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Barriers and Incentives to Potential Adoption of Biofuel Crops by Smallholder Farmers in selected areas in the Chris Hani and O.R Tambo District Municipalities, South Africa

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A Thesis Submitted in the Fulfilment of the Requirement for the Degree of Master of Agriculture in Agriculture Economics

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ABSTRACT

Since the launch of the Biofuels Industrial Strategy in 2007 by the South African government, only a few smallholder farmers have adopted biofuels for production. The government hopes to stimulate economic development and alleviate poverty by targeting areas that were previously neglected for agriculture by the apartheid government. However, there still appears to be a lack of a clear and comprehensive policy framework for the development of a South African biofuel industry, because the proposed initiatives have not been implemented to date. There are also concerns among stakeholders that government policy is taking too long to formulate, compounding existing uncertainty in the industry.

This study therefore aims to identify barriers and incentives that influence the potential adoption of biofuel crops in selected areas in the Eastern Cape Province, South Africa. The study utilised a semi-structured questionnaire to record responses from 129 smallholder farmers that were identified through a snowballing sampling technique. Descriptive statistical analysis and a Heckman two-step model were applied to analyse the data. Analysis was done using SPSS 21 and EViews 8.

Results obtained showed that the variables: arable land, incentives offered, challenges faced, labour source and farm experience were statistical significant at 5 or 10 percent ***p value*** to awareness of farmers to biofuel crops. Adoption of biofuel crops was statistically related to gender, qualification, membership to association and household size. The study recommends that the Biofuels Industrial Strategy Policy be revisited in order to have a mechanism of including smallholder farmers that it aims to empower with employment and improvement in their livelihoods. The government can help smallholder farmers by addressing the challenges they face in improving their output. Furthermore, it recommends that a national study on barriers and incentives that influence the adoption of biofuel crops be carried out in order to identify other factors that may hinder the Biofuels Strategy Policy aims in empowering the disadvantaged farmers.

Key words: Barriers, Incentives, Adoption, South Africa, Biofuels, Smallholder

DEDICATION

To my mother Mrs I Cheteni and to my late father Mr J Cheteni, and brothers and sisters who have immeasurable faith in me. I love you all.

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ACRONYMS

BIS	Biofuel Industrial Strategy
FAO	Food and Agriculture Organisation
DME	Department of Mineral and Energy
ISRDS	Integrated Sustainable Rural Development Strategy
SPSS	Statistical Package for Social Scientists
REEEP	Renewable Energy and Energy Efficiency Partnership
CHDM	Chris Hani District Municipality
NEPAD	New Partnership for Africa's Development
IDP	Integrated Development Planning
SADC	Southern Africa Development Committee
DEDEA	Department of Economic Development and Environmental Affairs
OR	Oliver Tambo
OLS	Ordinary Least Square
SADC	Southern Africa Development Committee
GHG	Green House Gases

DAFF	Department of Agriculture Fishery and Forestry
MEA	Millennium Ecosystem Assessment
UNDESA	United Nations Department of Economic and Social Affairs

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CHAPTER 1

1.0 Introduction

This chapter presents the background of the study, defines the nature of the research problem and provides justification or motivation for undertaking this study. It also sets out the objectives of the study, hypotheses, and research questions.

1.1 Context of the study

Biofuels can be described as solid, liquid, or gaseous fuel consisting of, or derived from biomass. Biofuel crops are crops that are used to generate biofuels. In 2004, a joint meeting of the Southern Africa Development Community (SADC) under the theme 'Farming for Energy' stressed that biofuel production provides or presents an opportunity for the region to produce its renewable energies. Challenges like high-energy costs facing economies from SADC justify the proposal of a green economy. Biofuels therefore have now become an alternative to the reduction of energy costs, with fuel production through farming expected to increase rural employment, reduce Greenhouse Gases (GHG) as envisaged by the Kyoto Protocol (Takavarasha *et al.* 2005). In Africa, the real potential of biofuel production lies in social development.

In 2007, the Department of Minerals and Energy (DME) launched a Biofuel Industrial Strategy for South Africa. A number of factors influenced the launch of the Biofuel Industrial Strategy (BIS), and some of these are that the launch was part of the government efforts to uplift smallholder farmer's productivity (DME, 2007). Other factors include; support for cleaner and environmentally friendly energy; support of renewable energy and the upliftment of the agricultural sector-using surplus farming land; promoting sustainable development and improve energy security.

Of particular importance are the Biofuel Industrial Strategy (2007) targets in the upliftment of agricultural sectors and unlocking of economic benefits in the Sub-Sahara region, by attracting investments in rural areas and promoting agricultural development. These targets will help overcome trade distortion that the Sub Saharan Africa has faced with subsidised agricultural production. A special requirement within the strategy is to create a connection between the first and second economy, by creating agricultural opportunities in areas previously undermined by the apartheid system (DME, 2007). According to the strategy, a first economy is characterised as being industrialised and producing the country's wealth and the second economy as the underdeveloped, poverty-stricken and marginalised (DME, 2007). Since 2007, the Department of Minerals and Energy (DME) in collaboration with the Department of Agriculture, Fishery and Forestry (DAFF) have been actively involved with smallholder farmers in the production of biofuels (Shi *et al*. 2009).

Smallholder farmers face a number of challenges that impede their growth and ability to contribute to agriculture. According to DAFF (2012), some of the challenges include; lack of access to land, inadequate infrastructure, and institutional challenges. Smallholder farmers struggle to pay for inputs like fertilisers, seeds to name a few. Moreover, lack of reliable markets, high transaction costs, unreliable distribution in remote areas are some factors affecting smallholder farmers (DAFF, 2012).With the proposed BIS, however, smallholder farmers are set to benefit immensely through the production of biofuel crops that perform well in semi-arid regions, like the Eastern Cape.

In the Eastern Cape Province, biofuel crops are anticipated to be a game changer for smallholder farmers because the region has vast underutilised semi-arid lands. The underutilised lands were identified by the DME as potential areas that are suitable for biofuels crops production. With this in mind, the production of biofuel crops is set to create jobs for the Eastern Cape Province. However, to date biofuel production has been limited. Sapp (2013) states that the slow pace of the adoption of biofuels production has been due to the lack of supportive policy guidelines, and an ineffective implementation strategy to the food and fuel debate.

ln the light of this background, a need arises to identify challenges and barriers that may influence the potential adoption of biofuel crops by smallholder farmers. Otherwise, the low rate of adoption of biofuel crops by smallholder farmers may indicate a serious problem within the Biofuel Industrial Strategy Policy.

1.2 Background of the study

This section gives brief background information on the agriculture sector in South Africa and the status of Biofuels Production.

1.2.1. Agriculture in South Africa

South Africa has a dual economy system composed of the commercial and subsistence sector. The subsistence sector has an estimated 200000 emerging black farmers in rural areas, yet, the commercial sector is composed of 35000 large scale farmers, mainly white farmers owning over 82 million hectares of land (Mathivha, 2012). Agricultural activities are in the form of intensive crop farming and livestock farming.

It is estimated that only 13 percent of land can be used for crop production in South Africa and the most pressing problem is the availability of water. Rainfall is distributed unevenly across the country with more than 50 percent of water used in Agriculture, with 1.3 million hectares of land under irrigation (Mathivha, 2012). Goldblatt (2010) reports that declining farming and water scarcity has left South Africa with less than two thirds of the number of farms it had in the early 1990s. Moreover, there is a decline in agricultural employment (DAFF, 2013). Agriculture's contribution to employment also dropped by 75 percent between 1993 and 2005, to about 628000 farm workers (Agricultural Statistics, 2012). Some of the reasons attributed to the decline are that there is lack of participation from the youths and a decrease in farming operators. Vink and Kirsten (1999) pointed the decline of employment in agriculture after apartheid to bad policies that reduced export opportunities, discouraged labour saving and encourage adoption of capital-intensive farming practices.

Over the past 15 years, South Africa has undergone structural changes that have resulted in an open market oriented economy (Goldblatt, 2010). A number of agricultural policies were crafted after apartheid to address the land imbalances between blacks and whites. Most of the adopted policies were intended to remove control of the white minority on agricultural lands. Subsequently, this led to a launch of a number of land programmes to support emerging farmers (Goldblatt, 2010). Land redistribution has been a major challenge in the new South Africa. Figure 1.1 shows the total land utilised for farming in South Africa:

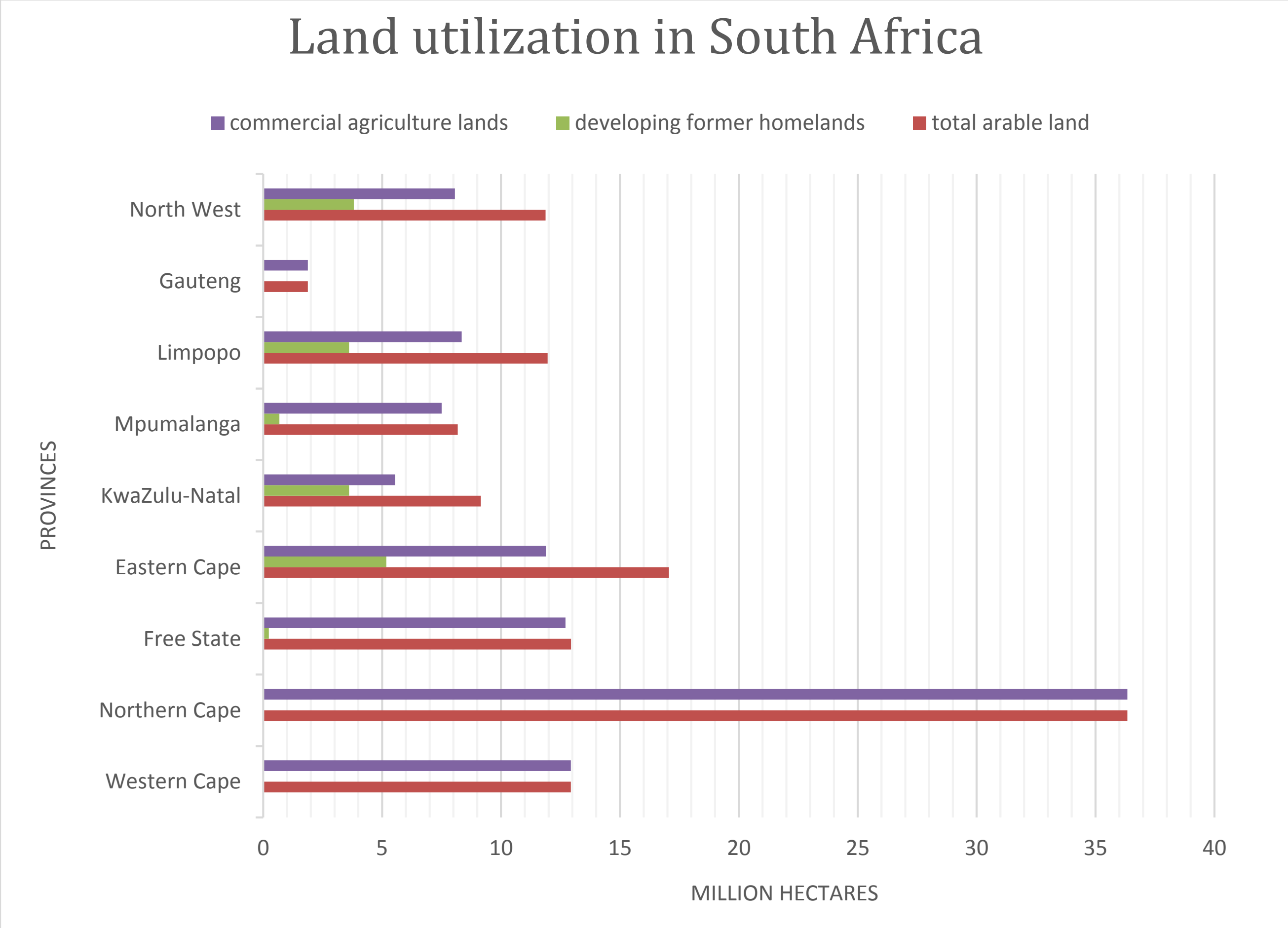


Figure 1.1: Land utilization in South Africa

Source: Author computation from Agriculture Statistics, 2013

From the graphical presentation in Figure 1.1 above, there are two types of agricultural lands: commercial and former homelands. The developing former homelands are depicted as underutilised land. The total available arable land is between 123-125 million hectares, and commercial farming utilises about 105 million hectares leaving 17 million of hectares underutilised. The underutilised land in the former homelands are mainly in rural areas as shown in the diagram, with the Eastern Cape Province having at least 5 million hectares of land underutilised. KwaZulu Natal Province has less than 4 million hectares, Limpopo Province and North West Province also have 3 to 4 million of hectares which are underutilised; Mpumalanga has less than 1 million hectare homelands. The underutilised land in the former homelands can be put into productive use by establishing biofuel crops production.

1.2.2 Biofuels Industrial Strategy in South Africa

The Biofuel Industrial Strategy was necessitated by the government's need to create a link between first and second economies. Targeting areas that were neglected during apartheid and rural areas that do not have access to markets for their produce will make the link. Furthermore, the strategy targets 14 percent of arable land in rural areas that is underutilised (DME, 2007). The strategy proposes that for production of biofuels, maize be excluded in the initial stages of implementation until such a time when there is certainty on the ability of the current underutilised land to develop.

Letete (2009) investigated types of land classified as underutilised and came up with this conclusion:

- ✓ Communal land is defined as land composed of a number of large pieces of land in the rural areas that are utilised by the whole community for agricultural purposes. All farming in this land is pure subsistence.
- ✓ State land are former homelands that are state owned that are of agricultural quality which were meant for agricultural purposes but were never demarcated by the apartheid government. Hence, this form of land is left unused by the community.
- ✓ Lastly land owned by emerging black farmers. This is a form of land that was distributed through the land reform. Nevertheless, due to lack of financial, management and technological skills, most farmers have not developed it.

This study adopts Letete's (2009) broad definition of underutilised land.

1.2.3 Biofuel crops

In producing biofuels, a proper mix of crops is a critical factor in the development of a good production system. Canola, soya beans, sunflower, groundnuts, sugarcane, sugar beet, and sorghum are the most suitable or favoured crops for biofuel production as envisaged in the Biofuels Industrial Strategy. Table 1.1 below shows the conditions necessary for each targeted crop to grow. Understanding the conditions necessary for biofuel crops to grow is crucial in identifying former underutilised land in the former homelands that support these crops.

Table 1.1 illustrates that most crops can be easily grown in semi-arid regions. A semi-arid region is defined as a region receiving lower precipitation below potential evapotranspiration, but not extremely. Sugarcane, maize, wheat and sorghum production are the most suitable crops for bio-ethanol production because they are sugar rich. The Food and Agriculture Organisation FAO (2013) favours sorghum because it requires fewer inputs such as water and fertilisers than sugar cane or sugar beet. The Biofuels Strategy spells out clearly that maize is excluded from the targeted crops because it is one of the most important crops with regard to food security in the Southern Africa Development Community (SADC).

Table 1.1 Conditions for Biofuels crops

Crop	Temperature requirements	Water requirements	Soil requirements	Average yields per ha	Production levels	Sugar/Ethanol/oil Content
Maize	Annual Summer	550-750mm rain per annum	Sandy loam to loamy soil types	2.5-3 tons under dry land 5 ton irrigated	8-10 million p.a	75percent starch (sugar content)
groundnuts	Annual summer crop	500mm rain per annum on dry lands	Light coloured, light textured with good drainage and low organic matter	1.1-1.8 tonnes dry land	60000-70000	42-52 percent
Soybean	Annual summer crop	Rainfall above 600mm constant supply throughout the growing seasons	Variety of soils i.e. clays soils, arcadia and sandy soils	1.5-2 tonnes	200000-300000	19-22 percent
Sugar cane	Perennial subtropical crop. Annual mean temperature between 26 to 32 degrees Celsius	750-1200 mm per annum irrigation needed in low rainfall areas	Sandy loam	66 tonnes 5 years average	2-3 million tons p.a of sugar	80 percent starch
Sunflower	Annual summer crop	500 mm rain in dry land	Variety of soils from sands to clay soils. Good in sandy loan and clay soils types	1.2-1.8 tonnes in dry land	500000-700000	39-50 percent
Wheat	Annual Summer	600mm/annum irrigation necessary in summer	Loamy to sandy	2.5 tonnes under dry land and 5 tonnes irrigate land	1.5-3 tonnes per annum	60 percent starch
Canola	Cool season crop. Winter annual crop	Minimum rainfall of 400 mm.	Medium textured well drained soils.	1-1.5 tonnes dry lands	30000-45000	42-45 percent
Sorghum	Annual summer crop	400mm-750mm per annum	Variety from sands to black clay	2.1 tonnes under dry and 3.5 tonnes irrigated	200 000-450000 tonnes per annum	72 percent starch

Sources: NEPAD-CAADP, 2007

Furthermore, Farrell *et al.* (2006) highlights that although wheat is one of the largest produced crops in South Africa, it is not targeted for biofuels because it is widely used in value added products such as bread, which are an important part of the South African diet. Wheat was one of the top produced commodity crops in 2012.

To understand the potential of the agriculture sector in South Africa, a background of the top produced field crops is necessary. Figure 1.2 shows the top ten produced commodities in South Africa. It shows that in 2012 over 15 million tonnes of sugar were produced as output. Sugar cane is the most highly produced field crop in South Africa and it generates revenue of more than US$1. 8 billion through exports to the SADC and European Union.

Maize is the second most produced commodity with over 12 million tonnes per annum, generating at least US$1.3 billion. Since, the biofuels strategy stipulates that maize be excluded in the targeted crops for biofuel; its production is mainly for consumption. Soybeans, Sunflower seeds, barley and sorghum are other commodities that have a combined output of over 1 million tonnes. It can be ascertained from the diagram above that most proposed biofuels crops have stable production currently.

The fact that grain commodity crops are in top production currently, should highlight the potential of the biofuel industry. In many instances, a sustainable industry is supposed to be producing extra output to sustain its people. The extra output from sugar cane can be used to produce ethanol without influencing or affecting the prices of sugar consumed by people. Therefore, most field crops produced are not expected to affect consumer prices through shortages. For instance, in the 2013 season a total of 834000 tonnes of soya beans was consumed locally, and 30000 tonnes was exported (DAFF, 2013). Similarly, maize that was domestically consumed in 2013 was estimated to be around 10.427 million tonnes and the surplus 2.120 million tonnes was exported around the world (DAFF, 2013). However, the only risk is when producers divert those crops for biofuels production leading to artificial shortages.

1.2.4 The land use debate

Sugrue and Douthwaite's (2007) report on land use claims that agriculture production rose by 70 tonnes per hectare on leased plots, higher than organised small scale farming that was 30 tonnes on average. However, it was less than commercial farming that stood at 120 metric tons per hectare. In addition, Sugrue and Douthwaite (2007) are of the view that maize should not be used for energy, instead, they suggest that Jatropha or Moringa tree be used. Jatropha can produce 2.5 metric tons of biofuels per hectare, which is better than soya that produces 0.8 tonnes per hectare on average. However, proponents of sustainability favour the development of a food forest that includes different types of plants and species. Their contention is that the arable land available for farming is degraded; therefore, planting food crops would stabilise and improve soil fertility in the long run, subsequently helping smallholder farmers and communities who own a lot of arable land.

In contrast, Renewable Energy and Energy Efficiency Partnership (2007) is of the view that increased agricultural production has the potential to conflict with a number of resources, not land only. Their line of reasoning is that increased agricultural production will increase inputs including water, fertilizers, agricultural chemicals and these may have a negative impact on the production system through a loss of soil fertility, soil biodiversity, and available quality of water. Still, social and environmental benefits may be realised through agricultural diversification and energy, as well as rural development using the land productively.

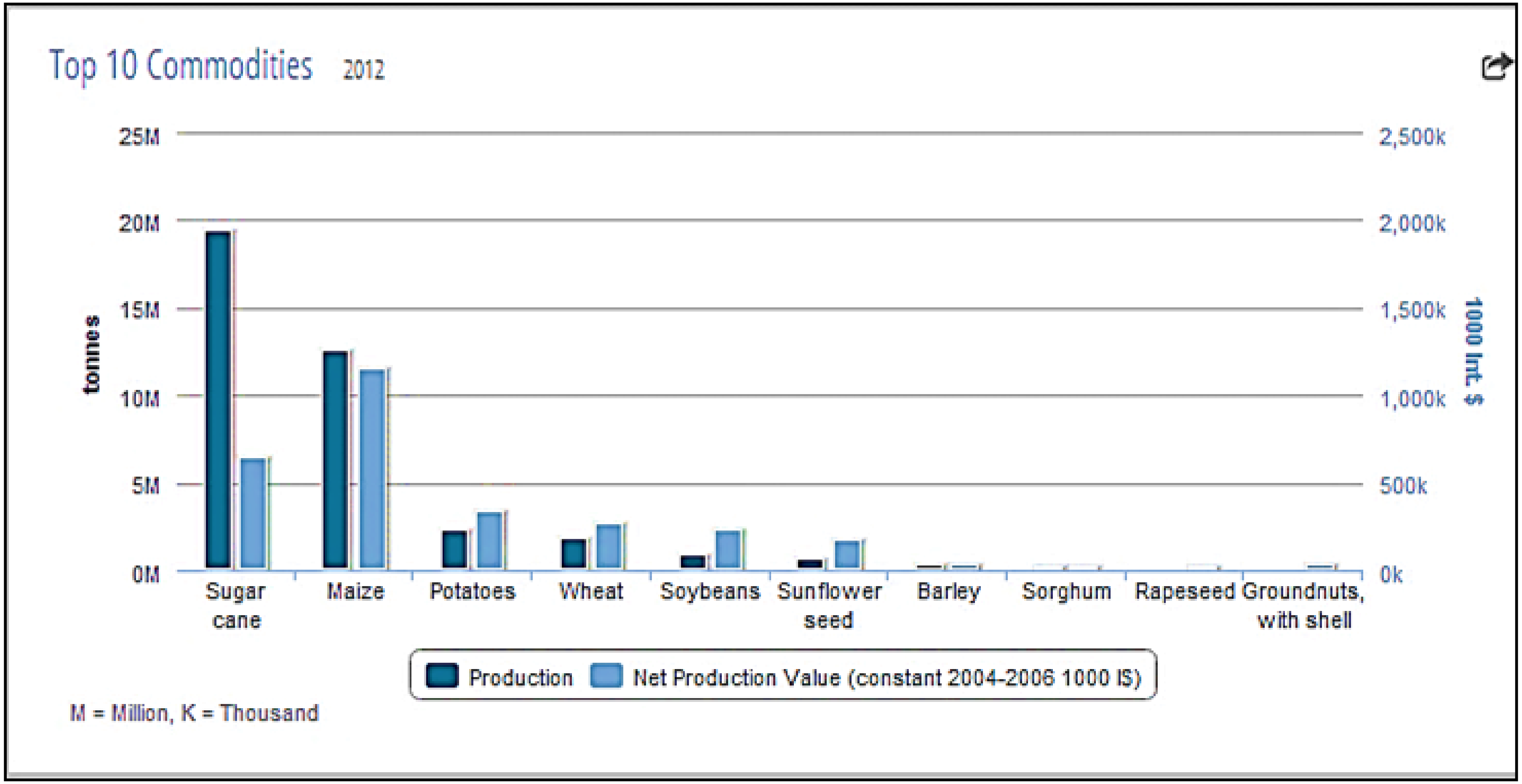


Figure 1.2 Top 10 commodities in South Africa

Sources: FAO, (2013)

Sugrue (2007) argues that even though the South African government opted for a Biofuels Policy that targets smallholder farmers, Europe will import the biofuel energy, yet more than 30 percent of South Africans do not have access to energy. For this reason, biogas is suggested as an option, which can be used locally, and is the most suitable option.

