann and King, 2010).
Agriculture is also faced with risks associated with climate change. Globally, climate change has led to extreme temperatures and less rainfall resulting in water shortage (NCCR, 2012). Atmospheric accumulation of greenhouse gas emissions caused by use of fossil fuels, increased population growth, and economic activities are some of the major factors responsible for increasing rate of climate change (Ancharaz and Sultan, 2010; and Vanhove and Van Damme, 2011). Global temperature is expected to rise by 1 or 2°C in the first half of the 21st century and this would lead to decreased crop yields especially in the semi-arid and tropical regions (Ancharaz and Sultan, 2010; and Vanhove and Van Damme, 2011).

The overall objective of this research is to determine risk preference patterns and attitudes that influence the transition from homestead food gardening to irrigate farming of smallholder farming systems in the Eastern Cape province of South Africa. Specifically the study will pursue the following objectives: (i) To describe the demographic and socio-economic characteristics of smallholder farmers; (ii) existing farming systems among smallholder farmers in the study area; (iii)Analyse the adoption of new agricultural technology by smallholder irrigation farmers; (iv)Assess the risk perception of smallholder irrigation farmers;To elicit farmers risk preferences (v)and empirically analyse farmers sources of risk and risk management strategies.

The outcome of which will inform make policy recommendations that have an implication on technology adoption, increase smallholders capacity to bear risk and enable government and other role players have a clear understanding of smallholder farmers decisions.

8.2.2. Agricultural technology adoption

The literature reviews and summarises the basic concepts and theoretical foundations to technology adoption as well as the factors affecting adoption of agricultural technologies. These include age, gender, education and training, household size, farm size, liquidity and income, land tenure security, location, risk attitudes, extension services, social capital and cooperatives and livestock ownership. The mode and sequence of agricultural technology adoption is presented as is the barriers to the adoption of agricultural technologies. Further information is reviewed on the commercialisation of smallholder farmers. Approaches used to model adoption including non parametric and econometric models are reviewed and presented.

8.2.3. Risk and risk management

The study further lays the foundation for risk in agriculture and its importance in agricultural economics research as risk and uncertainty are pervasive characteristics in agriculture and the basis for decision making. A critical analysis is made of the sources of risk in agriculture and management strategies based on empirical studies. The foundation of the expected utility theory as articulated by von Neumann Morgenstern is presented and measure of risk aversion of producers is presented. The latter are the Arrow Pratt Absolute Risk Aversion, Arrow Pratt Relative Risk aversion and the Partial Risk Aversion. The literature behind the importance of adjusting the Arrow Pratt Absolute Risk Aversion is argued in this section. A review is done of the three methods for measuring risk attitudes among agricultural producers. These are the direct estimation of utility function, experimental methods and the observed economic behaviour. Furthermore, studies that elicit and analyse farmers risk preference in developing countries and in South Africa are discussed.

8.2.4. Methodology

The study was carried out in the provinces of KwaZulu-Natal and the Eastern Cape. The selected study area is in the rural former Ciskei homelands, in the Amathole District, Nkonkobe Local Municipality of Eastern Cape Province in South Africa. A total of 101 respondents are surveyed consisting of 38 smallholder farmers and 68 homestead food gardeners in the Eastern Cape Provinces. The survey was conducted in July- August .smallholder and household structured questionnaires were used to record household activities, socio-economic and institutional data as well as household demographics through personal interviews. The Arrow Pratt Absolute Risk Aversion (APARA) coefficient was used to measure the farmer‘s degree of risk aversion and the experimental gambling approach to establish the risk classification. The respondents were also asked about their knowledge about new agricultural technology, attitudes and perceptions towards technology, preference and patterns. Models used in the analysis of data presented theoretically and mathematically were (i) ordered probit model, (ii) principal component analysis, (iii) ordinary least square model, (iv) binary logistic model, and the (iv) discriminant analysis model.

8.2.5 Determinants of new agricultural technology adoption among smallholder farmers

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 farmers‘ risk preference status. The ordered probit model successfully estimated the significant variables associated with the farmer‘s adoption decisions. These were the farmer‘s age, household size, land size, locational setting, risk attitude, number of livestock (goats and chicken) and asset ownership. Homestead food gardeners were less risk averse that the smallholder farmers. Farmers who reside in the sub-wards Binfield, and battlefield were more likely to take risk than those who reside in Melani. This suggests the presence of local synergies in adoption which raises the question about the extent to which ignoring these influences biases policy conclusions. The negative correlation between land size and adoption implies that smaller farms appear to have greater propensity for adoption of new agricultural technology. This finding is supported by several studies reviewed in the literature that allude to the fact that homestead food gardeners tend to be smaller than smallholder farmers.