1.2.5 The biofuel debate

Pingali *et al.* (2008), Rosegrant *et al.* (2008), Elobeid and Hart (2007) are of the view that food items constitute significant in consumption bundles of low-income earners and high prices may have an adverse effect on the poor. Furthermore, inadequate food security, food deficits, and undernourishment make the poor more vulnerable and volatile to prices changes in commodities, hence, any increase in biofuel production is expected to have an adverse effect on them. Hochman *et al.* (2008) and Coyle (2007) are of the opinion that the rapid growth of biofuels production has a potential negative effect of diverting food crops to biofuels, and consequently pushing commodity prices higher, which will have a serious effect on global food and related markets.

However, another school of thought challenges the above view. Pingali *et al*. (2008) suggest that an adverse effect may be realised as a positive supply response that may help small scale farmers emerge. Furthermore, Pingali *et al*. (2008) are of the view that biofuels will serve as a new source of demand for agriculture which could assist in revitalising agriculture in developing countries. Of the same view is Schmidhuber (2006) who posits that benefits may increase producer prices and biofuel production which may uplift rural economies.

A deeper look into literature suggests that there is a consensus about maize not being used to produce ethanol, as it has a huge effect on food prices and poor communities. Cassman and

Liska (2007) noted that the sub Saharan region relies heavily on cereal import, hence, it is the most vulnerable to price shocks. FAO (2013) stated that food prices are likely to remain volatile in the period of 2011-2020, thus, any move that would destabilise prices further would be borne by the vulnerable communities, consequently increasing poverty and promoting poor standards of living in the end. Harrison (2009) argued that there is growing evidence that shows that higher maize prices contribute to inflated food prices in the form of higher feed prices, especially animals that depend on corn as feedstock for poultry, beef, pork and others.

From the information presented above, it can be deduced that as much as literature has differing opinions concerning biofuel crops on agriculture, a growing body of literature believes that as long as traditional crops such as corn and wheat are withdrawn from production, there are greater chances that biofuel production would uplift impoverished communities.

1.2.6 Participation in Biofuel Market in South Africa

Farm household participation entails growing crops for sale to a biofuel firm or land rentals contract and feedstock supply contracts by smallholder farmers. Mabiso and Weatherspoon (2011) conducted a survey on household participation in biofuel production in the rural areas in the Eastern Cape, Limpopo, and North West provinces of South Africa. A total of 247 households were randomly selected and given questionnaires to record answers on their participation in biofuel markets. The findings are indicated below:

- ✓ Biofuel firms were not employing local labour, instead they were importing labour. The reason was that most firms had not yet created employment opportunities for locals. Furthermore, the only labour recorded were few farmers hired by one biodiesel plant who were mentoring less experienced biofuel crop farmers. A further analysis from the study identified the firm was a Non-Governmental Organisation not necessarily a Biodiesel firm, whose business model had objectives of empowering entrepreneurs in biodiesel markets by providing free training in business management and farming skills. It was discovered that the hired mentors were engaged by the firm four years before and received assistance and training to produce sunflower and soybean to supply feedstock to the biodiesel firm. Generally it can be concluded that no employment opportunities have been created this far.

- ✓ Secondly, a number of crops were used as feedstock. Biodiesel firms used sunflower, soybean, and canola; yet, ethanol firms used maize, sugar beets, and sugarcane. Smallholder farmers were not participating in a number of biofuels programmes because the firms excluded them.

- ✓ It was noted that certain biofuels companies were using maize as feedstock yet the government banned it. Moreso, none of the smallholder farmers were producing canola as feedstock, but the farmers were leasing land to the biofuels firm that produced the canola for its production. The main reason cited for this approach was that some firms were focused more on renting land than training smallholder farmers.
- ✓ It was difficult to define biofuel crops as feedstock in that study because farmers viewed crops as cash crops or consumption crops depending on whether it is sold or consumed.

Mabaso and Weatherspoon (2011) therefore concluded that biofuels crops are also used as food crops in South Africa excluding sugar beet. Although the study was not aimed at smallholder farmers, it gives an idea about the current biofuels industry operations.

1.3 Problem statement

Biofuels are regarded as a means of decreasing greenhouse gases, thereby reducing global warming. They also offered a solution in the reduction of non-renewable energy use and a potential of alleviating poverty in areas with unsuitable land for cash crops. Consequently, areas that were utilised for food production came under threat to meet the ever-growing demands of biofuels.

In addition, instability in oil producing countries and climate change that has adversely affected agriculture leading to poor yields has contributed to food cost (Dufey *et al*. 2007). Trade barriers have increased food shortages as producing countries attempt to fight local price increases (International Monetary Fund, 2008). Although no clear indications point to biofuels, still they have been associated with food insecurity.

In South Africa, biofuel crops were identified as a potential to solving smallholder farmer challenges. These challenges include creation of rural employment, creation of markets for smallholder farmers and energy security (BIS, 2007). Peters and Thielman (2008) argue that biofuel crops could be cultivated in a sustainable way and offer significant opportunities to the developing countries.

Some biofuel crops can survive in semi-arid regions; hence, this makes them a good incentive for smallholder farmers living in semi-arid regions like the Eastern Cape Province. The Eastern Cape Province is a semi-arid region not good for commercial agriculture, thus, the region specialises in livestock rearing (DAFF, 2012). Due to these characteristics, the region is well suitable for biofuel crops production.

Although the Biofuel strategy seeks to address poverty and economic exploitation by promoting agriculture in areas previously ignored by the apartheid system, since its launch it has struggled to persuade smallholder farmers to look at producing biofuel crops. A large number of smallholder farmers have not yet adopted biofuel crops regardless of the benefits they stand to get from the biofuels industry. Despite the advantages proposed on biofuels crops cultivation, adoption of biofuels crops remains low (von Braun, 2007).

This study therefore investigated the barriers and incentives that influence the potential adoption of biofuel crops by smallholder farmers in selected areas in the Chris Hani District Municipality and Oliver Tambo District Municipality in the Eastern Cape, South Africa.

1.4 Objectives

The main objective of the study was to identify factors affecting/influencing the potential adoption of biofuels crops by smallholder farmers in the Eastern Cape, with an emphasis on farmer's characteristics.

Specific objectives are:

1. To investigate awareness of smallholder farmers of biofuel crops in selected areas in the Eastern Cape Province.
2. To assess the level of potential adoption by smallholder farmers in selected areas in the Eastern Cape.
3. To estimate determinants of farmers' awareness and the potential to adopt biofuel crops in the Eastern Cape Province.

4. To identify incentives that influence the potential adoption of biofuel crops by smallholder farmers.

1.5 Research Questions

1. What theoretically determines the adoption of biofuel crops and farmers' characteristics?

2. What is the potential level of adoption of biofuel crop by smallholder farmers in selected areas in the Eastern Cape?

3. What determines the actual adoption and awareness of biofuel crops and what are the bottlenecks?

4. What kind of incentives are needed to influence the potential adoption of biofuels crops.

1.6 Hypothesis

1. Farmers are aware of biofuel crops in the Eastern Cape Province.

2. The level of potential adoption of biofuel crops by smallholder farmers is high.

3. Social, economic, and farming factors influence farmers to adopt biofuel crops.

4. Capital, funding, markets are some of the incentives needed by smallholder farmers in order for them to adopt biofuel crops.

1.7 Significance of the study

This study is based on the premise that agriculture constitutes one key element, within a broad spectrum of strategies that can be adopted to reduce poverty and contribute to local economic development. Furthermore, it was influenced by the interest shown by the government of South Africa in trying to uplift rural smallholder farmer livelihoods using biofuels. In 2013, the government set a clear target of 2 percent penetration of renewable energy (BIS, 2007); unfortunately, this was never achieved. In order for the strategy to have a meaningful impact, a thorough assessment of existing production capacity, adequate resources to drive the green economy and incentives are needed to persuade smallholder farmers to adopt biofuel crops production.

This study thus fills the gap in literature by digging deeper into the main factors affecting awareness and adoption of biofuel crops by smallholder farmers in South Africa. To note are these studies: Cloete and Idsardi (2012) measured biofuels effects on food security and tradition crops; Mabiso and Weatherspoon (2011) estimated the impact of biofuel crops and land rental markets in South Africa, and lastly Letete and von Blottnitz (2010) critically analysed the biofuel policies in South Africa.

This study therefore will provide guidance to policy makers, government, agencies, academics, and other relevant stakeholders who will find it useful in trying to understand factors that influence smallholder farmers to adopt biofuel crops in South Africa, more specifically in the Eastern Cape. Further, the study will provide key lessons to policy makers and practitioners engaged in agricultural development in South Africa.

1.8 Delimitations of the study

The study focused on biofuel crops that grow in semi-arid areas and excluded any potential plants used for biofuel extraction like Jatropha or Moringa. This is due to biodiversity concerns raised by the Biofuel Industrial Strategy, such as, animal species poisoning and alien plants that are toxic. Furthermore, the study did not attempt to identify all barriers and incentives to potential adoption of biofuels crop in South Africa, but was limited to the Eastern Cape Province because these factors are not uniform in all provinces. However, valuable lessons from this study can be drawn as a directional tool in the formulation of incentives that can help in the adoption of biofuels in South Africa.

1.9 Definition of terms

Incentives

Following Clark and Wilson (1961), an incentive is any factor that influences an individual to behave in a certain way or something that motivates an individual to do a set behaviour. The incentives of an individual can be separated into three motivations:

Intrinsic motivations- refer to the motivation that comes from within an individual such as pleasure that one gets ahead of a task or from completion of a task.

Signalling motivation - refers to the motivation that individuals have on how they are perceived by others, for instance, how people think.

An extrinsic motivation - refers to the motivation that comes from external factors affecting an individual, such as material rewards. This includes money, assets, grades and so on. The motivation rewards more satisfaction than what a task itself may not provide. Incentives of this nature can be coercive, meaning an individual expects some of form punishment. These incentives can also be legal, for example, tax incentives.

This study adopts Clarke and Wilson (1961)’s definition of incentives.

Biofuel

Biofuel are liquid fuels that have been derived from materials such as plant waste and animal matter. They are separated into two groups; first generation and second generation. According to Naik, Vaibhav, Prasant and Ajay (2010) first generation biofuels include biodiesel, bio ethanol and biogas, and are resourced mainly from edible source current food material such as maize, soybean, oil palm, sugar cane and cassava. Second-generation biofuel are fuels sourced from non-edible sources such as jatropha and algae.

1.10 Study outline

This study consists of seven chapters. Chapter 1 introduces the study by presenting the background to the study, aims, research problem, significance of the study and definition of terms, among others. Chapter 2 discusses the literature on the adoption of new crops and investigates more particularly the role of farmers' characteristics in the adoption of new technology. Chapter 3 describes the study area. Chapter 4 presents the econometric model and estimation procedure. The chapter concludes with a theoretical model of adoption. Descriptive results are discussed in Chapter 5. Chapter 6 provides a general discussion of results of the econometric model. Lastly, Chapter 7 concludes the study and offers recommendations for the way forward.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of relevant literature in an effort to explore the current debates surrounding the adoption of biofuel crops among smallholder farmers. The chapter starts by defining adoption and factors influencing or affecting adoption of new technology or seed varieties. Factors affecting awareness to adoption of certain technologies are explained as well. Lastly, barriers to adoption of biofuel crops conclude the chapter.

2.1 Adoption

Adoption of crops describes the decision to use or not use the crops and the spread of such crops to economic agents. Adequate understanding of the process of adoption is necessary in the improvement of agricultural programmes or research.

Following Rogers (2003), adoption is defined as the decision to use a new technology or practice by economic agents on a regular basis. Feder, Just, and Zilberman (1985) posit that adoption is in two forms, that is individual adoption (farm level) and aggregate adoption. Individual adoption is said to be the degree of use of a new technology/innovation in long run when the farmer has full information about the new technology and its expected potential. Aggregate adoption is when a group of individuals or farmers adopts a new technology or seed variety collectively. Feder *et al.* (1985) noted that adoption decisions involve choices of how many resources are to be allocated to old and new technologies, if the technology is indivisible, for instance, irrigation or mechanization, and lf the technology is divisible, for example, fertiliser, improved seeds, then the decision process involves the allocation as well as the rate of application. As a result, the adoption process includes simultaneous choices of whether to adopt a technology or not and the intensity of the technology use. Feder *et al*. (1985) further explain that a distinction should be made with regard to divisible and indivisible technology when measuring intensity of adoption. Intensity of adoption can be measured individually in a given period by the share of the farm under such new technology. Whereas when it comes to indivisible agricultural technologies such irrigation machines and others at a farm level in a given period is either use or non-use, the aggregate measure is continuous. This means aggregate adoption can be measured by the percentage of farmers using the new technology in a given area.

Two approaches are common in agricultural technology adoption literature. The first approach dwells on adoption as a whole package and the second approach explained adoption as a systematic event. Byerlee and Hesse de Polanco (1986) strongly argued that farmers do not adopt technologies as a package, but rather adopt a single component or a few suitable technologies. Leather and Smale (1991) supported Byerlee and Hesse de Polanco’s argument that farmers choose to adopt inputs sequentially. Profitability, riskiness, uncertainty, and institutional constraints are identified as the main agents determining the sequential adoption stages. However, a study that was done by Ryan and Subrahmanyan (1975) focused on farmers as rational agents who adopted based on trying to reduce the losses in an event that the crop fails. As such, sequential adoption is a rational choice for farmers with limited cash. Rauniyar and Goode (1996) defined farmers’ adoption as random which directly clashes with what Rogers (1983) stated.

2.2 Adopters categories defined

Rogers (1983) identified five categories of adopters in a social system. These categories are; innovators, early adopters, early majority, late majority and laggards. Rogers (1983) indicated that the majority of early adopters are expected to be young, educated and ambitious and risk takers. Contrary, late adopters are expected to be old, less educated, and conservative and risk averse. The study identified five stages of the adoption process; awareness of the innovation; interest and persuasion toward the innovation; evaluation or decision whether to adopt or not the innovation; trial and confirmation sought on decision made and adoption. Adoption thus is a sequence of events passing through these stages (Rogers, 1983). This is shown in Figure 2.1.

The innovation decision process by Rogers (1995) can be explained in five stages as follows:

- ✓ Knowledge - this is when the individual is exposed to the existence of the innovation and seeks information on how it functions.
- ✓ Persuasion - is when the individual develops an attitude towards the innovation. This maybe negative or positive attitude.
- ✓ Decision - is when the individual engages in activities that lead to a choice to adopt or reject the innovation.
- ✓ Implementation - this is when the individual puts the innovation into use.
- ✓ Confirmation - the individuals seek more positive aspects of an innovation. The individual has hope of reversing that decision if it falls below his standard.

In Figure 2.1, the individual is influenced by prior knowledge when thinking of adopting. This knowledge comes in the form of socio-economic factors and other personal variables. Then the next stage is greatly influenced by interest or persuasion generated from prior knowledge. If the individual is interested, a decision is made whether to adopt or not. If the decision is not to adopt, the individual jumps the implementation stage and confirms his/her reaction to new technology. If the decision is to adopt, the individual's next stage is to implement the decision and use the innovation. In the process, the next stage would be for the individual to confirm if the innovation meets his/her standard by continuously evaluating. A decision is sort by the individual if to reconsider adopting based on positive aspects seen in the innovation or to discontinue using the innovation if there are more negatives with the innovation.

2.3 Adoption Characteristics and Stages

2.3.1 Adoption speed

Adoption speed is known to have an influence on adoption of technologies or crop varieties in agriculture. A typical example can be given of technologies such as irrigation or mechanisation that require a group's action for adoption, compared to technologies that need an individual will, such as, improved seed variety(Feder *et al*, 1985). The former are generally adopted slowly compared to the latter technology that is independent of individuals.

2.3.2 Relative advantage

The relative advantage of a technology has the strongest effect/influence on the rate of adoption. Examining the rate of adoption and other economic factors, Byerlee and De Polanco (1986) suggested that the adoption pattern of a certain technology is a function of five characteristics (riskiness, profitability, divisibility, complexity, availability, and initial capital outlay).

The adoption process depends on how farmers value risks associated with the proposed technology or innovation. Therefore, farmers pass through stages in deciding to adopt a technology. A number of studies (e.g. Feder, 1980; Collier, 2001; Foster and Rosenzweig, 1995) identified that most individuals are risk averse when adopting technology. Hence, farmers behaviour is guided by risks and uncertainty expected from adopting a certain technology.

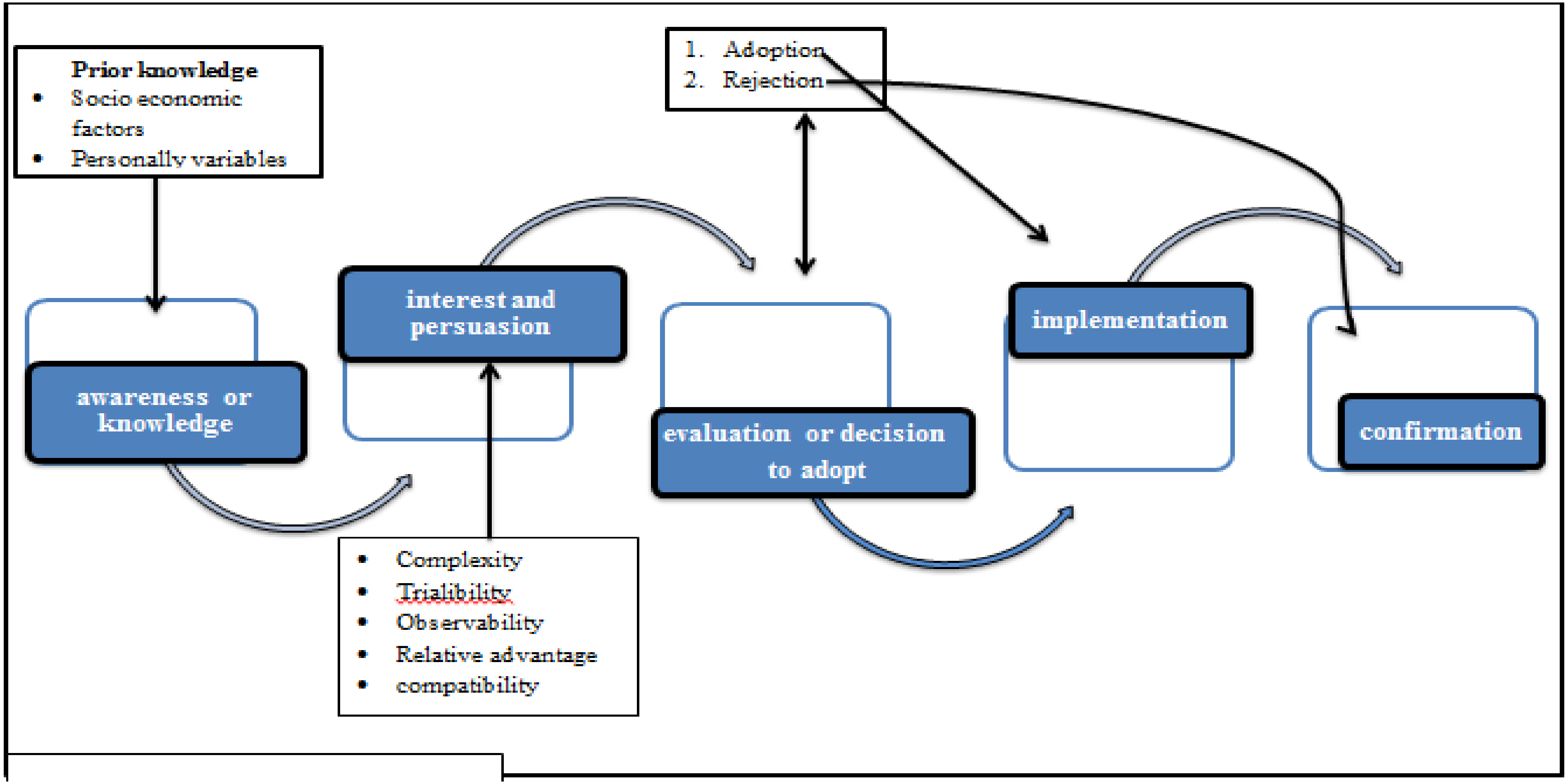


Figure 2.1: Adoption Model

Source: Rogers (1995)

The study highlighted that profitability and riskiness are a function of social-economic environments such as prices or rainfall. Price and rainfall therefore are said to affect the adoption rate.

In Figure 2.2, Mills *et al.* (1998) explained the adoption profile of farmers.

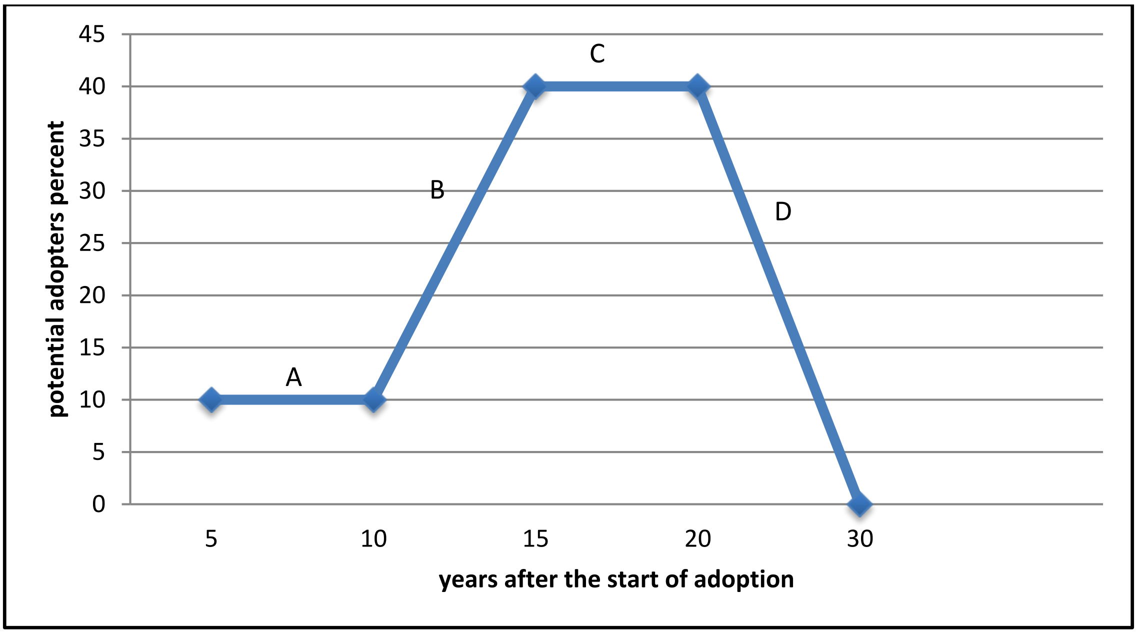


Figure 2.2: Adoption profile

Source: Mills *et al.* (1998)

Stage **A** explains the development lag that ends with a new technology. At **B** when a number of farmers are aware of the technology they increase in adopting, then an adoption plateau occurs at **C** when the targeted farmers have decided to use and have been exposed to the technology. Stage **D** is when the technology is now getting obsolete. All these components determine the rate of adoption.

2.3.3 Insights from literature

It has to be noted that adoption is hypothesised as happening in stages by literature. Furthermore, adoption varies based on the innovation. Agriculture technological innovations like tractors takes more time to be adopted because of the longer consultation period needed. Yet, seed varieties can be adopted easily since the decision to adopt is done individually.

A number of studies (Rogers, 1983, 2003; Feder, 1980, Collier, 2001) admit that most individuals are rational when deciding to adopt innovations, hence, they are risk averse. These studies fail to understand that risk aversion is a concept influenced by a number of factors like incentives offered, subsidies, or anything that can offer a profitable solution to farmers or individuals. Risk aversion can be overcomed by incentives or output from adopting a certain technology. A typical scenario is when farmers are promised that their produce would be bought or when farmers are offered a stable market with heavily subsidised production costs. Most farmers although rational, may behave irrationally when presented with such offers. This scenario shows that risk aversion and rationality are concepts that are not clearly defined in a number of studies.

It would be worthwhile if a number of studies on adoption could explain the concept of risk aversion and rationality in line with the five proposed adoption stages by Rogers (1995). It may be surprising to note that in each stage these two concepts may work in contrast. Limited research in trying to understand these concepts in adoption studies presents a gap in literature.

2.4 Determinants to farmers' adoption of new technology

This section introduces factors that influence adoption of new technology or seed varieties.

2.4.1 Institutional factors

Institutional factors can be summed up as factors such as having credit, access to price information, being a member of an association and access to extension services. These factors have been widely used as variables in a number of adoption studies in order to evaluate farmers' behaviour. Uaiene *et al.* (2009) analysing agriculture technology adoption in Mozambique reported that difficulties in accessing credit were a major constraint in adoption. Pattanayak *et al.* (2003) noted that access to extension services, other stakeholders and Non-Governmental Organisations have an influence in farmers' adoption of new technology. The argument is that farmers who usually meet extension officers and demonstrate the proposed technology have a high chance of adopting technology. On the other hand, the Bandiera and Rasul (2005) study on social networks and technology adoption by farmers pointed out that farmers with access to paved roads, markets, farmers association, and in contact with extension agents are more likely to adopt technology because they are exposed to information. lt is clear that institutional factors also play a major role in determining whether farmers adopt certain technology or decline it.

2.4.2 Farmers' socio-economics factors

A number of studies have used socio economic characteristics (i.e. gender, age, education, household head) to explain household adoption behaviours. A study by Adegbola and Gardebroek (2007) on adoption of technology by farmers noted that educated farmers are more able to process inputs, allocate them efficiently, and assess the profitability of new technology better than less educated farmers. Uaiene *et al.* (2009) is of the same view that educated households are high adopters of technology in agriculture. On the contrary, a study by Adesina and Forson (1995) on adoption of new agricultural technology found that both young and old farmers adopted new technology. This was mainly influenced by these factors; young farmers are risks takers and have long-term goals, yet, old farmers have more capital or have access to credit. Zavale *et al.* (2005) disputed this notion and reported that older farmers in Mozambique are less likely to adopt improved maize variety compared to young farmers.

2.4.3 Farmers perceptions

Farmers' perceptions need to be understood when interpreting farmers' adoption behaviour. Neil and Lee (2001) are of the view that the adoption of new technologies is affected by farmers' perceptions of the amount of investments or initial capital outlay and labour that needs to be allocated if they adopt the technology. Direct costs, profits associated with the improved seeds, and yields were identified as factors affecting farmers' perceptions (Adegbola and Gardebroek, 2007). Martel *et al.* (2000), however, offered a different opinion on new technology adoption after conducting a study in Honduras on adoption of dry beans. The findings were that farmers adopt new technology when they perceived that it would reduce labour costs, reduce risks in crop diseases and other farm costs. In addition, farmers are more likely to adopt when they view a seed variety as having a potential to increase their income or survive under different environmental conditions. Gonzales's (2003) study purported that farmers also consider environmental aspects such as climate, soil fertility and suitability of seed varieties. Hence, it can be drawn from literature that farmers' perceptions differ when it comes to adoption and no clear factor can be generalised to each new technology.

2.4.4 Economic benefits and risks of new technologies

Economic profitability and risk of new technologies have an inherent effect on farmers when adopting. Adegbola and Gardebroek (2007) stated that farmers who are aware of certain technology will adopt if they evaluate the profitability or benefit that they anticipate will be gained, taking into consideration investments and costs associated with such a technology.

Additionally, a study conducted in United States by Cornejo and McBridge (2002), on adoption of bio-engineered crops discovered that farmers evaluate the impacts of farm location, soil fertility, and climatic conditions on new technology before they adopt. However, farmers who own land with poor physical conditions like fertility may adopt fertiliser with the hope of improving those conditions. Uaiene (2009) recorded no positive correlation between land tenure or farm size and land physical futures on farmer adoption behaviours. The study noted that farmers in possession of land are less likely to adopt any technology like fertilisers because land was abundant. Literature therefore is inconclusive about economic factors that influence adoption. However, one view that is commonly held is that if technology leads to economic benefits, it will be adopted.

2.5 Awareness of biofuels

2.5.1 Awareness of new technology/crop varieties

One of the crucial stages in the adoption of new technology that has been identified by literature is the awareness stage. This is the stage when an individual has information about a certain technology. Beale and Bolen (1955) conducted a study on agriculture technology and they stated that awareness of a technology was the first stage of adoption. Beale and Bolen (1955) defined awareness as a stage where an individual learns of the existence of a technology or has little knowledge about it.

However, it seems in literature there is no consensus on what constitutes and influences awareness. McBride *et al.* (1999) noted that awareness and attitude are influenced by agricultural producers' social economic characteristics. Rogers (2003) reinforced similar claims. In introducing new technology or seed varieties, the first phase consists of making the farmers aware of such technology, for instance, through demonstrations or other means and the new technology is then be adopted if seen as beneficial. Diagne, (2010) and Daberkow and McBride (2003) are of the opinion that an individual can adopt technology/crops without knowing anything about its performance or characteristics.

A study conducted in Benin by Dandedjrohoun *et al.* (2012) on determinants of diffusion and adoption of improved technology for rice parboiling pointed that the number of years in parboiling experience, membership of women in an association, and ethnic group contributed immensely to the awareness of the new technology. Similarly, Kromm and White (1991) are of the same view that media, agricultural extension, crop consultants, play an important role in early stages of adoption.

Studies done by Rollins (1993) and Korsching and Hoban (1990) noted that information sources are very influential in the initial stages of adoption, because it is through media that individuals get to be aware of the technology existence. Kinuthia (2010) discovered that awareness of tree planting programme was positive and statistical significant. The claim was that farmers who received information were in a better position of choosing to adopt new technology than those who were not. Furthermore, Collier *et al.* (2002) got similar results that farmers with better information on labour afforestation were in a better place to engage in tree planting activities in their land. However, Dolisca *et al.* (2006) stated that although improving information flow to a decision maker is a necessary condition, it does not necessarily mean everyone who receives it would act on it.

Although much of the current research on technology adoption goes beyond awareness and focuses on adoption rate or extent (Rogers, 1995, Feder *et al.* 1985, Adesina and Forson, 1995), there is a broad consensus amongst researchers that awareness does have an influence on adoption of technology. Diagne (2010) states that studies which exclude the awareness of technology in adoption studies usually run the risk of producing an unidentified model.

Similarly, studies conducted by Diagne (2010), Diagne and Demont (2007) acknowledged that any adoption study that does not account for awareness of the technology/crops to the individuals leads to spurious conclusions about the potential adoption rate for the targeted population. Nowak and Korsching (1998) stated that ignoring awareness stage in adoption process and treating adoption as a dichotomous event could be partly responsible for the poor predictive power of research using binary analytic models.

2.5.2 Insights from literature

From the literature studied, there is a consensus about including awareness as a determinant to adoption of innovation or new seed varieties. However, detailed studies are required to investigate factors that influence individuals to adopt a certain innovation or seed varieties. It is surprising that there are limited studies from South Africa that have tried to explore factors that influence awareness to innovations. This gap in literature can lead to policies that are only good on paper, yet difficult to implement as shown by the current study.

2.6 Current biofuel development in South Africa

Biofuels are seen as a major source of employment and economic development in reducing the decline of agriculture, especially in middle income and industrialised economies (DoE, 2014). The South African government launched a Biofuels Industrial Policy in an effort to resuscitate the agricultural sector and a 2 percent penetration target in national liquid fuel supply was announced. Since this announcement was made, little has been achieved up to date (DoE, 2014). The major reason being that biofuels projects are not financially attractive at the prevailing feedstock and crude oil/liquid prices. However, the problem seems to have been partly addressed because eight companies have been offered operation licences to date (DoE, 2014). Table 2.1 shows the status of the licenced companies and their potential in biofuel blending.

Table 2.1 Biofuel licences status as at 2013

Company Name	Crop / Feedstock	Capacity (million litres/yr)	Location	Licence status
BIOETHANOL				
Mabele Fuels	Sorghum	158	Bothaville, FS	Issued
Ubuhle Renewable Energy	Sugarcane	50	Jozini, KwaZulu Natal	Issued
E10 Petroleum Africa cc	Sugarcane and other crops	4.2	Germiston, Gauteng	Granted
ARENGO 316 (Pty) Ltd	Sorghum and sugar beet	180 (in two phases of 90 each)	Cradock, Eastern Cape	Granted
TOTAL BIOETHANOL CAPACITY		**392.2**		
BIODIESEL				
Rainbow Nation Renewable Fuels	Soya Bean	288	Port Elizabeth, Eastern Cape	Issued
Exol Oil Refinery	Waste Vegetable Oil	12	Krugersdorp, Gauteng	Granted
Phyto Energy	Canola	>500	Port Elizabeth, Eastern Cape	Applying for licence
Basfour 3528 (Pty) Ltd	Waste Vegetable Oil	50	Berlin, Eastern Cape	Granted
TOTAL BIODIESEL CAPACITY		**850**		

Source: Department of Energy, (2014)

It can be seen from Table 2.1 that sorghum, sugarcane, sugar bee, soya been, canola and waste vegetable oil are current the only feedstock that are expected to be used by the licenced companies to produce fuel. To note are projects located at the Eastern Cape Province in Cradock, Berlin and Port Elizabeth that are projected to produce over 900 million litres of biofuel combined. The total capacity of the projected biofuels plants is expected to be about 1.262 million litres per annum, which is way above the targeted 2 percent level of biofuels in the national liquid supply (DoE, 2014). Although the targets set by the Department of Energy seem achievable. It is worth mentioning that none of the licenced project has been commissioned because of a lack of an appropriate Biofuel Pricing Mechanism (DoE, 2014).

2.7 Barriers to Biofuels development

Biofuels development may offer growth in agriculture. However, there are two concerns that have reinforced barriers to biofuels crops production.

Firstly, the possibility of requiring additional land and water resources means biofuel crops may pose a threat to those resources, for instance, biofuel crops like the sugarcane are water intensive and produced under monoculture (Liao, de Fraiture & Giordano, 2007). In order to meet water requirement, irrigation withdrawals may have to increase by 20 percent even under optimistic conditions (de Fraiture *et al*, 2007).

Secondly, the likely competition with food is one of the growing concerns about biofuel crops. Pimentel (2003) noted that while price increase in food may benefit farmers, they have adverse effect to urban and landless poor. Raswant, Hart and Romano (2008) pointed that as food prices increase and staple foods become more expensive it will lead to alternatives getting expensive as well, leading to food insecurity.

In 2007, the United Nations Department of Economic and Social Affairs (UNDES) undertook a study on small-scale production of biofuels in Southern Africa region. The findings were as follows:

Feedstock awareness- it was discovered that there is limited experience in choosing the right feedstock to be used for small-scale farming.

Land ownership-land patterns are inconsistent in many nations. Land ownership rights may become a thorny issue as biofuel cultivation competes with agricultural land. This situation is set to lead to a diversion of cash crops being diverted to biofuels cultivation.

Policy support- it was discovered that there are a lack of policies to support small-scale biofuels development at the local level. Also, in cases were Biofuels policies exist they tend to focus on the commercials side of the biofuels production. Hence, the potential for biofuels development to supply local energy needs has not been recognised.

Financing- a serious barrier that was said to affect many smallholder farmers was the issue of financing or accessing affordable financing. This challenge affects smallholder farmers who need to buy seeds and equipment for the production of biofuels crops.

Institutional awareness and capacity- the study noted that in sub Saharan Africa, there is a lack of awareness in small-scale production of biofuels, as well as the capacity to improve or develop production.

Market development- the findings also revealed that for any small-scale biofuel market to exist, it is necessary to understand needs and establish supply chain for product delivery, servicing and financing. Therefore, a number of smallholder farmers do not have business models to sustain their production of biofuels crops.

2.8 Conclusion

The literature review reveals that farmers' attitudes and perceptions remains a focal point in any decisions to adopt technology or farm programmes. Further, it highlights that successful adoption of agricultural technologies by smallholder farmers involves a process of analysing a number of factors such as socio economic, institutional and household characteristics. However, the varying degrees of factors influencing adoption have led to the adoption debate to be inconclusive in literature, with some researchers arguing that a number of factors such as economic situation and attitudes affect adoption. Yet, other researchers are of the view that adoption is determined by awareneness to certain technology or seed varieties.

CHAPTER 3

STUDY AREA

3.0 Introduction

This chapter presents the population, geographical area, economic, social, and physical characteristics of the study area. A description of the Chris Hani and Oliver Tambo District municipalities under study is given.

3.1 Location of study areas

This research was carried out in the Eastern Cape Province of South Africa. The province is shown diagrammatically in Figure 3.1 below with all district municipalities.

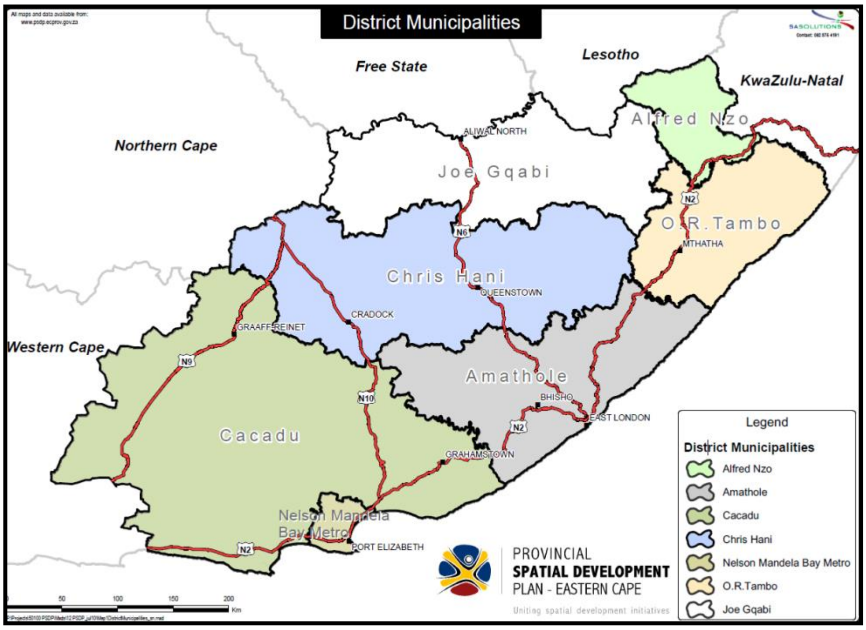


Figure 3.1: Eastern Cape Province

Source: Provincial Spatial Development Plan-Eastern Cape (2012)

The Eastern Cape is well known for its history in the struggles between native people (Xhosa) and the European Colonialists (Lahiff, 2005). People were separated along racial lines, as was the rest of South Africa during apartheid. This led to widespread dispossession of land and other property (Kingwill, 2000). Rural areas or former homelands (Transkei and Ciskei) dominate the province. Van Averbeke and Hebinck (2007) notes that the deep rural areas of the former Ciskei and Transkei have presented enormous challenges to the land claim, land restitution, and land redistribution reform policies introduced by the government since 1994.

The majority of people are poor and located in former homelands of Ciskei and Transkei, with poverty dominating mainly in black, female-headed households (Lahiff, 2005). According to Lahiff (2003) more than 10 million hectares of land (95 percent) in the Eastern Cape was in the hands of 6500 white commercial farmers, employing over 70000 farm workers. The land is for vegetable production, mixed farming, cattle ranching, sheep and dairy farming. Rainfall is plentiful in the eastern side along the coast during summer more than the inland. Van Averbeke (2000) points out that rainfall differs in accordance to proximity to the ocean. Villages close to the ocean receive enough rainfall to grow crops and veld management; yet, the ones further away receive little rainfall. During droughts, the communities' socio-economic activities are greatly disturbed as livestock perish and most are reliant on off farm activities (Van Averbeke & Hebinck, 2007). One of the crops that usually gauges the potential of agriculture is maize. That is, for the purposes of this study, maize was used to benchmark the potential of agriculture in Eastern Cape because of its semi-arid conditions. According to Figure 3.2, it can be seen that areas close to the coastal are more suitable for maize production.

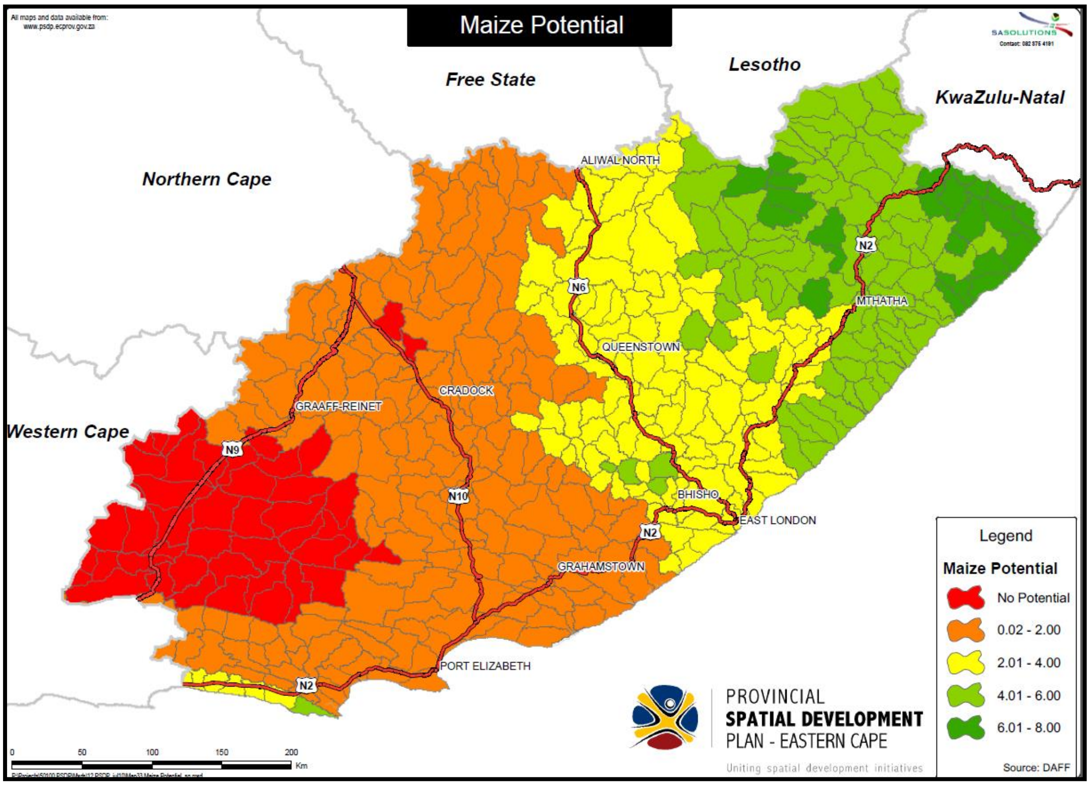


Figure 3.2: Maize Potential

Source: Provincial Spatial Development Plan-Eastern Cape (2012)

Figure 3.2 shows that areas lying to the western area of the Eastern Cape province have no potential in maize production. This therefore may also highlight the places of interest for the biofuel crop production, because most of the crops are suitable for semi–arid regions. The Cradock area in the western side of Queenstown has been targeted for biofuel productions and a multi-million biofuel production facility is under construction.

3.2 Oliver Tambo District Municipality

It is of great importance to identify the study area set-up because all these characteristics contribute to the livelihoods of the targeted respondents. One of the study areas that is important to this research is the O.R Tambo District Municipality. Figure 3.3 shows the demarcations and boundaries separating districts at the OR Tambo Municipality.

Figure 3.3: O.R Tambo Municipality

Source: The Local Government Handbook, 2013

The O.R Tambo district municipality lies on the eastern coast of the Eastern Cape Province. The district is bordered by Chris Hani District Municipality in the southwest, Alfred Nzo District in the northwest, and Amathole District in the south. O.R Tambo Municipality has a population on over 1.74 million (DAFF, 2012). The district has high levels of poverty, underdevelopment and infrastructure backlogs (O.R Tambo IDP, 2013). The district has a low urbanisation rate of 9.24 percent and a population that is predominately black (90. 22 percent) is resident to tribal land. O.R Tambo Municipality has a youthful population with over 39 percent of residents aged below 20 years and an unemployment rate of 40.8 percent, grant dependency ratio of 75.1 percent (O.R Tambo IDP, 2013). Poverty in the area is defined as deep and pervasive with at least 37.7 percent of residents living in squalid conditions (O.R Tambo IDP, 2013). The district per capita income is R14679 per annum. The district has a poor skills base with a literacy rate of 51.6 percent (O.R Tambo IDP, 2013).

According to the Department of Economic Development and Environmental Affairs (DEDEA, 2012), almost 65 percent of the households have access to water. The Human Development Index is 0.40 as from 2009. Although it increased from 3.8, it still reflects a lack of access to basic services, high illiteracy rate, and low standards of living, similarly to the Chris Hani District Municipality.

3.2.1 Poverty levels

Global Insights (2011) estimated that approximately 60.6 percent of the African population in the O.R Tambo District Municipality is impoverished. Of this number at least 58.9 percent of the total population where living in poverty. However, comparing on a national basis only 37.7 percent of the total population was living in poverty (O.R Tambo IDP, 2013). The Ngquza Hill local Municipality had the highest percentage of people living with poverty (64.8 percent), although the urban municipalities had a lower rate of people living in poverty (O.R Tambo IDP, 2013)

3.2.2 Education

According to the O.R Tambo IDP (2013), the district is characterised by lower levels of education. A total of 22 percent of the population had no schooling in the year 2001. However, this improved from 2001-2011 to 9 percent of the population (O.R Tambo IDP, 2013).The district has been facing challenges with tertiary education facilities, hence, only one tertiary institution is present in the district.

3.2.3 Vegetation and soils

The O.R Tambo District Municipality is composed of dense mixed grass veld, with no dominant species. Acocks (1953) describes the vegetation as Dohne Sourveld. Soils are mainly composed of mudstone and sandstone, which are structureless (Manona, 2005). The topsoil is approximately 300-400mm deep with the underlying soils composed of impenetrable rock or high clay. Manona (2005) noted that soils are of doleritic intrusions generated from the Karoo Dolerite. The soils are of Karoo origin making it ideal to farm drought resistant crops like sorghum or millet.

3.2.4 Rainfall, Temperature and Hydrology

The O.R Tambo district receives annual rainfall of above 800 mm (DAFF, 2013). The rainfall decreases inland and lower in major river valleys (O.R Tambo IDP, 2013). During winter months rain falls in the coastal areas and the inland areas receive 80 percent of precipitation or more during the months of October to March. The temperature ranges from a mean minimum of 14.3 -19.8 degrees in January and 1.8-13.4 degrees Celsius in July. The mean maximum range is 14.3-25.3 degrees Celsius in January and 19.5-21.4 degrees Celsius in July.