The significance of livestock is explained by the importance of manure for farming. The study also found that older farmers tend to be adopters supporting findings by Feng and Chenqi (2010). The average age of the farmers in the study area is over 50 years lending credence to the argument that young people tend to shun farming especially in rural areas. When farmers have security of land tenure the propensity to adopt certified organic farming is higher. A larger family size is more conducive to adoption of certified organic farming which is a labour intensive technology (OECD, 2000). The propensity to adopt was also positively influenced by asset index which is a proxy for wealth.

8.2.6. Risk and risk management by smallholder farmers

Farmers‘risk preferences were spread across all classes of risk aversion. The majority revealed their preference for prospects representing intermediate and moderate risk aversion alternatives. Smallholder farmers represented the highest percentage of respondents classified at extremely risk averse both within (24%) and across (56%) farmer groups. This may explain why they have not adopted new agricultural technology despite certification being introduced in the area since year 2000. Comparing the results from this study to the Ethiopian, Zambian, Côte d‘Ivoire and Indian experiments, it is found that the proportion of farmers falling in the extreme to severe risk category to be higher in the Ethiopian experiment, but lower in the Zambian, Côte d‘Ivoire and Indian case. The results from this study suggest that farm households in KwaZulu-Natal are less risk averse than in Ethiopia, Zambia and Côte d‘Ivoire but are much more risk averse than in India and Philippines. The findings are in tandem with findings of the studies done in India, Philippines, Zambia and Côte d‘Ivoire where the majority of the respondents are classified as intermediate to moderate risk aversion.

Seven principal components (PCs) that explained 66.13% of the variation were extracted. According to the loadings, the factors 1 to 7 can best be described as ‘financial and incentives index’, ‘input-output index’, ‘crop production index’, ‘ labour bottleneck index’, ‘lack of production information index’, ‘ lack of market opportunity index’, and ‘input availability index’ respectively. In general, price, production and financial risks were perceived as the most important sources of risk. Socio economic factors having a significant effect on the various sources of risk are age, gender, education, location, information access and risk taking ability. The most important traditional risk management strategies used by the surveyed smallholder farmers in eastern Cape are crop diversification, precautionary savings and participating in social network. The findings are consistent with economic theory which postulates that in the absence of insurance markets, poor farm households tend to be risk averse and are reluctant to participate in farm investment decisions that are uncertain or involve higher risk.

8.3. Recommendation

Today, Africa appears to have a monopoly on poverty and hunger. New technologies and access to seeds and inputs and better management practices are critical to changing this situation, but they are by no means sufficient. To unlock the potential of smallholder farmers to fight hunger and food insecurity, and to bring prosperity, these innovations must reach farmers. Investment in research and technology development is critical in transforming Africa's agriculture. From the summary findings presented above policy proposals and areas for further research are presented below.

8.3.1. Policy implications

This study sought to identify among others, independent variables that explain the adoption of new agricultural technology and thereby facilitate policy prescriptions to augment adoption in South Africa and around the world. The technology adoption analysis of the independent variables used in the ordered probit analysis revealed some underlying patterns of influence. Given the limited prospect of identifying such variables through further research, it is concluded that efforts to promote new agricultural technology will have to be tailored to reflect the particular conditions of individual locales. The propensity of adoption decisions by neighbourhoods to affect others must be given due importance, for price marketing, extension delivery and development purposes, while delineating target domains for introducing new technologies especially where resources are limited. An insight into the sources of risk has clear implications as to how the perceived riskiness of new agricultural technology may be reduced, thus increasing the likelihood that relatively more risk averse farmers will adopt to new agricultural technology.

Nevertheless, the adoption of farming technologies, productivity and growth is a dynamic process that requires persistent research and development programmes. Therefore to maintain and further improve productivity and growth, there should be continued investment in agricultural research aimed at generating new and improving old technologies that could shift the production frontiers and improve the efficiency of input use. Research and development programmes can be undertaken by Government, development agencies and or research institutions. This will provide a basis for knowledge dissemination and documentation.

Identified sources of risk faced by smallholder farmers provide useful insights for policy makers, advisers, developers and sellers of risk management strategies. This information can yield substantial payouts in terms of the development of quality farm management and education programs as well as the design of more effective government policies. New technologies and rural development programs need to be tailored to the risk attitudes of a particular group of farmers if they are going to be effective. Due to the risk aversion nature of these smallholder farmers, policy makers need to develop strategies that enable them better manage and reduce risk while mitigating against the identified sources of risk.