One large river system called Umzimvubu and two medium rivers namely Mthatha and Umtamvuna provides the area with water. The area has a number of coastal rivers with limited catchments stretching no more than 60 km inland (O.R Tambo IDP, 2013).

3.2.5 Transport Infrastructure

The low historical investments in road infrastructure in the O.R Tambo resulted in very poor access to the major road routes. The effect is that it isolates the already impoverished communities from important livelihood socio economic opportunities and limits economic development making it expensive to move inputs and outputs within the district and outside (O.R Tambo IDP, 2013). Furthermore, the district roads are below provincial average concerning surfacing due to the remoteness from major economics hubs (DEDEA, 2012). The status of the road infrastructure may prove to be a significant factor in improving smallholder farmers' access to biofuel markets. Currently, a number of national, provincial and district roads are being upgraded and refurbished in the area (O.R Tambo IDP, 2013).

3.2.6 Economic activities

According to the South Africa National Disaster Management Centre (NDMC, 2011), the district relies mostly on retail and wholesale sectors that have minimum growth potential with little to offer towards employment opportunities. Furthermore, mixed farming of crops and livestock is predominant, with crops such as cabbage and potatoes dominating, although maize is usually farmed in the district. The area has a high crime rate, poor road infrastructure and rail, making it hard to link to nearby seaports.

3.3 Chris Hani District Municipality (CHDM)

According to the Department of Provincial and Local Government DPLG (2013), Chris Hani District Municipality lies in the northern – eastern part of Eastern Cape. It was established in 2000 after the new demarcation of districts. The study area map is shown in Figure 3.4 with clear demarcations of small villages.

Figure 3.4: Chris Hani Municipality

Source: The Local Government Handbook, 2013

3.3.1 Socio- Economic information

There are about 795461 people who live in CHDM and they cover an area of 36558km^2(Chris Hani IDP, 2013). At least 79 percent reside in rural areas or former homelands, while the remaining are urban based. Generally, the population density is 21.83 persons/km^2. More than 55.9 percent of the population is composed of youths that are younger than 24 years of age (Chris Hani IDP, 2013). Households headed by women contribute around 53.5 percent of the population and the predominant language is (IsiXhosa) spoken by 93.3 percent in the district (Chris Hani IDP, 2013).

3.3.2 Economic Overview

The area is reliant on Community Services which contributes 52 percent to the GDP and it is characterised by agricultural activities wish contribute 4 percent in GDP (Chris Hani IDP, 2013). The Gini coefficient that measures inequality is 0.6. A value of zero means that they is a case of perfect equality, and one is perfect inequality. The inequality is more on black communities. The Human index that measures development should be preferably above 0.50 to represent an acceptable level of development. In CHDM, the index is 0.46, which is an unacceptable level (Chris Hani IDP, 2013). This is caused by a lack of basic services such as housing and infrastructure to name a few.

3.3.3 Agriculture

Timber and livestock production are the two agricultural sectors that have a comparative advantage in the area. Although crop production and agro processing remain vital, the transport cost and high volume markets makes these sectors uncompetitive (Chris Hani IDP, 2013). In 2008 an Integrated Agricultural Strategy was develop, and the following sectors were targeted for investment in agriculture: Agro–processing, livestock farming, crop production with special emphasis on biofuels, and irrigation schemes (Chris Hani IDP, 2013). The area is faced with challenges in livestock production due to low skills, access to land, poor veld, limited access to market and credit access to emerging farmers due to insecure land tenure (Chris Hani IDP, 2013). Furthermore, biofuel development has been of prime importance with the establishment of a project near Cradock. The project is set to revive and re activate sectors of the economy in the area (Chris Hani IDP, 2013).

3.3.4 Temperature

The temperature in CHDM is characterised by extreme weather patterns. In summer, the maximum temperature exceeds 40 degrees Celsius in the lower lying areas in the western (arid) section (Chris Hani IDP, 2013). Minimum temperatures are often below zero degrees Celsius and frost is a common occurrence in winter months in high lying areas. The period of frost is usually from mid-April to early October (Chis Hani IDP, 2013). Temperature in the eastern part of the district is usually moderate, with frost occurring from May to September. The high temperature rates predominate in the area offers great opportunity for biofuels crops that are usually adaptable to semi-arid conditions. Hence, this shows that the area has a huge potential in biofuels production

3.3.5 Rainfall

The rainfall is usually in summer with 70-80 percent precipitation in form of thunderstorms and hail. Rainfall varies over the area depending on altitude and distance to the coast (Chris Hani IDP, 2013). In western arid areas, the rainfall is around 200mm-300mm, whereas in eastern, it is 700mm-800mm (Chris Hani IDP, 2013). However, the huge part of the area is generally semi-arid and receives less than 400mm of rainfall. Evaporation is much higher than rainfall. This situation complicates crop production, as it requires other moisture conservation methods for dry cropping and irrigation management. Hence, the area may be well suited for biofuel crops such as sorghum, sunflower and soya that can be easily grown in semi-arid regions.

3.3.6 Land type

According to the Chris Hani Municipality Spatial Development Framework (2011), the area is composed of Beaufort sediment with dolerite intrusions. This type of landscape was formed through a combination of shale, mudstone, and sandstone. The soils are rocky and not suitable for crop production. However, in the valleys deeper soils are predominating. Rocky soils can be considered for crops such as sorghum. Thus, utilizing land that is available for productive uses. Soils in the more arid areas are shallow and consists of mainly Mispah, Glenrosa and Swartland (Chris Hani IDP, 2013).

3.4 Conclusion

The OR Tambo Municipality is the only district that receives more rainfall than any other municipality in the Eastern Cape Province because of its geographic location. Inland areas receive little rainfall, hence, they may be targeted for biofuels production. Briefly, agriculture in the O.R Tambo District Municipality is predominantly subsistence farming in communal lands. The area is favoured by moderate temperatures that are ideal for farming rain fed crops like maize, potatoes, and others.

The Chris Hani Municipality District is characterised by moderate rainfall, high temperatures, poor soils and many thunderstorms. Families who grow crops on dry land have a serious shortage of water due to high evaporation rates prevalent in the area. However, the area is good for farming especially in deeper valleys with the use of irrigation. The next chapter explains the methodology employed in the study.

CHAPTER 4

RESEARCH METHODS

4.0 Introduction

This chapter presents the research method and clarifies the research procedures that were adopted in this study. This is important in order to evaluate the usefulness of the research results. Issues addressed include the research design, data collection reliability, validity and the underlying population of the study. The chapter proceeds to discuss how the data collection and interpretation are particularly linked to the conception of the biofuel industry. The chapter concludes by the Heckman model specification that was used for a regression analysis.

4.1 Unit of analysis

Trochim (2006) stated that the unit of analysis is a major entity in any study. It can be of the following nature; groups, individuals, geographic units to name a few. In this study, individual farmers were used as the unit of analysis. The farmers were from Chris Hani and Oliver Tambo District Municipalities. A questionnaire was administered in person to record data.

4.2 Sampling Frame

A sample frame is defined as a list of units from which a sample is drawn (Lewis-Beck *et al.* 2004). In this study, farmers were selected based on their willingness to participate in the survey. Not all farmers in study areas were selected, but a sample was drawn from the targeted population. The two districts were purposively selected because of their agricultural potential, geo-climatic and soil characteristics, as well as, cropping history.

4.3 Sampling technique

This study adopted a non-random purposive sampling technique to select the smallholder farmers. A snowballing sampling technique refers to a situation in which the probability of including each element of the population in a sample is unknown (Kish, 1987).The snowballing sampling technique is used to capture a range of perspectives relating to the thing under study. This technique helps in gaining deeper insights into units under study. These units may exhibit a wide range of attributes, behaviours, experiences, qualities, situations and so forth.

The main reason for choosing this method was to focus on particular characteristics of the population of interest. This in turn helped in answering the research questions proposed for the study. However, this method can be prone to bias. In order to correct the sample bias a Heckman Two step model was then used to remove any sample bias.

A non-exhaustive list of farmers was acquired from the Department of Agriculture in Chris Hani Municipality and Oliver Tambo District Municipality with the help of the Agricultural Extension Officers. Interviews were then conducted on households that had access to arable land. Then farmers in both municipalities were classified as non-land utilizer and land utilizers after using a snowballing sampling technique. Non-land utilisers where farmers who did not farm for the last two seasons and land utilizers where farmers who farmed their land in the past two seasons. Utilised land is land exclusively for farming crops.

In order to draw the sample a random sampling technique was applied to choose the first respondent. Then upon finishing with the respondent, they will suggest the next respondent to be interviewed. Since, the technique was applied randomly at the first instance, the samples of land utilizers and utilizers were not likely to be equally. Therefore, the snow balling technique started after the first interview.

The sampling frame is shown on Table 4.1.

Table 4.1 Sampling Frame

Oliver Tambo Municipality		**Chris Hani Municipality**		**Total**
Land Utiliser	Non-Land Utilisers	Land Utiliser	Non-Land Utilisers	
50	29	30	20	129

4.4 Sampling size

A bigger sample size is always preferred when collecting data about a group. Although it is more representative, it tends to be costly, while a small sample is less accurate but more convenient (Singh & Chaudhary, 1979). As stated above, the study consisted of two areas namely, O.R Tambo and Chris Hani municipality districts. In Chris Hani District, areas sampled had farmers partaking in irrigation farming and consisted of smallholder farmers utilising and non-utilising land. The two types of farmer groups were purposively selected in order to identify certain characteristics or traits that would help in identifying farmers that were likely to adopt biofuel crops and those who would not.

The areas sampled were Zwelitsha, Maya, Entla kweFolo, Mkhukhwini, and Elalini. In the OR Tambo District smallholder farmers selected were utilising and non-utilising land, but mainly those who were involved in rain-fed crop production. The areas sampled were Blekane, Bomvu and Hlophe. The selection of the sampled areas in each municipality was done random.

In the Oliver Tambo Municipality, 50 smallholder farmers were identified and in Chris Hani District Municipality a total of 79 smallholder farmers were part of the sample. This contributed to a total sample size of 129 smallholder farmers. In choosing the number of farmers sampled per area, accessibility of farmers and distance were taken into consideration. In Chris Hani District Municipality, farmers were far much spaced than OR Tambo Municipality. Meaning one had to travel a long distance to get a farmer to interview. The challenge of the data collection process is that since all the interviews were voluntary, it was costly to travel a large distance and fail to interview the farmer or farmers.

4.5 Orientation stage

This stage involved visiting the study areas in 2013 and holding discussions with farmers. The main objectives for the study were outlined to the farmers through agricultural extensions officials. This was done to familiarise and interact with the farmers so as to identify key issues pertaining the study areas.

4.6 The survey

After the orientation stage, the actual survey was done between the period of January and February 2014. A questionnaire was used to collect data. This was done through the administration of a similar semi-structured questionnaire.

4.7 Data collection procedures

In order to fulfil the objectives of the study, both primary and secondary data was recorded. Secondary data was used mainly for the description of the study areas and background information.

Primary data was collected using semi-structured questionnaires. The questionnaires were interviewer administered to reduce problems of misinterpretations and misunderstanding of words or questions, since the areas had illiterate and literate farmers. Kvale (1996) states that interviews standardize the order in which questions are asked. Open-ended question allow individuals to express their opinions. However, most of the questions were closed ended to make it easier when coding and for simplicity in capturing information without wasting time for the respondents. Each interview lasted approximately 20 minutes.

Face–to-face interviews were the means of administering the questionnaires based on the following advantages:

- ✓ High reliability of data was obtained since the interviewer can probe with further questions if respondents seem to not understand the questions or appear to be falsifying information. The method ensures that all the necessary information found in the questionnaire was answered to avoid having a lot of missing data. Hence, this improved the validity of the questionnaire.
- ✓ The method enhances internal validity of the conclusions drawn.

Factual questions relating to respondents background and personal data such as educational level, gender, age, marital status were asked at the beginning of the questionnaire. This was followed by farm characteristics questions. Lastly, question relating to biofuels completed the interview.

4.8 Ethical considerations

The following steps were taken in order to comply with the ethical requirements and standards:

- ✓ The right to participate and withdraw voluntary at any stage of the interview was practised, to ensure that the respondent was not coerced into participation.
- ✓ The purpose of the study was explained beforehand so that the individual understood the nature the research.
- ✓ The procedures of the study were clarified, so that the individual could expect what was anticipated in the research.
- ✓ The right to privacy within the research and after, as well as, the right to obtain results was maintained.
- ✓ The benefits to be accrued from study were explained clearly.
- ✓ Signatures of both participant and researcher formalising such an agreement gave a go ahead to the study.
- ✓ The findings of the research will not be falsified, suppressed, or invented to suit the need of the respondents and researcher.

4.9 Confidentiality and anonymity

The confidentiality and anonymity of respondents was assured in the study. This was achieved by not asking names from respondents. However, the district or village that the respondents came from were required.

4.10 Coding of data

According to Rossman and Rallis (1998), coding is the process of organising the material to get a meaning from that material. This process involves taking an image, text data, or sentences and labelling those categories with a term. The data that was extracted from respondents was recorded on a Windows Excel spreadsheet and transferred to SPSS version 21 for coding and analysis. Furthermore, the same Excel spreadsheet was taken to the econometrics software package of EViews version 8 to analyse the Heckman two-step model.

4.11 Reliability

Reliability of the instrument used to collect data was ensured by the use of different types of question formats. This enabled the research design to pick inconsistencies in the responses. A Cronbach Alpha was used to test reliability. This is a measure of internal consistency or how closely related a set of items are as a group. A high value in the alpha is often used as evidence that the items measure an underlying or latent construct. The Cronbach's Alpha was above the minimum 0.6 resembling the reliability of the instrument in capturing what it intends to capture. Table 4.2 shows the test results.

Table 4.2 Reliability Test

Cronbach's Alpha	No of Items
.624	129

4.12 Validity

To ensure that the conclusions drawn by the study are as valid as possible, the study ensured that municipalities exhibiting conditions of grain or crop farming formed part of the study. The validity issue is linked to generalisability of the research to other provinces that did not form part of this study. The study can certainly generalise its results within the areas it has studied and areas exhibiting similar conditions as the study areas. When linking the results to provinces that did not form part of the sample, readers and researchers should be careful and view the study results as indicative, instead of descriptive.

Model Specification

4.13 Models analysing adoption

This section reviews theoretical and empirical models used to analyse adoption studies.

4.13.1 Rational utility maximisation model

This model is based on a few assumptions. Firstly, households are assumed to be rational utility maximizing units that select their preferences from a set of participation or adoption preferences in a biofuels related market. Household decisions are based on farm household's utility obtained from participation or adoption subject to its reservation utility, farm household characteristics, and resource constraints. Therefore, the underlying farm household's utility from participating/ adopting in a biofuel market ***q:***

$$U_q^* = X\beta_q + K_q \alpha_q + \epsilon_q, \ldots\ldots (1)$$

where **X** is a vector of the observable independent variables, for instance, farmland, incentives, household characteristics (rent, landholding size, gender, education), $\mathbf{K_q}$ is a vector of unobserved latent variables (farm potential that affects the choice to adopt biofuels or participate in the market and household earnings), ϵ_q, is the error term which is assumed to be independent of $\mathbf{K_q}$ yet β_q and α_q are respective parameters associated with **X** and $\mathbf{K_q}$. $\mathbf{U_q^*}$ is the unobserved farm household choice to adopt/ participate in a biofuels market, ***q*** is the observed. If ***K*** is assumed to be latent denoting the specific market adoption/participation choice of farm household, then we can write ***K*=*q*** when $\mathbf{U_q^* = Max\ (U_z^*)}$**.** Where $\mathbf{U_z^*}$ is a complete set of optimising utility levels associated with ***z*** adoption/participation decision that the farm household can make. Therefore, the expected household income to be achieved by each participating or adopting choice can be expressed as follows :

E (y) = u* (fβ+I$_q$λ$_q$+ iγ)………………………………………………………..(2)

Where ***f*** is a set of exogenous variables with associated parameters ***β*** and $\boldsymbol{\lambda_q}$, which represents the effects of adopting or participation in a biofuels related market in farm household earnings relative to non-participation. The expected earnings are also a function of the unobserved variables ***Kq*** with marginal effects parameters ***γ***.

The utility maximization model can be used empirically as a multinomial probit model that has an error term that is assumed to follow a normal distribution with correlation between alternatives (Greene, 2012). This is more favoured over the multinomial logit model because it relaxes the independence of irrelevant alternatives assumptions (IIA) (Greene, 2012).

4.13.2 Static Models

A static model tries to weigh farmers' decisions to adopt an improved technology at a specific period. The model tries to answer questions of what determines whether a particular technology is adopted or not and what determines the pattern of adoption. A simple static model is a logistic model that can be shown as follows:

$$\frac{\partial N_t}{\partial t} = g_t(N^M - N_t)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where $\frac{\partial N_t}{\partial t}$ is known as the rate of changes in adoption over time,t and g_t is the coefficient of diffusion (which is a measure on how fast adoption occurs). The cumulative frequency of adopters is represented by $N_t$at time *t* and N^M is the maximum numbers of adopters in a system over time. $(N^M - N_t)$ represents the number of potential adopters not joining at a time *t.*

A number of models in adoption studies are set in static binary or probit or logit models (Jansen, 2003). In such models, the adoption process is strictly dichotomous (to adopt or not) where the functionality relationship between the probability of adoption and a set of variables are estimated using the logit or probit model. These two models investigate the effect of regressors on the decisions to use or not, they do not measure the intensity of adoption (Feder *et al.* 1985). For instance, a decision to adopt a one quarter of recommended new seed variety is treated the same as a farmer who adopts the recommended level of seed. Therefore, a Tobit is mainly used in such instances where the amount of seeds can be ascertained (i.e. data on the area planted those seeds)

Other alternatives to analyse adoption decisions involve the use of a double hurdle model that takes into account zero observations (Heckman, 1976). The model choice is very important because it influences the results obtained within the study. Amemiya (1984) states that inappropriate use of non-user data can lead to bias and inconsistent in estimates, for example, a Tobit model assumes that results or decisions regarding adoption and its intensity are equally similar. Yet, studies conducted by Coady (1995) proved otherwise by indicating that the results are not similar. Heckman (1976) produced a model that is most restrictive since it assumes that non-zeros for non-adopters are generated by the decision, making the standard Tobit model irrelevant in such instances.

A study by Negatu and Parikh (1999) used a Probit and an ordered Probit to test the significance of the impact of farmers' perception in the adoption of new technologies. The Probit model was used to analyse the adoption decisions, while perception of farmers were modelled using the ordered Probit. Consequently, a simultaneous model combining the Probit and Ordered Probit approaches provides a useful approach in modelling a two-way relationship between adoption and perception. To determine dependent variables of simultaneous nature of discrete and continuous endogenous, the Heckman (1978) was proposed. The Heckman uses a reduced form of parameter estimates as instruments to overcome the problem of estimating system of equations, with discrete and continuous endogenous variables. For instance, if estimating the effects education of men has on their income, a problem met is that men who are not working do not have income. If it happens that unemployed men are a result of poor education, running a regression with income as a dependent would lead to biased estimates.

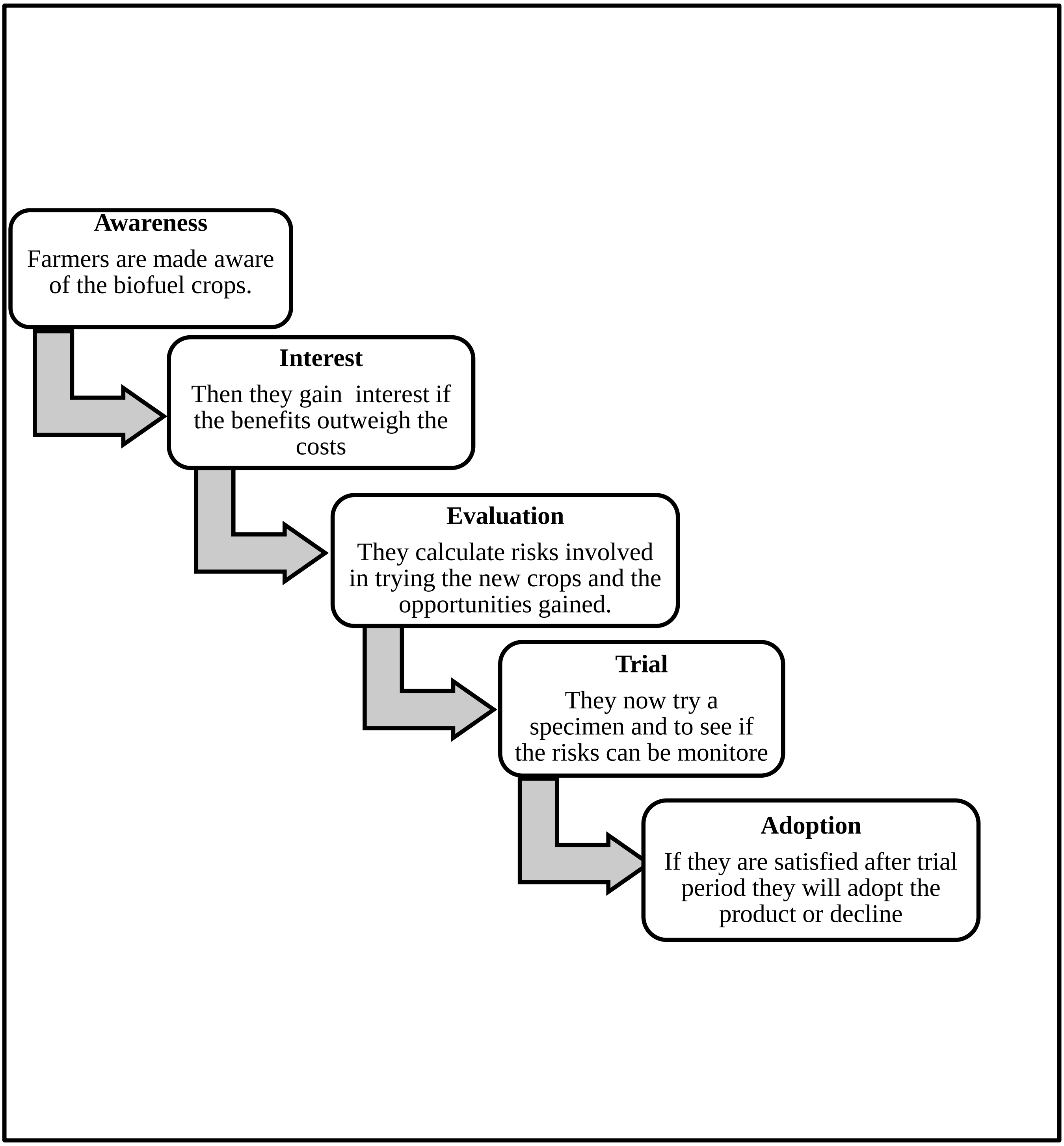
Thus, a Heckman procedure offers two steps in correcting that bias. The first step is to test the model using a probit model, and then the residuals from the probit analysis are used to create Lambda that is equal to the lnverse Mills Ratio. The value of the Lambda is added as an additional variable. In the second step, the analysis is done using an Ordinary Least Square regression. Therefore, two models are created, that is the selection model and outcome model. The main caution for the method usage is that the selection equation or model should contain at least one variable that is not related to the dependent variable. If such a variable is not present, issues of multi-collinearity may lead to estimation difficulties and spurious coefficients.

4.13.3 lnsights from literature

Some studies justify the use of binary or dichotomous models, while other studies are of the view that failure to measure awareness when testing adoption potential generally leads to spurious results.

Nevertheless, every model has its strengths and weaknesses. As long as a model can come to conclusive results that many studies agree upon, it is a suitable model. Therefore, they are many criterions that can be used to access a model viability. Therefore, if it passes all the required steps of a model fit, then it is a good model.

4.14 Conceptual Framework



Source: Author

Figure 4.1 Conceptual Framework

Figure 4.1 demonstrates that awareness is the first stage to any adoption process. Therefore, in order to have a buy-in from the targeted population, one must try to disseminate information.

4.15 Econometric Model

In this study, a binary choice model in the form of a two-step procedure known as the Heckman model was used to investigate factors affecting/influencing the potential adoption of biofuel crops. The model was designed to measure choices between two discrete alternatives. The model has been widely used in adoption studies (Usman *et al.* 2011; Deressa, 2007; Gennrich, 2004; Demeke, 2003). Furthermore, it has been widely used to correct any sample selection bias. It takes the form explained below:

4.15.1 Heckman two stage model

The Heckman estimation corrects for non-random sample selection by using two equations. A typical model for interest is : $y = x\beta + u \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$

Where $E\left(\frac{u}{x}\right) = 0,\ s = 1[z\gamma + v \geq 0]$ where s =1, if we observe y and 0 otherwise. The correlation between *u* and *v* leads to sample selection problem. Therefore, the first step would be to estimate γ on a probit of $s_t = z_t$ using the whole sample. Then an inverse Mills ratio $\lambda_t{}' = \lambda(-z_t\gamma')$of each *i* is computed. Using a selected sample with observation for which $s_t =1$, the second procedure would be to run a regression of y_t on x_t, $\lambda_t{}'$ (Wooldbridge, 2000)

The inverse Mills Ratio is extracted from a probit equation in the first stage to provide OLS selection bias corrected estimates. A simple equation model with a random sample size of n can be written as follows:

$$Y_{1t} = X_{1t}\beta_1 + U_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$Y_{2t} = X_{2t}\beta_2 + U_{2t} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3)$$

Where X_{jt} is a (1 x K_J)vector of explanatory variables and β_t is a (K_Jx 1) vector of parameters j=1,2 ; and U_{1t} ,U_{2t} are normally distributed. The Heckman model assumes normal errors.

4.15.2 The first stage of the Heckman model

The first equation in a Heckman model is a probit estimator. The model estimates the effects of X_i on response Pr[y=1 | X].The probit model of awareness of biofuels crops is derived from an underlying latent variable model expressed as:

$$Y_i^* = \beta_0 + \beta_{ij}X_{ij} + \varepsilon_i \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (4)$$

Where Y_i^* is an underlying index reflecting the difference between awareness and non-awareness; β_0 is the intercept, β_{ij} is a vector of parameters to be estimated; X_{ij} is independent variables which explains biofuel awareness; ε_i is a standard normally distributed error term that is independent of X_{ij} and symmetrically distributed about 0. From the latent variable in equation (4), the smallholder farmers' awareness of biofuels model is derived as follows:

$$P(Y_i^* = 1 \mid X) = F = (\beta_0 + \beta_{ij}X_{ij}) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (5)$$

Where F is the function that ensures the likelihood of being aware of biofuel crops maintained between 0 and 1. Hence, a smallholder farmer is aware of biofuel crops when $Y_i^* > 0$ and otherwise $Y_i^* \leq 0$.Therefore a normal distributed function of a probit model can be written as follows:

$$P(P(Y_i^* = 1 \mid X) = F(BX) = \int_{-\infty}^{\beta X} \frac{1}{\sqrt{2\pi}} \exp(-z^2/2)\, dz \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . (6)$$

Where P is the probability that the *i*th smallholder farmer will be aware of biofuel crops and 0 otherwise; X is the (k x1) vectors of the independent variables; z is the standard normal variable and β is the (k x1) vector of coefficients to be estimated.

4.15.3 Second stage of the Heckman Model

The estimates of γ of the probit model were used to generate the estimates of the inverse Mills ratio term that is as follows:

$$\gamma'_t(-Z_t\gamma') = \frac{\theta(Z_t\gamma')}{\emptyset(Z_t\gamma')} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

Where $\emptyset(.)$ is the standard normal cumulative distribution function (cdf) and $\theta(.)$is the standard normal probability density function (pdf) in a truncated standard normal distribution. Greene (2000) states that truncation takes place when a sample is drawn from a population of interest. The second stage is estimated by ordinary least squares and uses observations with positive values of the dependent variable, hence, it is the outcome equation that includes the inverse Mills ratio and X variables as regressors.

$$\Gamma_J = \phi\gamma'_J + \vartheta\Lambda_J + \mathrm{E}_J \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

Where Γ_J is the non f ,γ'_J is the inverse Mills ratio and Λ_J represents variables such as socio economic (age,education,farm size), economic variables (income) and more. The error term is E_J and consistent estimates of ϕ and α = 1. The sample selection equation is as follows:

$$P'_j = \eta X_j + \varepsilon_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(9)}$$

The sample rule is that Γ_J is observed only when P'_j is greater than zero. P'_j is the decision to adopt biofuels or not. Hence, the outcome mechanism is that:

$P'_j = \eta X_j + \varepsilon_j$ Where $P_t = 1$ if $P_t > 0$ and 0 otherwise. Therefore the regression model

$\Gamma_J = \phi\gamma'_J + \vartheta\Lambda_J + \mathrm{E}_J$ is observed if $P_t = 1$, ($\varepsilon_j, \mathrm{E}_J$)~ bivariate normal and the error terms follow a bivariate normal distribution with mean 0 and correlation *p*.

4.15.4 Definition of the regression equations used in the study

The following equations were used to estimate the Heckman Model:

$$y_{1AWARE} = b_o + b_1 * GENDER + b_2 * AGE + b_3 * QUALIFICA + b_4 * MEMBERASS + b_5 * CONTACTEXT + b_6 * FARMEXPE + b_7 * FARMEQUP + b_8 * OCCUPATION + \varepsilon \ldots\ldots\ldots\ldots (\mathbf{10})\textbf{Selection Model}$$

$$y_{2ADOPT} = b_o + b_1 * HHS + b_2 * ARABLE + b_3 * INCENTIVEPART + b_4 * HHINCOME + b_5 * CHALENGE + b_6 * UTILIZELAND + b_7 * BORROWMONEY + b_8 * LABSOURC + b_9 * LANDACQUIRE + b_{10} * DISTANCE + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{11})\textbf{Outcome Model}$$

4.15.5 Definition of variables

The variables chosen for this study were directed by previous literature on adoption of agricultural technologies and crops. The literature was presented in Chapter 2 for easy reference. Independent variables are divided into three groups: demography characteristics of farmers that includes household size, age, and education. Institution factors such as; access to markets, tenure system, credit access, farm experience, membership to associations; and economic factors such as income, awareness of biofuels, adoption of biofuels. A detailed description of variables is provided in the subsequent sections.

4.15.6 Dependent variable

In this study, awareness and adoption were modelled as jointly binary dichotomous variables with the impacts of determinants of awareness estimated using a bivariate logistic specification. The dependant variable for the outcome equation is whether the farmers would adopt biofuel crops or not (ADOPT). Following Daberkow and McBride (2003) the ADOPT variable is specified in binary with (0 = adopt biofuel crops) and (1= not adopt biofuel crops). The dependent variable for the selection model is AWAREBIO. This variable is also in a dummy format like ADOPT where 0 means the farmer is aware of crops and 1 the farmer is not aware of biofuel crops. In order to identify respondents as potential adopters or not, a screening question was posed and through their responses it was then easy to identify the two separate groups.

4.15.7 Independent variables

Age- this variable measures the age of the respondents and it is continuous. As farmers age, advances risk aversion comes into play, thus, low chances of adopting a certain technology. Young farmers are risk loving and are expected to have a high probability of adopting new technology. The variable therefore has a positive or negative relationship with adoption depending on age. Kherallah and Kirsten (2001) posit that older farmers are resistant to change and therefore are likely not to adopt technology. On the other hand, Ngqangweni and Delgado (2003) are of the view that older farmers are experienced, hence, there are likely to adopt so as to increase their output.

Household size - this variable is a continuous variable that indicates the number of people in a household. This includes parents, children and other relatives who live in the same dwelling and share food together. A large family size means labour maybe available in form of young, middle aged and older people who may participate in farming. On the other hand, a large household size may mean added pressure for residential houses. This may lead to more land being used for housing, thus, leading to negative participation in farming.

Education- the variable measures formal or lack of education of a household head in the family. It measures the level of education with no education. Tadesse and Kasa (2004) hypothesised that education level was positively related to the adoption of agricultural technology. Educated people are more likely to be informed and interpret information better than the uneducated. This means they may understand innovations faster, as a result, making quick decisions on whether to adopt certain technology or not. Siebert *et al.* (2010) notes that farmers with a higher level of education may take advantage of any training and information, therefore, they are able to successfully participate in new technology adoption than the less educated.

Credit access - the variable measures if the respondents have access to credit facilities or the possibility of getting credit. It is a dummy variable, which takes a value of 1 if the farmer has credit and 2 if the farmer has no access to credit. Farmers with credit usually overcome difficulties or financial constraints and they are able to buy inputs. In contrast, farmers with no access to credit find it difficult to acquire or adopt agricultural technology (Taha, 2007).Access to credit therefore is expected to influence the probability of willingness to adopt biofuel crops.

Farming experience- measures the number of years of experience in farming. Farmers with a lot of experience as in the number of years appear to have better knowledge and might be able to identify advantages of new technology. Therefore, farming experience is expected to have a positive influence in adoption.

Contact with extension officers- this variable measures the number of times the agricultural extension officers' visit farmers per month and it is a continuous variable. Any contact with extension officers is expected to increase the likelihood of farmers adopting new technology (Habtemariam, 2003). The more the farmer is in contact with extension officers, the higher the chances of acquiring more information on proposed adoption technologies or crops.

Land tenure- It is a discrete variable. Land ownership is believed to have a huge influence on adoption of technologies linked to land (Feder, *et al.* 1985). Daberkow and McBride (2003) notes that land has a huge influence when the innovation requires investment to be tied to land. Farmers who own land are expected to be motivated to adopt agricultural technology or crops unlike those who rent the land.

Labour – this refers to active male or female members in a household or community. A household with a larger number of members per hectare is more likely to be in a position to adopt new technology or try an innovation. Kidane (2001) states that labour influences the adoption behaviour of farmers. This means that a farmer with access to more labour has a high probability of adopting production of biofuels crops.

Utilised land - farmers who are utilising land are expected to be influenced by what there might get if they adopt a certain technology. The relationship of adoption maybe positive or negative if they do not find a solid reason on why they should forego the current crops they are producing and adopt new crops. Farmers who are not utilising land may see this as a big opportunity to bounce back to agriculture, since the land can now be utilised to the fullest. Therefore, they have a higher probability of adopting biofuel crop production.

Gender – this is a categorical variable where 1 represents a male and 2 a female. It is expected to influence the adoption rate in biofuels because males are the ones more engaged in farming than females. Gender also influences the access to assets such as capital and land, which have a direct effect on productivity. In traditional societies, access to land is usually restricted to males and women access land through males. However, the decision to participate in production of biofuel crops will likely involve males, even though the households may be headed by females.

Members associations - this variable measures the involvement and affiliation of a respondent to any formal and informal organisation. Individuals who are active in associations are likely to have better awareness and knowledge than those not involved in any associations (Habtemariasm, 2004). It takes the value of 0 if the farmer is a member and 1 otherwise. Therefore, respondents who are active in associations are in a better position to understand the innovation before it is launched through grape vine engagements. Hence, being a member of an association is expected to influence positively the adoption of biofuels.

Distance to market- this variable measures the distance that the respondent takes to reach the nearest market or where the respondent sells his/her output. Markets that are far away usually discourage farmers from participating in any income benefiting activities. The reason being that transport adds more costs to the farmer. As a result, the shorter the distance to the market, the higher the chances of farmers participating or adopting new crops varieties.

Incentives - the variable involves the incentives offered to farmers to discontinue of current crops they are farming and opt for biofuels crops. It is highly likely that farmers who are offered incentives may be flexible in adopting biofuel crops, if there think incentives will improve their yield and income. Therefore, it is expected that incentives will have a positive influence on farmers adopting biofuel crops. The variable is a dummy, with 0 representing willingness to adopt biofuels based on incentives offered and 1 non-willingness to adopt biofuels when offered incentives.

Challenges - the variable expresses the challenges that farmers are exposed to when deciding to participate in an agriculture programme or adopting new technology. It is unlikely that farmers who face more challenges would adopt a certain crop or new invention, especially if it leads to more risks. Therefore, the more the challenges the higher the chances that the farmer will not adopt the production of biofuel crops. The variable was a categorical. Where challenges were grouped as institutional, financial and socio economic challenges.

The summarised variables and the expected priori are shown in Table 4.3 below.

4.16 Analytical software

Two statistical packages were used in this study to take advantage of different features in both programs. Statistical Package for Social Science (SPSS) is excellent in descriptive statistics, comparison of means and logit models. The Eviews software package is excellent in running econometric models and provides a number of tools for testing and screening data; therefore, it was used for testing heterescedasticity and the Heckman two step model.

Table 4.3 Variables for the study

Variable	Definition	Type	Unit of measurement	Expected Sign
Dependent Variables				
ADOPTBIO	Adoption of biofuels	Binary	1 = adopt & 0 otherwise	
AWAREBIO	Awareness to biofuels	Binary	1 = aware & 0 otherwise	
Independent Variables Farmers socio-demography characteristics				
HHGENDER	Household gender	Binary	0= Male &1 = Female	+/-
HHAGE	Household age	Continuous	Years	+/-
HHEDU	Household education	Continuous	Level	+
HHSIZE	Household size	Continuous	members	+/-
HHINCOME	Household income	Continuous	South African Rands	+
Farming, institutional and management factors				
UTILAND	Utilization of land	Binary	0 = yes &1 = no	+/-
ARABLE	Amount of utilized land	Continuous	Hectares	+/-
TENURE	How land was acquired	Discrete	tenure	+
DISTANCE	Distance to market	Continuous	Kilometres	-
FARMEXPE	Level of farming experience	Continuous	Years	+
CREDIT	Access to credit	Binary	0= yes &1 = no	+
LABOUR	Source of labour	Discrete	Type of labour	+/-
MEMASSOC	Member of association	Binary	0= yes & 1 = no	+
AGRICEXTE	Contact with agriculture extension agents	Binary	0= yes &1 = no	+
INCENTIV	Offered incentives	Binary	0= yes &1 = no	+
CHALLENGES	Challenges faced by a farmer	Categorical	Type	-

4.17 Conclusion

This chapter outlined the methodology and analytical tools that were used in this study. The chapter highlighted the major strengths of this study in the following format:

- ✓ The explanatory variables under consideration in Table 4.2 made the empirical model more reliable in measuring what it intends to measure.
- ✓ Use of primary data and the sample size that was purposive were selected in order to achieve an in depth response rate that would answer every objective that this study seeks to address. Further, the sampling method justified the use of the Heckman two-step model to correct for any sample bias.
- ✓ Use of two statistical packages that have been tried and tested to be good in analysing econometrics and statistics data, thus, increasing the reliability and validity of the data recorded.

The objectives are restated in Table 4.4 below.

Table 4.4 Objectives Summary

Objectives	Questions	Hypothesis	Analytical tool
1. To investigate awareness of smallholder farmers on biofuels crops in selected areas in the Eastern Cape Province.	What determines theoretically adoption of biofuel crops and farmers' characteristics?	Farmers are aware of biofuels crops in the Eastern Cape Province.	Descriptive statistics
2. To access the level of potential adoption by smallholder farmers.	What is the level of potential adoption of biofuels crop by smallholder farmers in selected areas in the Eastern Cape?	Farmers are aware of biofuels crops in the Eastern Cape Province	Descriptive statistics
3. To estimate determinants of farmers potential to adopt biofuels crops in the Eastern Cape Province.	What determines the actual adoption of biofuel crops and what are the bottlenecks?	Social, economic, and farming factors influence farmers to adopt biofuels crops.	descriptive statistics and econometric model
4. To identify incentives that influence the potential adoption of biofuels crops by smallholder farmers.	What kind of incentives are needed to influence the potential adoption of biofuels crops?	Capital, funding, markets are some of the incentives needed by smallholder farmers in order for them to adopt biofuels crops.	Descriptive statistics

CHAPTER 5

RESULT DISCUSSIONS

5.0 Introduction

This chapter presents the major findings of the study on barriers and incentives to widespread adoption of biofuels in the Eastern Cape. Firstly, descriptive statistics are presented so as to highlight the livelihoods of respondents and factors that may influence them in adopting biofuel crops. Demographic, farm characteristics, income sources, challenges, and incentives necessary for adoption of biofuels are also presented. The chapter concludes by analysing the Heckman two stage model in order to answer the objectives set for the study.

5.1 Descriptive characteristics of the study

Table 5.1 below summarises sample characteristics in which measurements such as the mean, standard deviation, median, skewness and kurtosis are given. The mean and median were in the range of zero to four, implying that there were no outliers. The following characteristics were negatively skewed. Suggesting that the mean is lower than the median.

- Age distribution of survey respondents
- Household income
- Systems of land tenure
- Credit Access
- Distance to market
- Farm experience
- Source of income

Table 5.1 Descriptive statistics

Variables	N	Mean	Median	Std. Deviation	Skewness	Kurtosis
Gender	129	.47	0.00	.501	.142	-2.011
Age of respondents	129	2.15	2	0.674	-0.185	-0.792
Highest qualification	129	2.17	2	1.276	0.959	-0.088
Household size	129	4.48	5	1.404	-0.872	0.18
Household income	129	3.11	3	1.517	0.045	-1.527
Arable land	129	2.3	2	1.101	0.23	-1.278
Utilize land	129	0.2	0	0.403	1.506	0.27
Arable land utilised last season	104	2.02	1	1.182	0.573	-1.297
Land tenure	129	3.59	4	0.989	-1.851	2.109
Crops produced	108	2.04	1	1.611	1.946	3.201
Distance to market	109	3.44	4	0.821	-1.286	0.662
Access to credit	129	1.65	2	0.478	-0.642	-1.613
Farm experience	129	2.32	2	0.729	-0.573	-0.922
Source of labour	127	1.22	1	0.435	1.655	1.551
Member of any association	129	1.46	1	0.5	0.173	-2.001
Contact to any extension	129	1.48	1	0.502	0.078	-2.025
Awareness to biofuels crop	129	0.48	0	0.502	0.078	-2.025
Willing to adopt	129	0.21	0	0.408	1.446	0.092
Willing to adopt if given incentives	129	0.35	0	0.478	0.642	-1.613
Sources of income	129	3.73	3	1.344	-0.277	-0.959

Skewness and Kurtosis values were less than one, with the exception of land tenure that was over two.

5.2 Respondents Statistics

The average age of the respondents was between 35-50 years and the prominent qualification was grade twelve. The majority of households had between 5-6 members with a household income on average of 2001-3000 per month. Most households had arable land of 0.5-1 hectares and the majority utilized 0.6-1 hectares last season. The distance to the market was over 10 kilometres and farm experience ranged between 6-10 years. This is presented in Table 5.2 .

5.2.1 Gender

The results in Table 5.2 show that males comprised 53.14 percent of the sample as a percentage of head of households. This represents the general norm in Africa where most households are male headed or dominated. This observation is similar to Montshwe (2006), who discovered that males still dominate in the agricultural sector in South Africa. At least 52.71 percent of respondents interviewed were 35 years and over, but less than 50 years. A total of 31.01 percent respondents were 50 years and above.

5.2.2 Marital status

The study also assessed the marital status of the respondents. Table 5.2 shows the distribution of households by marital status. At least 45 percent of the respondents were married, 21 percent single, 18 percent divorced, and 16 percent widowed. The marital status helps in accessing the duties of participants per household in the African society. In addition, married people are able to share household activities such as farming, herding livestock and harvesting. Whereas single, widowed and divorced households usually struggle with household activities.

5.2.3 Education

The majority of respondents had at least a primary education. A total of 39.53 percent attended grade 11 or lower, at least 28.68 percent attended grade 12; 16.28 percent had a diploma, 6.2 percent had a bachelor’s degree and 9.3 percent received a post graduate degree. Nkhori (2004) observed that the problem of education especially in rural areas household is set to decline as access of education improves. However, Musemwa *et al,* (2007) pointed out that the problem may be caused by the fact that most of the youths are employed in the formal sector and other informal sectors, as they view agriculture as a dirty job. Therefore, since the majority of respondents have secondary qualifications, this is not expected to affect potential adoption of biofuel crops because most of the older smallholder farmers have a lot of experience in farming.

5.2.4 Household size

Table 5.2 shows that households with more than 6 people were 28.58 percent of the sample. Similarly, households with 4 or 5 members made 25 percent of the sampled households. Smallholder agriculture is heavily dependent on household labour. FAO (2013) posits that increasing family size tends to provide families with the required labour for agricultural production, yet, larger families exert a great deal of insistence on consumption than the labour contributed to agricultural production. Hence, larger families are expected to be having adequate labour for farming.

Table 5.2 Respondents Summary

Variable	Description	Percent	Variable	Description	Percent
Gender	Male	53.5	**Farm experience**	0-5 years	15.5
	Female	46.5		5.1-10	37.2
Age of respondents	15-34	16.3		10.1 and more	47.3
	35-50	52.7	**Source of labour**	Family	77
	51 and above	31		Community	20.2
Qualifications	Grade 11 or lower	39.5		Other	2.8
	Grade 12	28.7	**Member of association**	Yes	54.3
	Post matric diploma	16.3		No	45.7
	Bachelor degree	6.2	**Source of income**	Donation	6.2
	Postgraduate degree	9.3		Agriculture	10.1
Household size	Live alone	5.4		Salary	34.9
	2	5.4		Pat time jobs	5.4
	3	7.8		Grants	38.8
	4	27.1		Business owned	3.9
	5/6	25.6	**Occupation**	Unemployed	45
	More than 6	28.7		Formal employed	29.5
Household income	0-1000	17.1		Pensioner	7.8
	1001-2000	27.9		Self employed	13.2
	2001-3000	12.4		Full time farmer	4.7
	3001-4000	12.4			
	4001 and over	30.2			
Distance to market	Less than 0.5km	2.3			
	0.6-5km	10.9			
	5.1-10km	18.6			
	10.1 or more	52.7			

5.2.5 Income

Table 5.2 shows different levels of income received by households in the study area. It is illustrated that 30 percent of respondents receive an income over R4000 a month, 28 percent receive income between R1000-2000 per month, 17 percent receive less that R1000 and 24 percent receive income between R2000-4000. It was noted that many respondents who earned above R2000 per month supplemented their income with pension grants or child support grants.

From the study, it emerged that most respondents depended on social grants. At least 39 percent depend on social grants for their livelihoods. These grants are in form of pensioners' grants and child support grants. A closer analysis at the respondents revealed that 34.16 percent survived on salaries, 10.16 percent on agricultural outputs through selling their produce, and 6.25 percent received donations, 5.47 percent worked part time jobs to raise income and 3.19 percent owned businesses that generated income. It can be deduced from the results that most farmers earn off-farm income. Therefore, since a number of respondents are earning off-farm income, they may be persuaded to farm biofuel crops to improve their on farm income.