Some of the sources of risk were common across the farmer groups. These include the uncertain climate and lack of cash and credit to finance inputs. This shows that communication and joint-problem solving may help to address some of the challenges. Investment in water harvesting technologies will ensure availability of water throughout the growing season and alleviate the risk associated with drought. Agricultural credit should be extended to farmers through service cooperatives and extension programmes. Input credit should be widely applied to enable farmers adopt improved agricultural technologies and more especially organic farming where the provision of cash credit services is limited.

While lack of liquidity may remain a risk in the short and medium-term for rural farmers, alternative sources of fund need to be considered through lobbying government to assist with legislation on the acceptance of Permission to Occupy (PTO) documentation as legitimate proof of ownership. Farmers can also access credit through Small Enterprise Development Agency (SEDA) that funds cooperatives and other legally registered farming organizations. Upgrading storage facilities should start at farm level to retail level to increase the shelf life of the produce and also ensure price stability. Improving the efficiency of the distribution channels and forward linkages will result in better turn around time for payment.

According to Hough, Thompson, Strickland III and Gable (2008), buyers have a stronger competitive advantage when they can exercise bargaining leverage over price, quality, service or other terms of sale. This component seems to capture risks associated with production and marketing by the smallholder farmers. These farmers should consider targeting the niche of health conscious consumers in order to obtain premium prices associated with certified organic produce. Smallholder farmers through their farmer association should exercise their bargaining power as a social network entity in order to influence better prices for producers.

Similarly, contract farming will limit the risk associated with unreliable market and prices for producers while buyers will have a guaranteed supply of produce. More information on market and consumer preferences would enable the farmers better understand how to meet market demand. It is important to note that while information on organic production and marketing are readily available at the Department of Agriculture, South Africa and on the internet through various economic bureaus, the challenge remains accessibility, packaging and dissemination to smallholder farmers. This could be addressed through the use of extension agents, farmer field days and forums for information exchange.

The smallholder farmers could also work with the retailers to identify new crops for production in order to increase the opportunity for these farmers to diversify their enterprise mix. The absence of insurance and credit markets has a bearing on the farmers risk behaviour and management strategies. Hence supplementary policy interventions that are aimed at improving access to credit and markets will reduce poverty and impact on risk behaviour of farm households. In the long run, broad based economic development including the development of credit an insurance markets is the most certain way to correct the existing imperfections and reduce the level of risk aversion among farmers. There is also a need for the development and investment in new technical packages which enable yield to withstand unexpected changes in weather condition and are highly reliable in on-farm practice.

8.3.2. Improving Land acquisition

Land acquisition was cited as a major hindrance for homestead food gardeners‘ participation in irrigation farming yet findings indicated that a unit increase in farm land result into a significant increase in maize and cabbage production. Therefore, policies that will ease access to land for the smallholder farmers especially on the irrigation plots and expansion of irrigated farm land should be encouraged. Contrary, the large part of potential arable land on the irrigation schemes especially at Melani is idle while some families are striving to have access to this land. Managers of the irrigation schemes were of the view to redistribute the land to families who have interests in farming. However, the land problem is still complex due to contradicting interests between the state and the traditional chiefs. Thus, the land redistribution should be a participatory exercise which incorporates all stakeholders‘ interests.

Increased population at Binfield and Battlefield resulted into more subdivision of land to small plots (0.25ha) which can hardly produce enough farm output to cater for the household food requirement and marketable surplus. Therefore, more land should be availed to smallholder irrigators to induce the desired agricultural transformation and development. This can be done by re-organizing the land size holdings to make smallholder farming more economic through catalysing the programme of land redistribution or resettlement. Due to the land acquisition problems, farmers are encouraged to expand their farming activities by utilizing both the homestead food gardens and irrigation plots. Caution should be considered that improved access to land as a single entity may not automatically result into increased marketable surplus but rather farmers need to be supported financially for acquisition of capital and build their capacity in farm management and marketing.

8.3.3. Further research

Further research on the following aspects is necessary

Formal risk management strategies: The purpose of formal risk-management strategies is to enable investment in more profitable activities through transparent sharing of risk. Most modern risk-avoidance measures are not readily available in developing countries. Hence, farmers in these regions are obliged to adopt traditional informal mechanisms for coping with risk, as was identified in this study. The role of the government to promote insurance provision to the poor through relevant regulatory framework as well as provide credibility to the overall system of social protection should be explored. Research in this area could also include the role of microfinance institutions within a partner-agent setup, smallholder farmers' willingness to take up formal insurance and their insurance purchase decisions as well as the cost effectiveness of these insurance options.