5.2.6 Sources of income

When it comes to employment, a total of 44.96 percent respondents were not employed. This was explained by a high percentage of respondents having grants as a form of income. Respondents that were formally employed constituted 29.46 percent of the sample. Pensioners were 7 percent of respondents, full-time farmers were 5 percent of the sampled respondents and 13 percent were self-employed.

5.2.7 Membership in association

Farming associations serve as a communication tool for many farmers. Therefore, membership to an association was considered for this study. A total of 54.26 percent respondents stated that there are members of agricultural associations or societies. Being a member of an association serves as a network where valuable information pertaining to agriculture can be exchanged. Members can also learn new things and this is a platform for discussing innovations, identifying constraints faced by members. With a number of respondents being members to agricultural associations, it is expected that they would be willing to participate in biofuels production. Being a member to agricultural association may have an influence to farmers in adopting new technology (Diagne, 2010).

5.3 Adoption potential and farmers characteristics

This section explains the association of variables to adoption of biofuel crops.

5.3.1 Gender of households and willingness to adopt biofuels

The relationship between gender and willingness to adopt biofuels crop was investigated. Males had a higher percentage (43.41 percent) of respondents who were willing to adopt biofuels and females had 35.66 percent respondents willing to adopt biofuels. Mihiretu (2008) claimed that males and females are likely to play different roles in technology adoption depending on the nature of the technology. This is mainly caused by the socio-cultural values and norms. For instance, males have a freedom to participate in a number of extension programs. Although the literature is inconclusive on gender concerning adoption, the results give an insight of the likely gender to adopt biofuel crops for production. The results are shown in Figure 5.1.

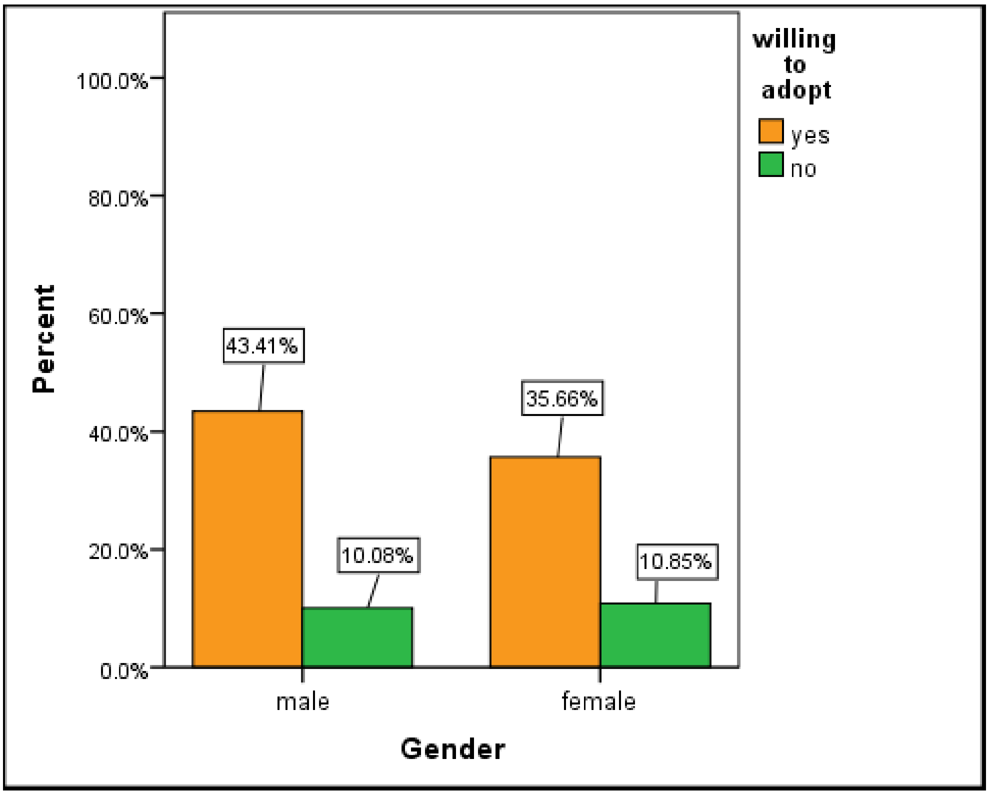


Figure 5.1: Respondents gender and willingness to adopt

5.3.2 Age of respondents and willingness to adopt biofuels

The age group of 35-50 years has the highest percentage (41.86 percent) of potential adopters of biofuel crops, followed by the over 50 years age group. The results are in support of literature, which states that many risk takers are farmers in their midcareer or mid ages. The findings are similar to Jera and Ajay's (2008) study on participation in fodder tree growing. Dereje (2006), however noted that as farmers' age increases the probability of adopting new technology decreases. Yet, Hofferth (2006) suggested that older people become more adaptive to technology because of experience in farming. The results are presented in Figure 5.2.

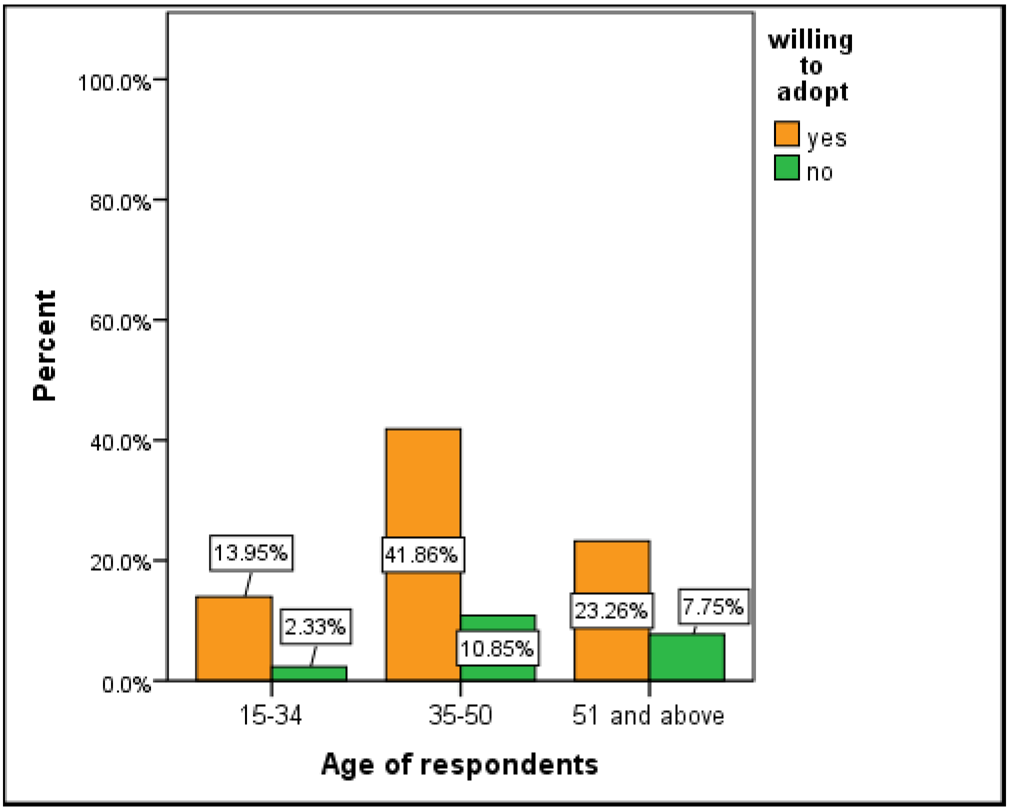


Figure 5.2: Respondents age and willingness to adopt

5.3.3 Marital Status and willingness to adopt biofuels

Figure 5.3 shows that married people have the highest percentage (42.11 percent) of adopting biofuel crops, followed by divorced people at 18 percent and single people at 18 percent as well. The results show single, divorced and married are high-risk takers as they have the largest percentages of respondents with a potential to adopt.

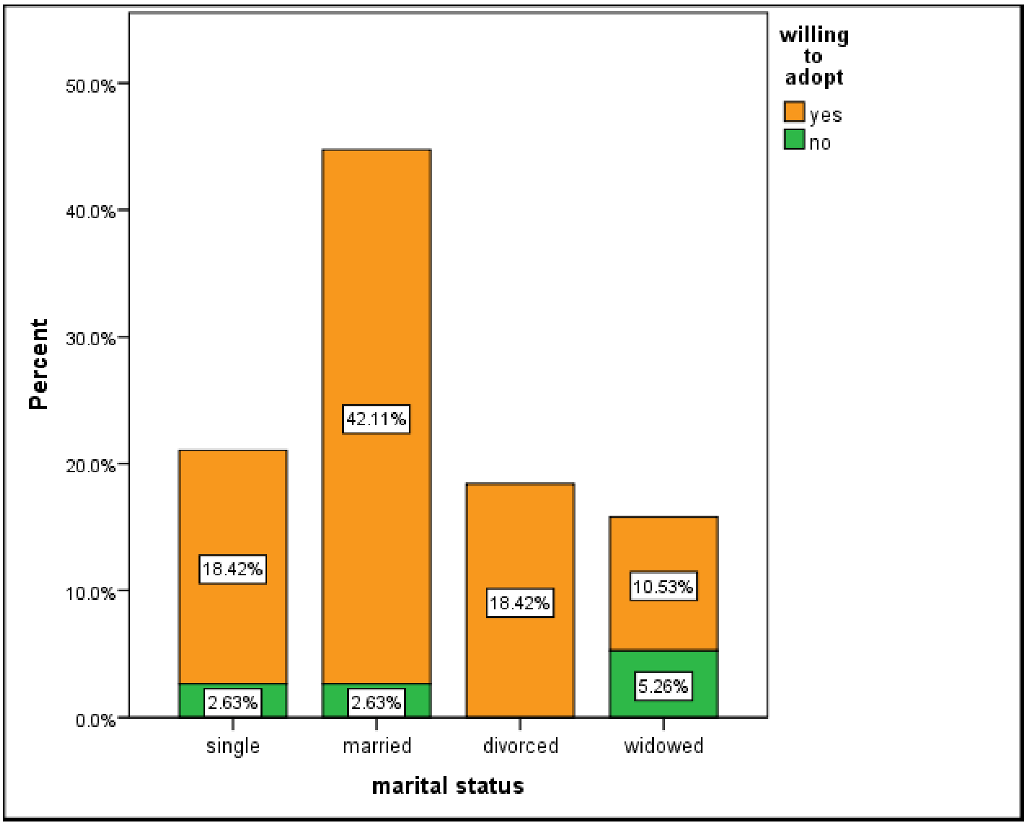


Figure 5.3: Marital status and willingness to adopt

5.3.4 Level of education of the respondents and willingness to adopt biofuels

Figure 5.4 shows that most of the respondents are beyond the youth age, hence, only a few respondents did tertiary level. Thus, the highest potential to adopt is seen from respondents who did Grade 12 and under. It is not surprising though that the highest respondents not willing to adopt 12.49 percent possess grade 11 and below. Partly uneducated people are expected to be resistant to new technology or seed mixtures, because they may struggle to understand the benefits of such technology or seeds. The results are similar to Joseph (2008) who observed that farmers with more education are likely to adopt new technology than those with primary level. Moreover, farmers with more education were said to be aware of information concerning adoption. Bembridge (1988) noted that lack of knowledge affects the potential to adopt new technology such as seed varieties.

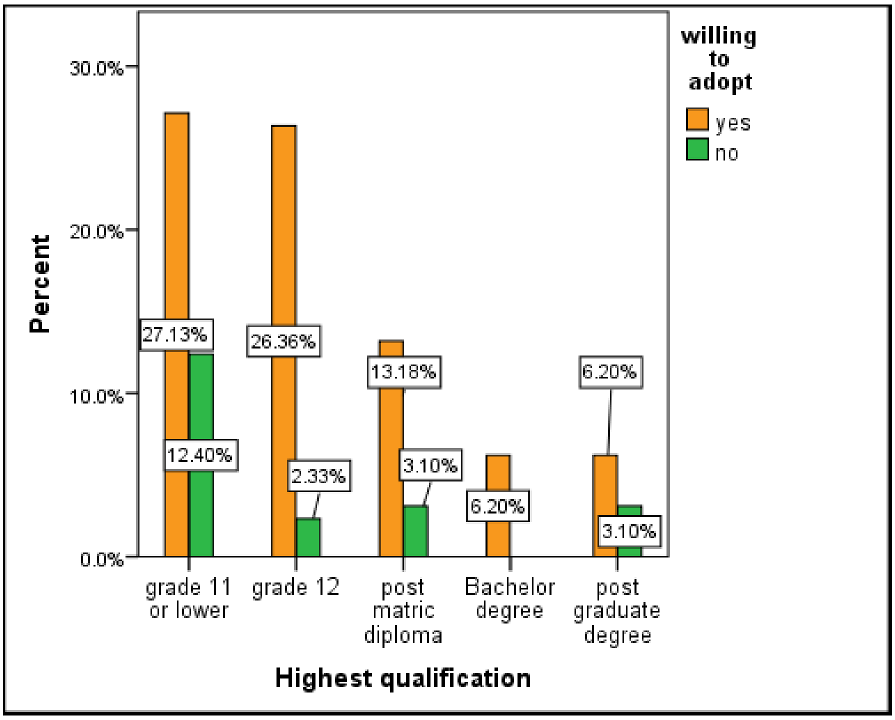


Figure 5.4: Highest qualification and willingness to adopt

5.3.5 Household Size and willingness to adopt biofuels

The study considered the household size effect to the potential adoption of biofuel crops. Figure 5.5 shows that households with more than 4 members have a higher chances of adopting biofuels crops (24.03 percent). Phororo (2001) stated that large households have extra labour capacity available, hence a large household may influence the potential to adopt biofuel crops. A close look at the findings reveals that as the household size increases, so does the percentage of not willing to adopt. The factors that influence large households may be tied to the need to generate additional income to nurture every member. Moreover, as the household size increases, so does the stress of finding reliable income to get into motion.

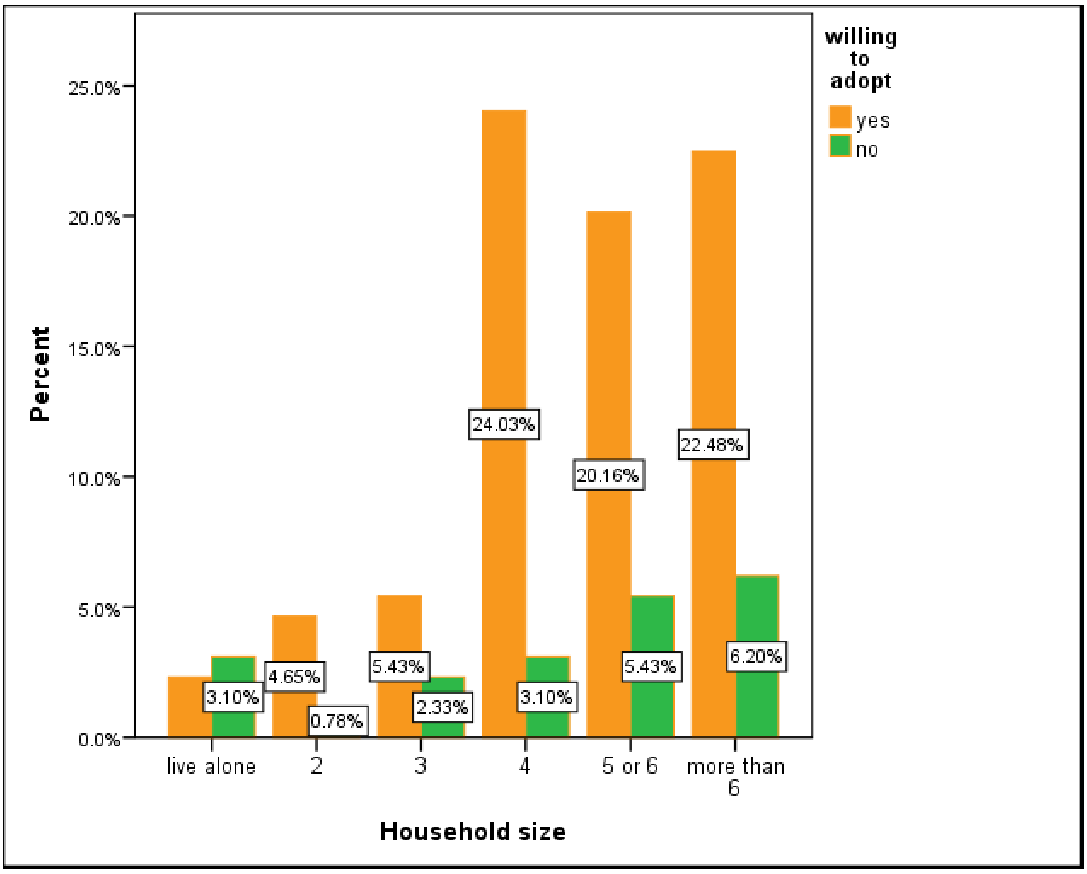


Figure 5.5: Household size and willingness to adopt

5.3.6 Household income and willingness to adopt biofuels

Household income status has an influence on the adoption of biofuel crops, in that households with higher income may be persuaded to adopt biofuel crops based on the premise that they can afford to buy seeds for farming. On the other hand, households with little income may not be persuaded to adopt biofuels unless they have some sort of subsidy or sponsorship. Over half of the respondents earning income through agriculture were not willing to adopt biofuels for production. Figure 5.6 shows that households earning R1000-2000 had 22.48 percent respondents willing to adopt biofuels and household earning R4000 and more had 23.26 percent potential adopters. This generally means that low-income households find themselves looking for alternatives to increase their income through adopting biofuels with the hope of benefiting financially. Steady income households however find the new technology as an opportunity of increasing their wealth.

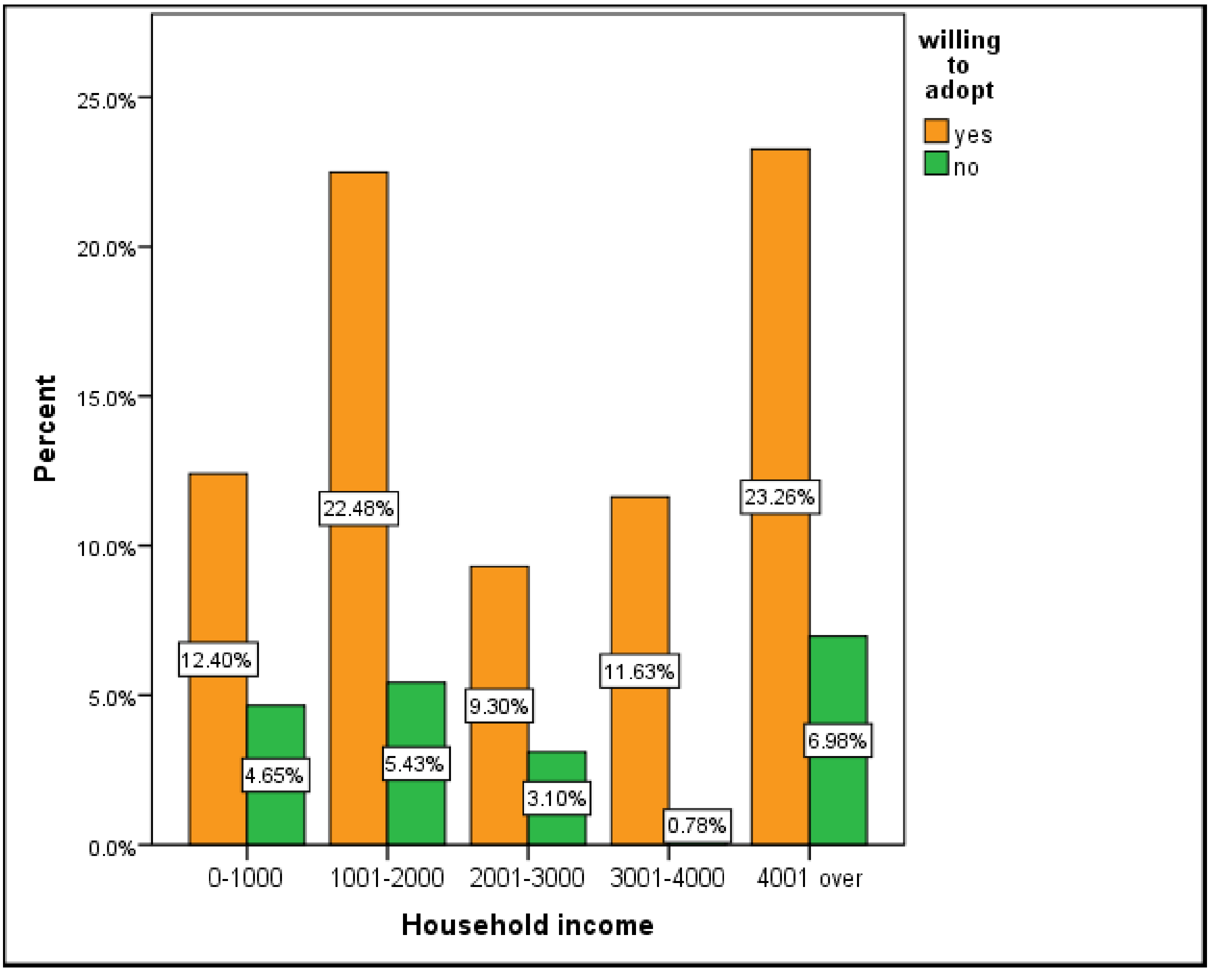


Figure 5.6: Household Income (In Rands) and willingness to adopt

5.3.7 Sources of income and willingness to adopt biofuels

Figure 5.7 shows that the largest number of respondents who were willing to adopt biofuel crops were mainly receiving income from grants (31.25 percent) and salaries (27.34 percent). Considering that respondents earning grants had little income, they were willing to increase their income by undertaking other ventures. Similarly, those working and earning salaries wanted to spread risks by producing biofuels with the hope of improving their financial status.

Respondents earning income from agriculture however were much willing to adopt biofuels crops due to the risks associated with new crops.

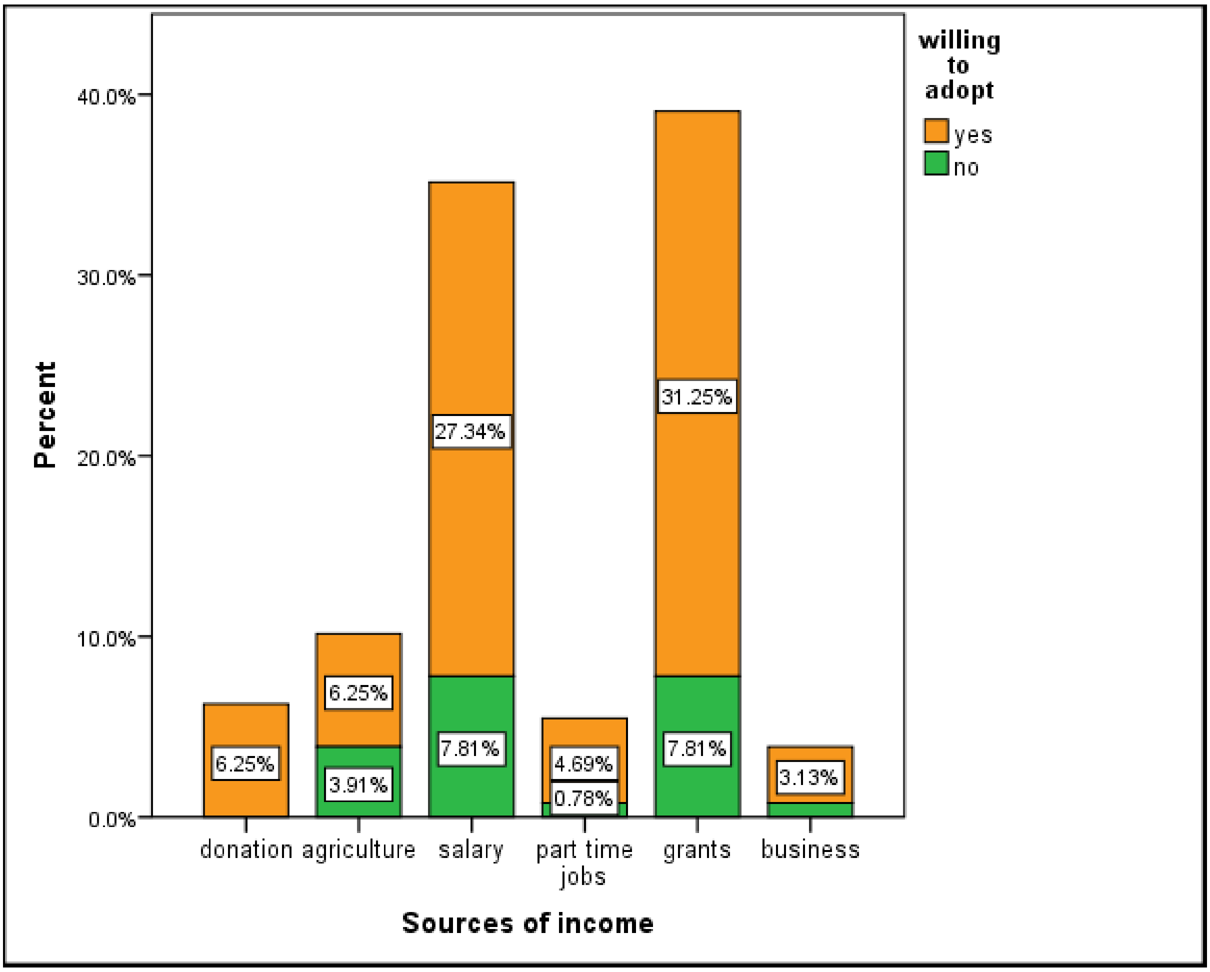


Figure 5.7: Sources of Income and willingness to adopt

5.3.8 Income received from farming and willingness to adopt biofuels

A closer analysis of household income received from agriculture highlighted that 47 percent of respondents were earning less than R2000/month from agriculture, 16 percent received R2000-4000/month from agricultural produce, 37.5 percent received more than R4000/month, and 5 percent benefited nothing from agriculture. Normally households consume their produce and sell when they produce a surplus. It is therefore necessary to understand how households try to diversify their income in trying to survive. Furthermore, realising how much income is generated from agriculture helps in identifying the number of respondents who are likely to adopt biofuel crops for production. Households receiving substantial income from agriculture may be motivated to increase that income and households getting little may turn around their fortunes and earn more through biofuels production. The income level earned from agriculture is shown in Figure 5.8 .

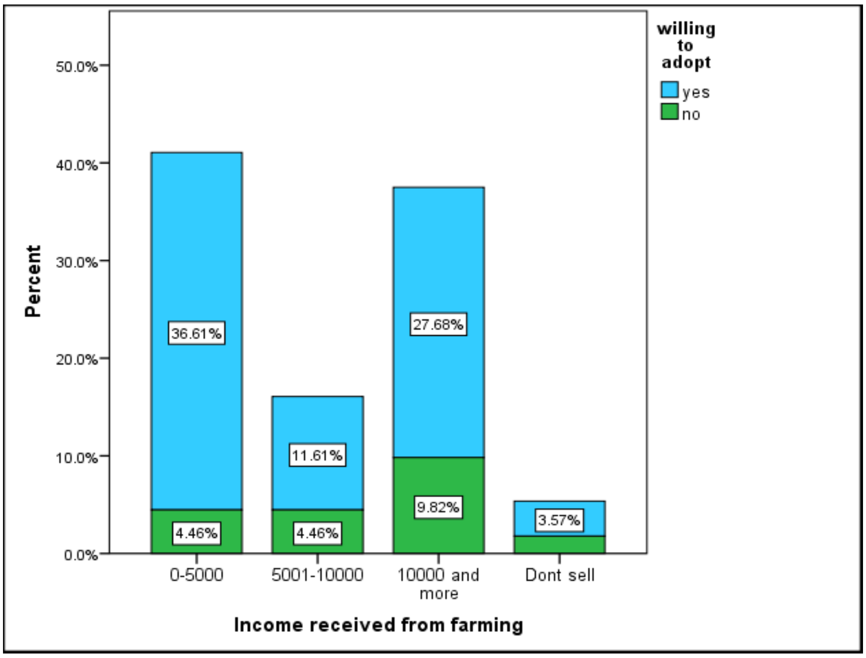


Figure 5.8: Income received from farming and willingness to adopt

5.3.9 Occupation and willingness to adopt biofuels

It is also not surprising that half of respondents practising farming as an occupation were not willing to consider adopting biofuel crops because of a lack of knowledge and other reasons. However, the unemployed constituted 40.3 percent of respondents willing to adopt biofuel crops. This was expected considering that they were not employed and anything that would give them income would be accepted. Moreover, the employed had 23.6 percent respondents willing to adopt. This meant that the issue of spreading risk was in consideration. The lowest percentage of those willing to adopt biofuels was from farmers. The farmers said that biofuels crops needed more land than they had; hence, there was no need to adopt. Figure 5.9 shows the results.

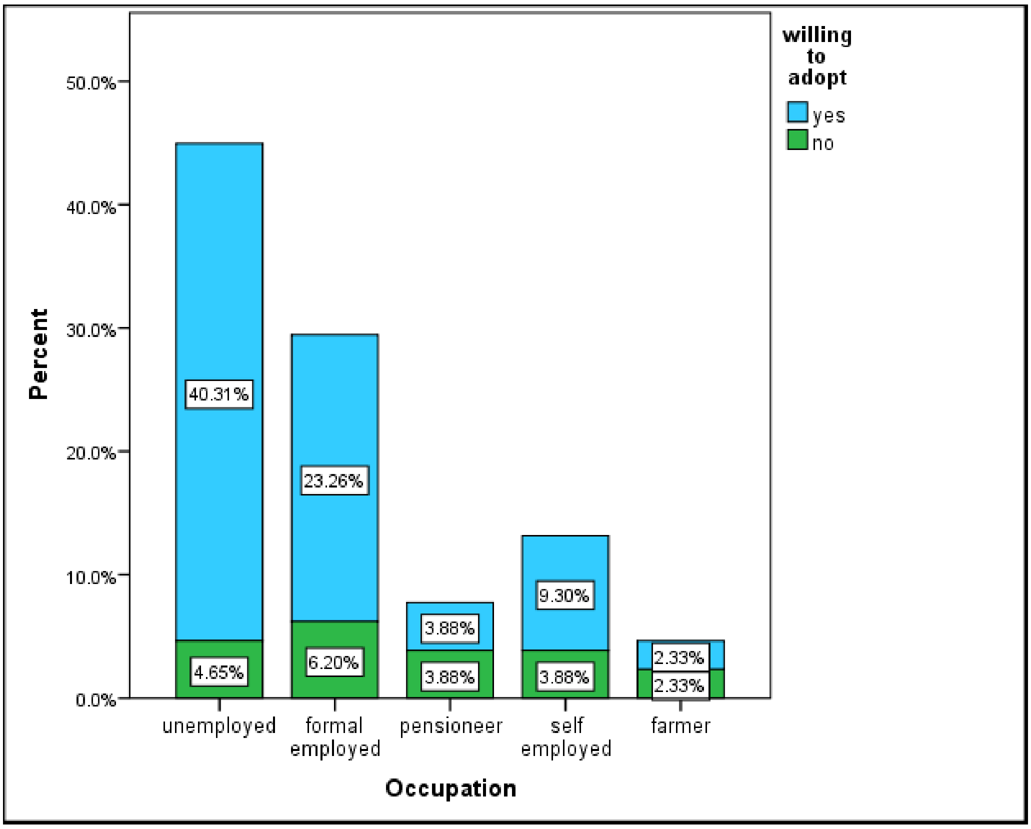


Figure 5.9: Occupation and willingness to adopt

5.4 Land Use

The study examined the patterns of land ownership and use in both municipalities under study. Further, the study assessed how much arable land was available to farmers and how much was utilised during the previous seasons.

5.4.1. Arable land and willingness to adopt biofuels

The respondents were asked a question on available land for agricultural activities. Figure 5.10 displays arable land available for farming.

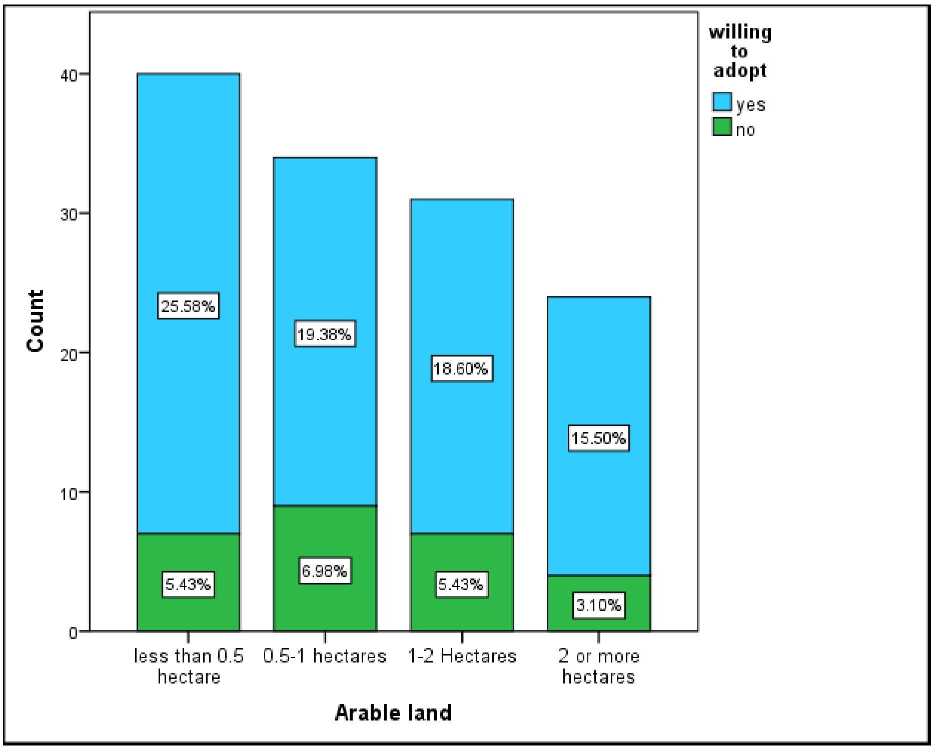


Figure 5.10: Arable land available and willingness to adopt

The land patterns show that households are small scale or are involved in subsistence farming. Households with less than 0.5 hectares had 25.5 percent of respondents willing to adopt biofuels crops. As the land size increases, the willingness to adopt decreases. The result means that there is a negative association between land size and adoption. The results oppose Joseph (2008) findings that adopters who own bigger pieces of land are likely to embrace new technology. Furthermore, Rosenzweig and Binswanger (1993) found a positive association between land and adoption.

5.4.2 Arable land utilized

A question was presented to respondents if they utilize their land for agriculture or not. According to Figure 5.11, of households that owned less than 0.5 hectares, 25 percent utilised the land and 5.14 percent did not utilise the land. Of the households owning between 0.5 – 1 hectares, 17.83 percent were utilizing their land and 8.53 percent were not. This was quite shocking considering that one would expect a farmer with a lot of land would be making use of it. However, it was quite understandable considering that a number of respondents were complaining of lack of support from government institutions and failure to get the required inputs.

At least 18 percent of households owning 1-2 hectares were utilizing their land and 5.43 percent were not. Some of the respondents who were not utilizing their land stated that the land was now treated as grazing plots for their animals. Some earned income by charging other farmers to put their animals for grazing in those plots. It was further noted that 17.83 percent of households owning over 2 hectares were utilising the land for agricultural purposes and 0.78 percent of respondents were not utilising the land. The number of respondents non-utilising the land was greatly reduced. This was contributed partly by the fact that some respondents were renting their larger farms, hence, they needed to pay rent regardless of the circumstances. For them the best option was to use the land and try getting something from it.

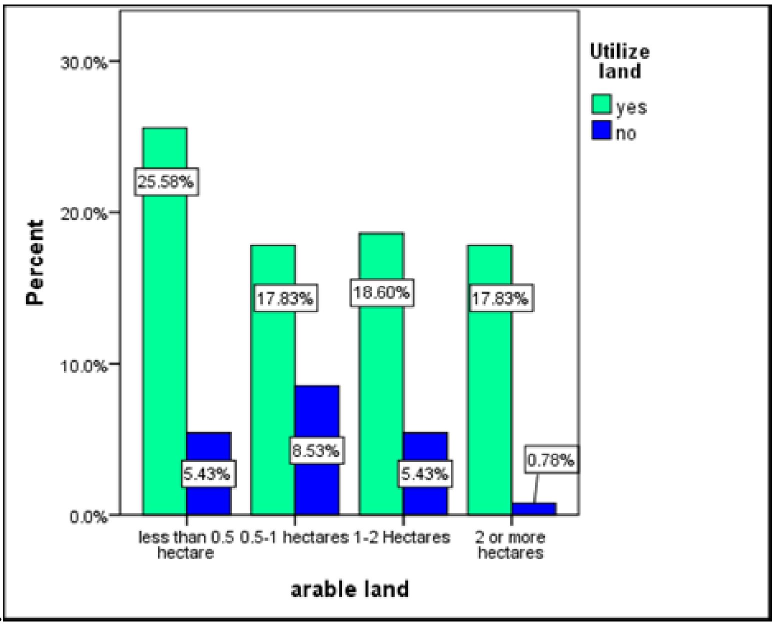


Figure 5.11: Arable land utilized

5.4.3 Land utilised last season

In order to understand the problems that usually face farmers in agriculture, an understanding of how much land was utilised last season was important. Another question was posed to farmers to clarify how much land was utilised for farming during the previous season. A total of 51.9 percent of households utilised less than 0.5 hectares, 10.58 per cent utilised over 0.6 - 1 hectares, 21.52 per cent utilised 1.1-2 hectares and the number of respondents who utilised more than 2 hectares was 16.35 percent. The percentages for land utilisation were expressed as a percentage for their household land holdings. The findings indicate that there was a decline in land use for people who owned over 1 hectare and less than 2 hectares. In contrast, households that utilised less than 0.5 hectare increased to over 50 per cent. Respondents highlighted that seeds and fertiliser were the challenges that caused decline in land use from the previous season. This is shown in Figure 5.12.

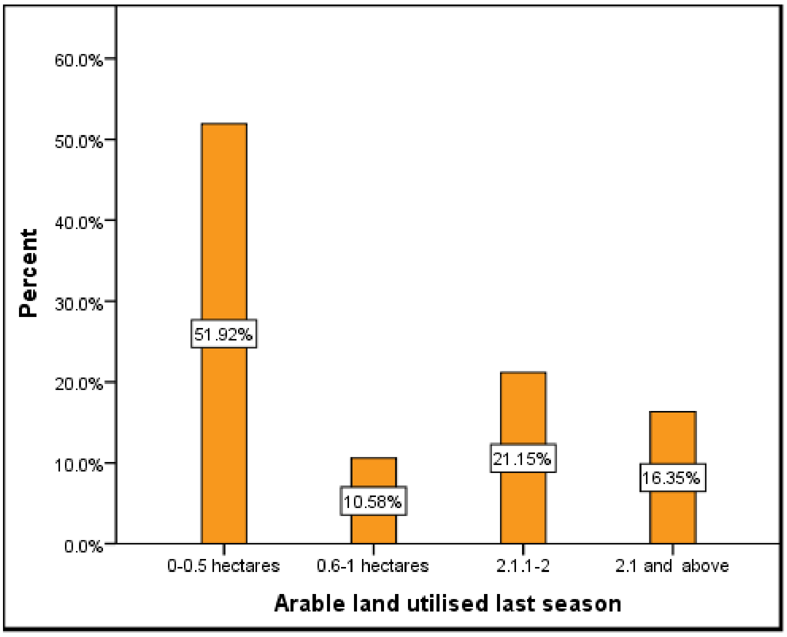


Figure 5.12: Arable land utilized last season

5.4.4 Land tenure

In order to understand how land tenure can influence adoption, Figure 5.13 shows potential adopters according to the land tenure system. A total of 63.67 per cent respondents who inherited land were willing to adopt biofuel crops. Property rights to the land might have influenced this. Respondents who had state land were willing to adopt as well. However, half of the respondents who were renting land were not willing to adopt based on the insecurity of the land and ownership, since they cannot amend the land without approval from the property owner. Land ownership therefore has an influence on those willing to adopt.

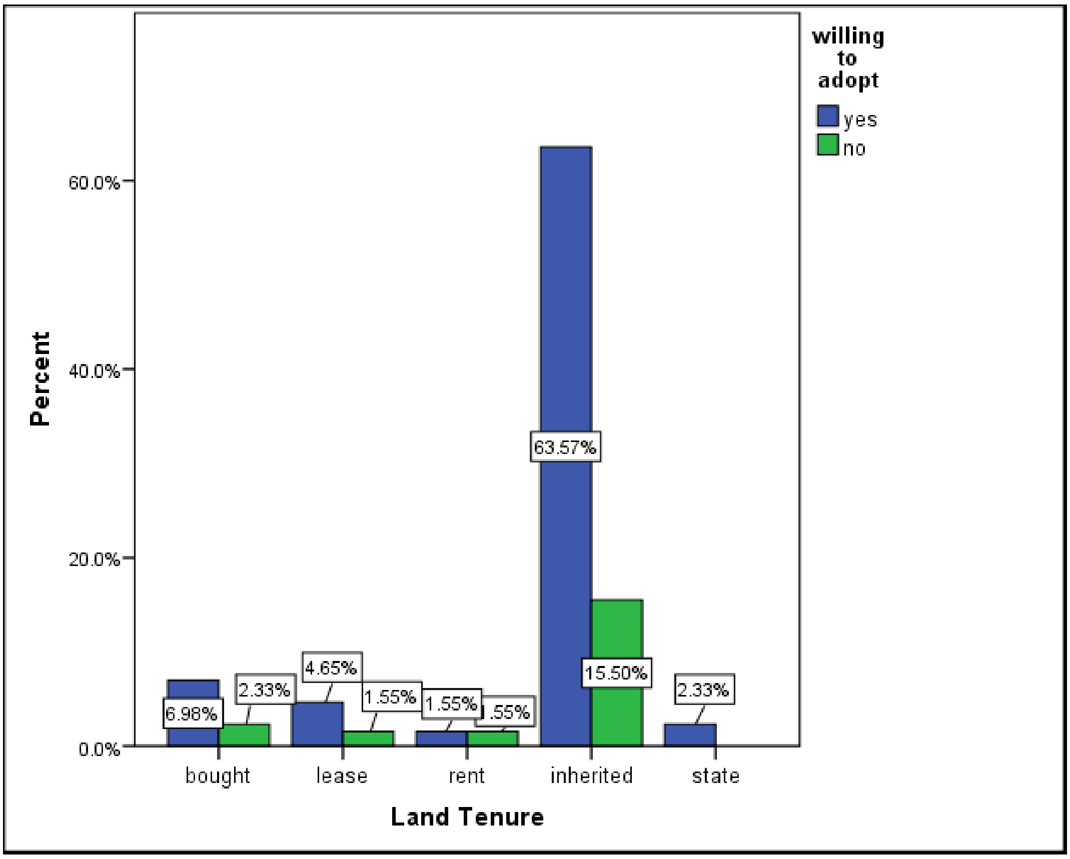


Figure 5.13: Land Tenure

5.4.5 Agricultural production

In order to understand factors that would influence the adoption of biofuel crops, respondents were given a question on their production in agriculture. Figure 5.14 shows crops that were cultivated by the respondents in the survey areas. Consequently, it was discovered that 56.86 percent produced maize for consumption, 22.55 percent produced potatoes for consumption, 12.75 percent produced cabbages, and the rest produced peas, spinach, onions or other crops. This implies that the maize was the only biofuel crop produced by most respondents and it was for consumption.

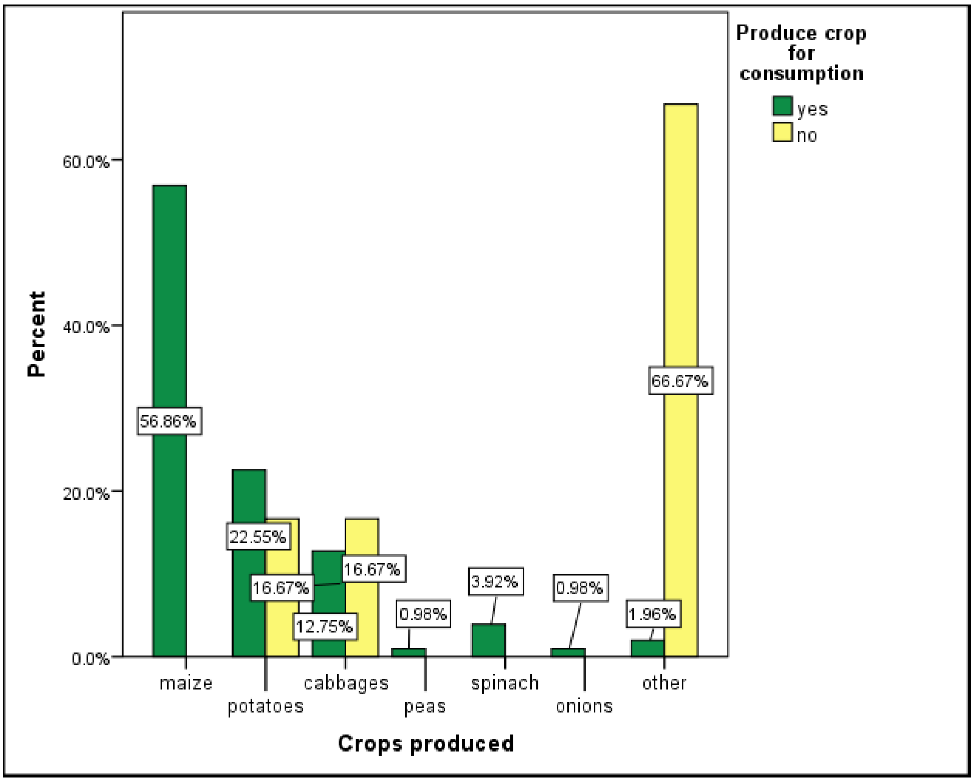


Figure 5.14: Crops produced for consumption

Figure 5.14 above shows that 66.67 respondents produced other crops for sale. These crops included carrots, beetroot, pepper, pumpkins to name a few. However, respondents producing maize were the highest likely adopters of biofuels crops with 48.15 percent of maize producers showing an interest. This is depicted in Figure 5.15. Potato production had the second largest respondents (18.52 percent) willing to consider biofuel production.