Efficacy of extension services: The role of extension services particularly in rural areas cannot be ignored. Limited extension service in the study area was evident as the main source of information on organic farming is from fellow farmers. An in-depth study on the current state and efficiency of agricultural extension services 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 agriculture in South Africa.

The farmers can also adapt to the use of draught power for ploughing and transporting goods from the field to their homes or the markets. This will help reduce costs of hiring a tractor since it is generally expensive and impossible for some farmers to hire tractor due to lack of funds. Despite the costs, they are few tractors available for high meaning that they cannot cater for the high demand in tractor use, in other words this makes draught power a better option. Furthermore the researcher recommends that farmers can have more access to market information so that they can be able to sell they produce at the current prices and also to be able to know the products that are one demand.

8.4. Conclusion

The South African smallholder agricultural industry has been identified as a major source of livelihood for the rural poor households despite its low and declining performance in terms of productivity. Due to government recognition of its importance, several attempts have been made to save its pathetic performance in the face of increasing food insecurity, unemployment and wide spread poverty as observed at Melani irrigation scheme. Despite the government efforts, the transition of smallholder farmers from low subsistence to smallholder commercial farming is slow. In the context of this study it was apt to establish the general performance of the smallholder farmers and the role of the intangible human dimensional capital in the transition from subsistence to smallholder irrigation commercial farming.

The transition from subsistence homestead food gardening to smallholder irrigation commercial farming for improved incomes, employment and poverty alleviation among the rural poor is inevitable. The findings of this study indicate that smallholder irrigators harvest more output and earn more incomes from maize and cabbage enterprise than homestead food gardeners. Furthermore, smallholder irrigators are more economically efficient and this provides a better future for increased marketable output and household incomes thereby reducing unemployment and poverty. However, the future performance of the smallholder agricultural industry is doomed to collapse due to low participation of youths as the aged generation fades away. This may worsen the situation by increasing food insecurity, unemployment and increased poverty levels in the face of increasing population. Insecure land tenure, rigid land markets and lack of access to farm land especially on the irrigation schemes is also a threat for the transition. Based on the findings extension services especially in terms of capacity building is desperately lacking and may hamper the intended transformation of the sector. In addition, monetization of agricultural production with insufficient provision of input subsides especially among the resourced poor smallholders is another threat for the declining productivity and increased food insecurity in rural communities.

Today, Africa appears to have a monopoly on poverty and hunger. New technologies and access to seeds and inputs and better management practices are critical to changing this situation, but they are by no means sufficient. To unlock the potential of smallholder farmers to fight hunger and food insecurity, and to bring prosperity, these innovations must reach farmers. Investment in research and technology development is critical in transforming Africa's agriculture.

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APPENDIX

Appendix I- Questionnaire

UNIVERSITY OF FORT HARE,

DEPARTMENT OF AGRICULTURAL ECONOMICS

Risk preferences of smallholder irrigation farmers in the former Ciskei Homelands of the Eastern Cape, South Africa

Questionnaire number [ ] Name of Interviewer [ ] Local Municipality [ ]

Village [ ] Smallholder irrigation farmer [ ] Homestead food gardener [ ]

A.HOUSEHOLD DEMOGRAPHIC INFORMATION

Position in the household	Head	Spouse	Child	Child	Other	Other	Other	Other	Other
1. Gender	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]	**M** [ ] **F** [ ]
2. Age in years									
3. Highest level of education **1-No formal Education** **2-Primary** **3-Secondary** **4-Tertiary** **5-Others**									
4. Occupation **1-Retired** **2-Unemployed** **3- Farmer** **4- Employee**									

5- Self employed **6- School/ pre-school**									
5. Salary income (R / mon)									

B. LAND USE AND ACCESS

6. Type of plot 1-Homestead (Water source – e.g. tap at home, communal tap, borehole spring etc) 2-Irrigated land (fields) (Water source, reliability, quantity, timing) 3-Dry land	Size and number (Hectares, acres, square meters	Tenure system 1-Own 2-(communal) 3-Lease 4-Other (Specify)	Time (yrs) for which tenure has been held?	Fees(R) (For water, for land. Specify how much and to whom)				Ploughing Method 1-Own tractor (specify whether hire it out, price, average income) 2-Hire tractor, price, 3-Hand tools 4-Employ labour (specify times, number of people and rates)
				water (R)		land (R)		
				Price (R)	To who	Price (R)	To who	

C. PRODUCTION INFORMATION

7. Fill in the following information on production

Crop name	Area Planted (ha, square metres, acres…..)	Quantity harvested (Specify unit; tons, kg, bags	Unit price (Selling price) (R)	Quantity sold (specify unit e.g. kgs.bags, packets)	Quantity 1.consumed 2.bartered 3.donated specify which (specify unit e.g. kgs.bags, packets)	Market outlet 1-local 2-shop 3-neighbours 4-hawkers, 5-contractor, 6-other	Season Planted 1-Summer 2-Autumn 3-winter 4-spring	Times Planted a year
1-Maize								
2-Spinach								
3-Carrots								
4-Cabbage								
5-Tomatoes								
6-Potatoes								
7- Other (Specify)								

D. IRRIGATION AND SOURCES OF WATER (Please tick the appropriate answer)

8. Are you are member of an irrigation scheme? Yes ☐ No ☐

9. Where do you obtain water for irrigation? a. Dam ☐ b. River ☐ c. Borehole ☐ d. taps ☐

e. harvested water ☐ f. Individual tanks ☐ g. other Specify-----------------------

10. Do you pay for water? a. Yes ☐ b. No ☐

11. If yes, how much(R) is the rate? ☐

12. Which type of irrigation system do you use? a. Sprinkler ☐ b. Drip irrigation ☐
c. Furrowing irrigation ☐

d. Pivot ☐ e. Others (specify) ☐

E. FINANCIALS

13. Credit and cash loans

A. Amount of cash Borrowed/ credit used	**Tick**	**Main purpose of the loan/ credit**	**Tick**	**Source of Credit**	**Tick**	**Financial Security**	**Tick**
1.Less than R5000		**1.Family support**		**1.Bank**		**1.Insurance**	
2.R 5001- R10 000		**2.Education of Children**		**2.Lender**		**2.Other (Specify)**	
3.R10 001- R15 000		**3.Inputs**		**3.Governmantal Institutions**			

4.R15 001- R20 000		**4.Other (specify)**		**4. Other (Specify)**		
5.R20 001- R25 000						

F. RISK

14. Rank the following sources of risk from 1 to 3 where 1 is no problem and 3 is a severe problem (tick where appropriate)

Constraint	**1 No problem**	**2 minor**	**3 severe**	**Constraint**	**1 No problem**	**2 minor**	**3 severe**
1. Livestock damage crops				**9. Inputs not available at affordable prices**			
2. Uncertain climate (e.g. draught)				**10. Tractor is not available**			
3. Uncertain prices for products sold to markets				**11. Cannot find labour to hire**			
4. More work than the family can handle				**12.Cannot access more crop land**			
5. Lack of cash and credit to finance inputs				**13.Delays in payment for products**			
6. Lack of information about producing crops				**14. Lack of proper transport for products)**			
7. Lack of information about alternative markets				**15.Other (specify**			
8. Lack of proper storage facilities							

15. Compared to other household decision makers in the area, are you more likely, less likely or equally likely to take risks?

a. More likely ☐ **b. Less likely** ☐ **c. equally likel** ☐

16. If a new farming technology (e.g. a new variety of seeds) were available, compared to other farmers in this area, would you be:

a. Early adopter ☐ **b. Would you wait and see attitud** ☐

17. The table below lists the six choices, each gamble with an equal chance of realizing the lower or higher pay off. Indicate which of the six choices you would most prefer: A, B, C, D, E or F

CHOICE	PAYOFF1(RANDS)	PAYOFF 2 (RANDS)
☐ A	100	100
☐ B	90	180
☐ C	80	240
☐ D	60	300
☐ E	20	380
☐ F	0	400

18. If you are faced with an option to take a gamble or the option to receive a sure amount of money, which do you prefer?

☐ **Option 1: A coin is tossed:** TAIL: You win R380 HEAD: You win 20

☐ **Option 2**

R220	R200	R180	R160	R140	R120	R80

19. Please consider the gambles below: which of the two gambles would you rather play?

Option A	Option B
☐ 50% chance to win R100 50% chance to lose R15	☐ 90% chance to win R100 10% chance to lose R10

20. Please consider the options below: which one is more attractive?

Option A	Option B
☐ Receive R250 today	☐ Receive R300 in a week

21. If you are faced with an option to take a gamble or the option to receive a sure amount of money, would you play this game?

Heads	Tails	Yes	No
Loose R50	Win R 100		
Loose R60	Win R 100		
Loose R70	Win R 100		
Loose R80	Win R 100		
Loose R90	Win R 100		
Loose R100	Win R 100		
Loose R150	Win R 100		