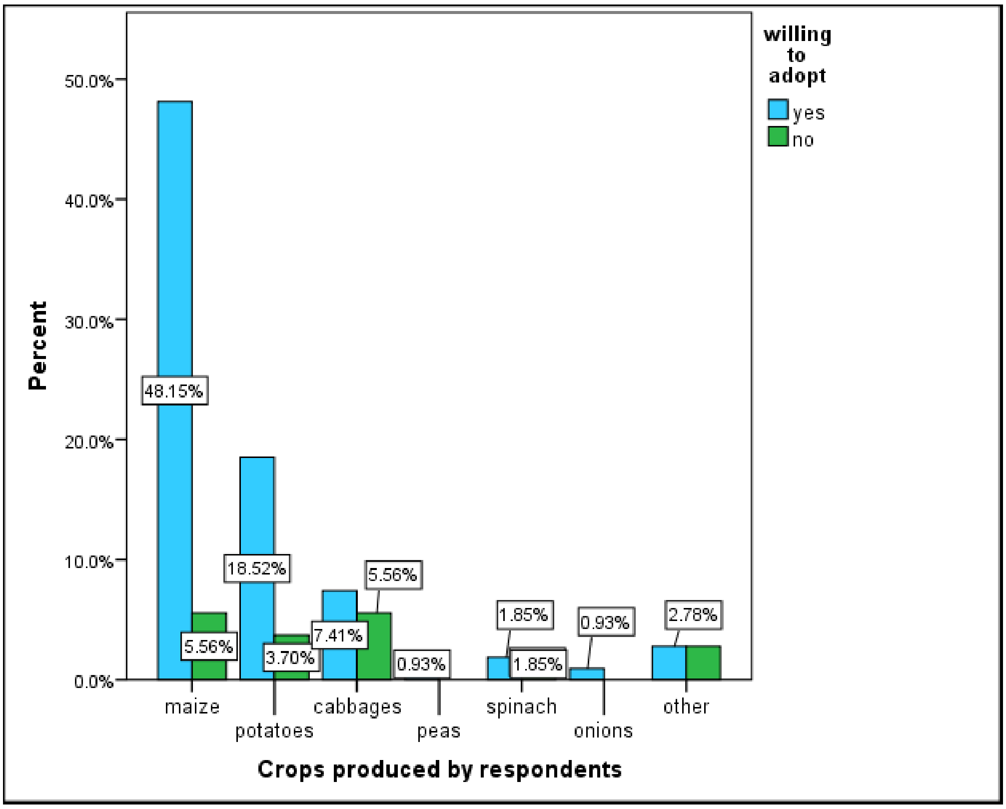


Figure 5.15: Crops produced by respondents and willingness to adopt

5.4.6 Source of food consumption

A close analysis of the sources of food consumed by the respondents showed that 58 percent respondents consumed food from their farms and 40 percent relied on food from the market. This proves that smallholder farmers produce mainly for family consumption even though they supplement their food from the market. This data is presented in Figure 5.16 .

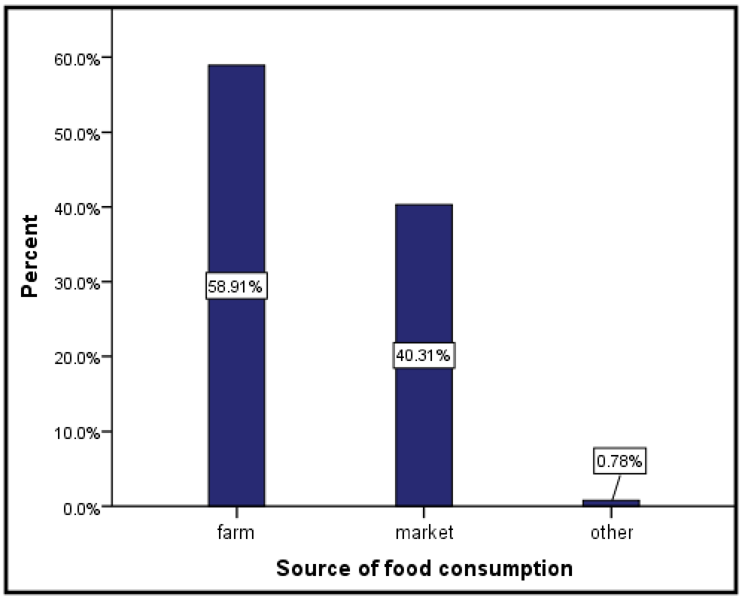


Figure 5.16: Sources of food consumption

5.4.7 Market Access

The distance travelled by farmers to sell their produce or buy their input has a serious bearing on how they participate in any agricultural programme. More than 62.39 percent travelled 10 kilometres or more to buy inputs and sell their produce. At least 22 percent travelled 6-10 kilometre to reach their closest market and 15 percent travelled 5 kilometres or less. This is depicted in Figure 5.17 . A number of farmers stated that distance increases their cost so they were forced to sell their produce locally, and in certain instances, they did barter trade to have access to other products they need for consumption. However, 48.62 percent respondents who were over 10 kilometres away from the market were willing to consider adopting biofuels for production regardless of the distance to the stores.

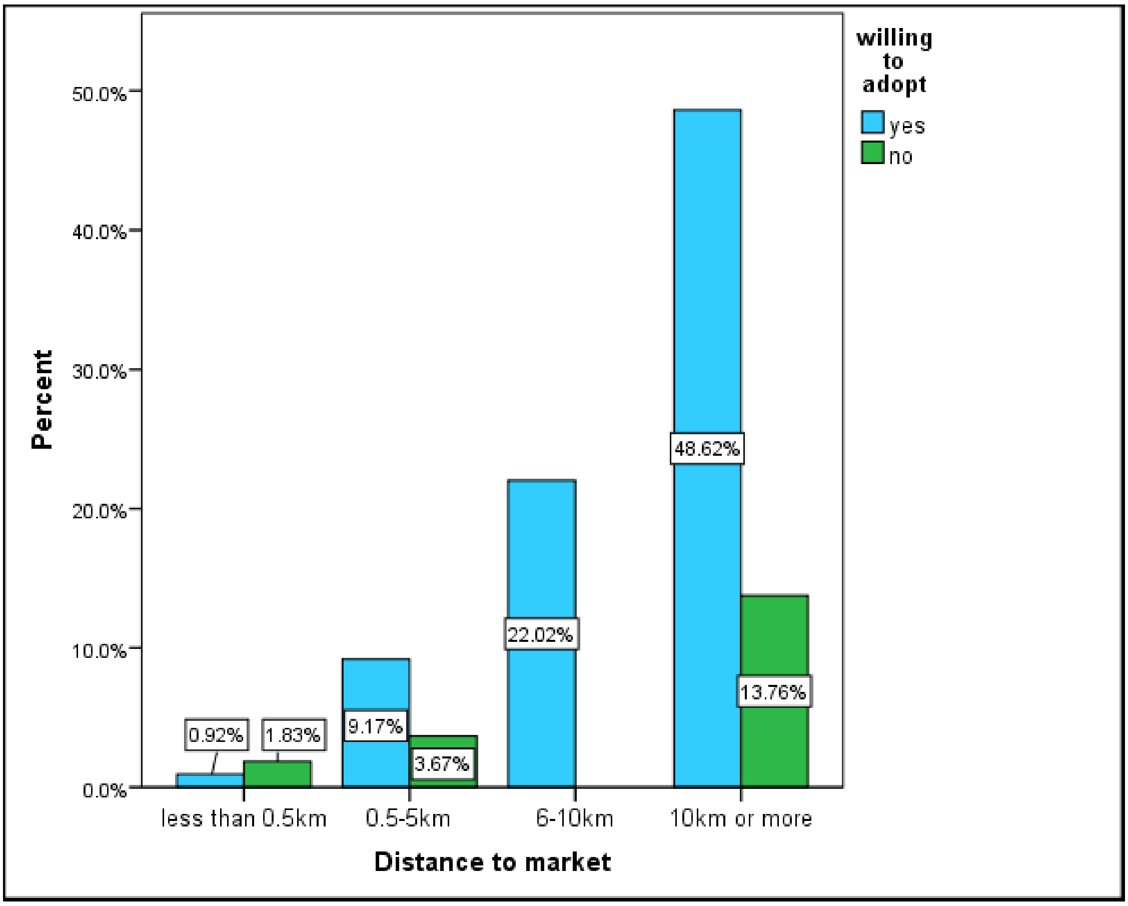


Figure 5.17: Distance to market and willingness to adopt

5.4.8 Access to credit

The study investigated if respondents had access to credit for agricultural purposes or not. Figure 5.18 shows that only 34.8 per cent had access to credit and the rest 65 per cent did not have access to credit. Information obtained from the respondents shows that access to credit is hard for most small-scale farmers since most lending houses require collateral in order to grant loans for farming. These findings are similar to those of Machete (2004) who discovered that in South Africa a significant number of farmers has no access to credit. Furthermore, the results prove that although a number of agricultural credit institutions were formed, their role is very limited or the procedures of obtaining financing through those institutions are not spelt clearly to farmers. It is surprising that more than 51.16 percent respondents who had no access to credit were willing to adopt biofuel crop production. In contrast, 6 percent respondents who had access to credit were not even considering the adoption of biofuels for production.

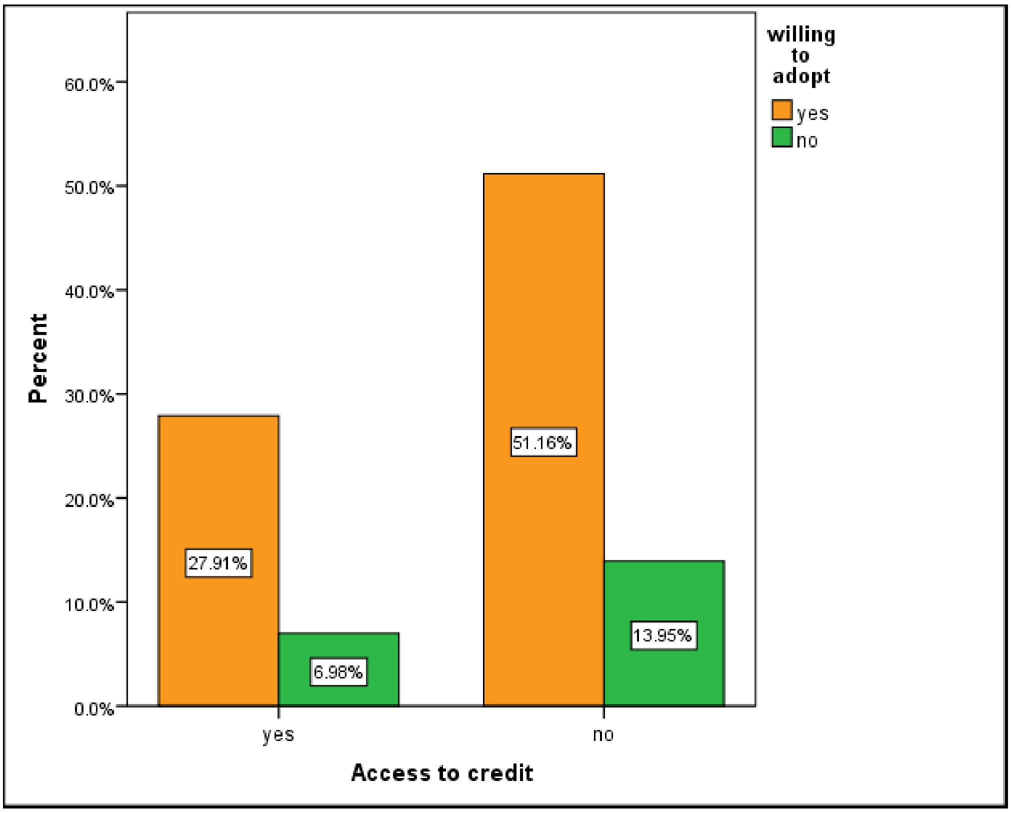


Figure 5.18: Access to credit and willingness to adopt

5.4.9 Farming Experience and willingness to adopt

Farming experience of the respondents highlights a number of characteristics in the adoption of new agricultural technology. The more experience the farmers have, the higher the chances of them participating in programmes that improve their agricultural production. In the survey, 47.3 percent of respondents had over 11 years of farming experience, 37.2 percent had more than 6 but 10 years' experience or less in farming , and lastly 15 percent had 0- 5 years' experience. The results tally with the ages of the respondents since most of the respondents were over the age of 15-34 . It was observed that as farmers' experience increases in years, so does the pace of adoption. The most likely adopters were farmers with over 11 years experience in agriculture. These results are presented graphically in Figure 5.19.

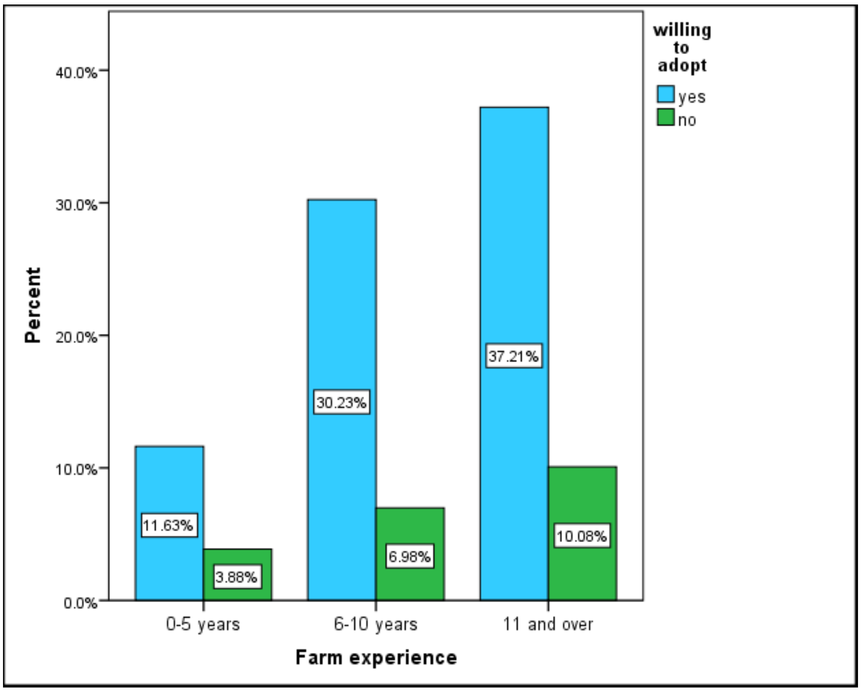


Figure 5.19: Farm experience and willingness to adopt

5.4.10 Labour and willingness to adopt

Labour is recognised as one of the most significant factors in smallholder farming, considering that most families cannot hire labour. In Figure 5.20 results are presented on sources of labour from the respondents. Of all respondents, 78 per cent relied on family labour for farming and 20 percent hired labour from the community. Mushunje (2001) notes that labour input largely substitutes for capital input in smallholder agriculture. This is especially true in the Eastern Cape where most people rely on social grants for their upkeep as shown in previous sections.

The fact that most respondents rely on their family labour suggests that smallholder farming has limitations in production. The use of family as labour was prompted by the fact that risks are reduced when using family labour. Additionally, in case the proposed adoption crops fail, the family would have a responsibility to pay hired labour and this is not a conducive situation for small-scale farmers.

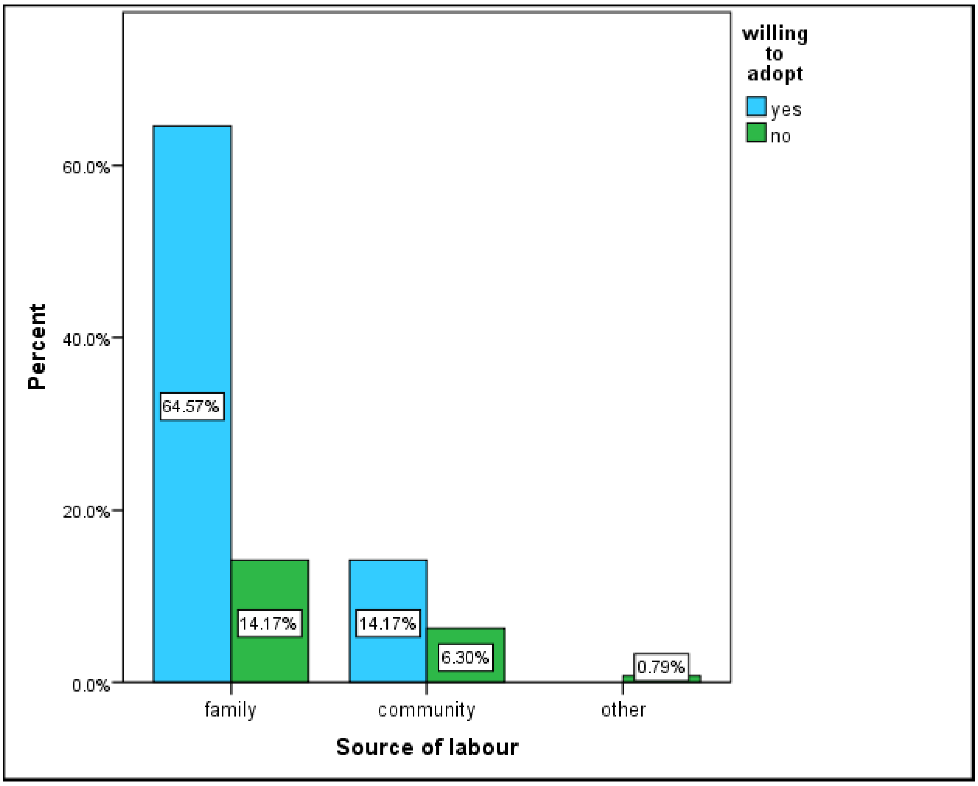


Figure 5.20: Source of labour and willingness to adopt

5.4.11 Asset ownership

According to the Figure 5.21, the majority of households have access to hoes. The hoe is the most common implement and in most cases it was found to be the only agricultural implement. This meant households afforded at least a hoe because it was the cheapest farming equipment. Farmers are still using the ox-drawn ploughs to till their land and the hoe is used to weed the crops. Ten farmers owned cultivators in both study areas. The cultivator is used by the farmers to cultivate land for farming. There were a few farmers who had access to irrigation systems. This was mainly attributed to the high costs needed in acquiring the systems. Hence, those who owned an irrigation system would lease or rent it to other farmers. It was further noted that a number of farmers did not have farming equipment, and they borrow during the farming season. This situation contributed to certain households failing to utilize their land last season. Therefore, it can be seen from the responses that if the biofuels industry is set to be a success, farming equipment should Donated to farmers since a number of them cannot afford it.

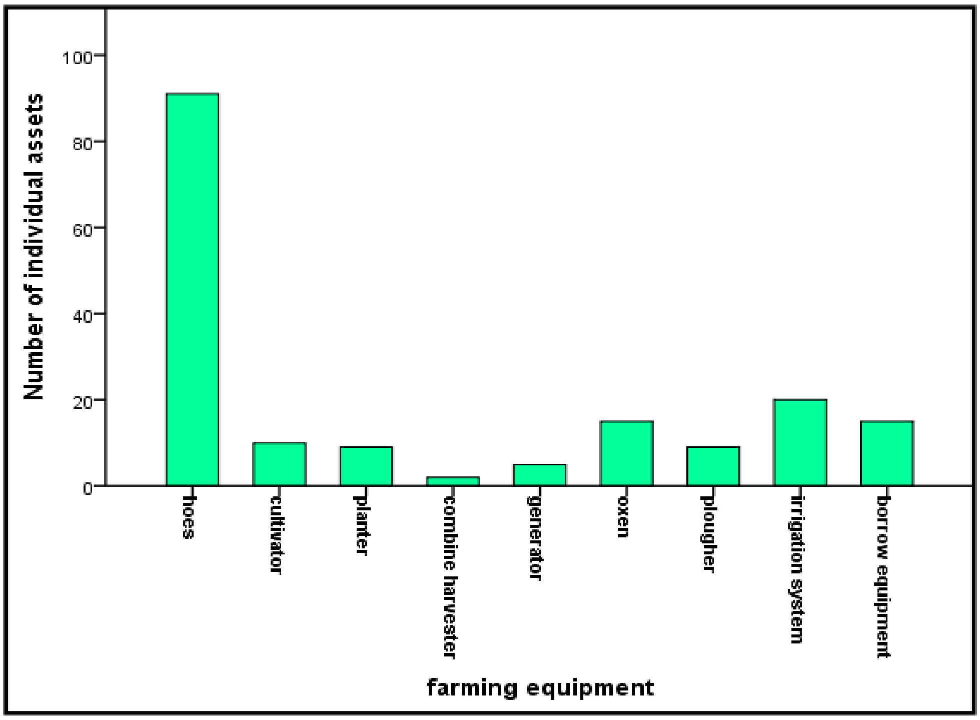


Figure 5.21: Farming equipment

5.4.12 Membership in associations and willingness to adopt

Respondents who were members of an association had the largest percentage (45.75 percent) of potential adopters compared to those who were not (33.33 percent). These findings are similar to Adegbola and Adekambi's (2008) findings which point that being a member to a farmers' association promotes access to information through other members, thus helping in adoption of new technology. Figure 5.22 presents the findings in percentages.

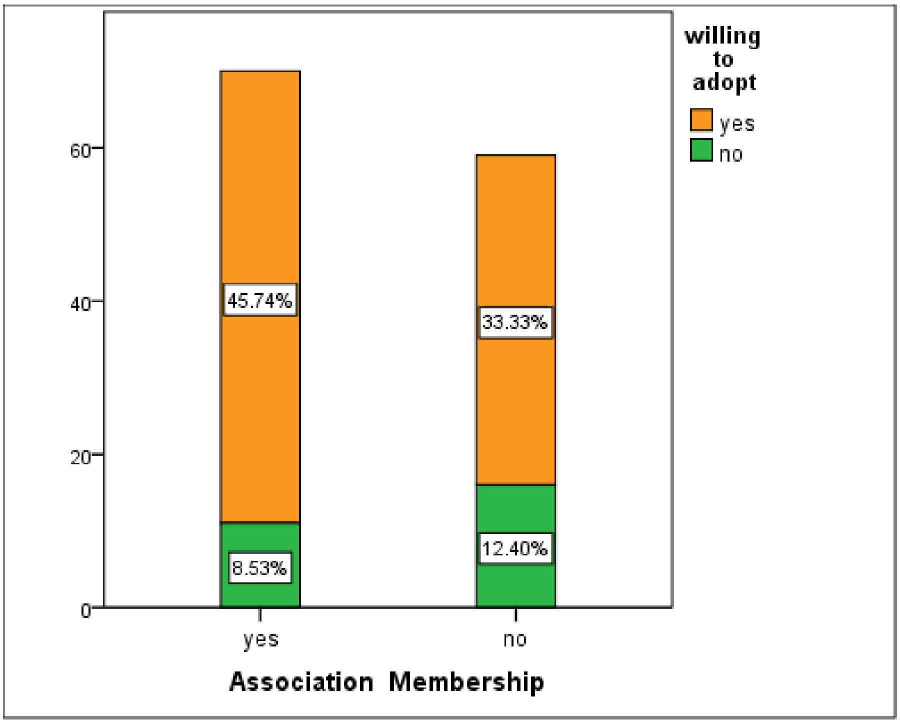


Figure 5.22: Membership in association and willingness to adopt

5.4.13 Contact with extension and willingness to adopt

Extension officers offer extension services to farmers. Therefore, any contact with extension officers is believed to have an influence in helping farmers adopt certain technology or let alone offer farmers information on innovations. Adesina and Forson (1995) noted that an extension service was one of the most authoritative sources available to farmers. Furthermore, it was hypothesised as having a positive relation to adoption of new technologies by exposing farmers to new information or innovations. A total of 41.86 percent respondents who obtained extension services were willing to adopt biofuels compared to the 37.82 percent who were not visiting extension. There were no significant differences between those with access to extension offices and those with no access with regards to their potential to adopt biofuels. The farmers' responses are shown in Figure 5.23 .

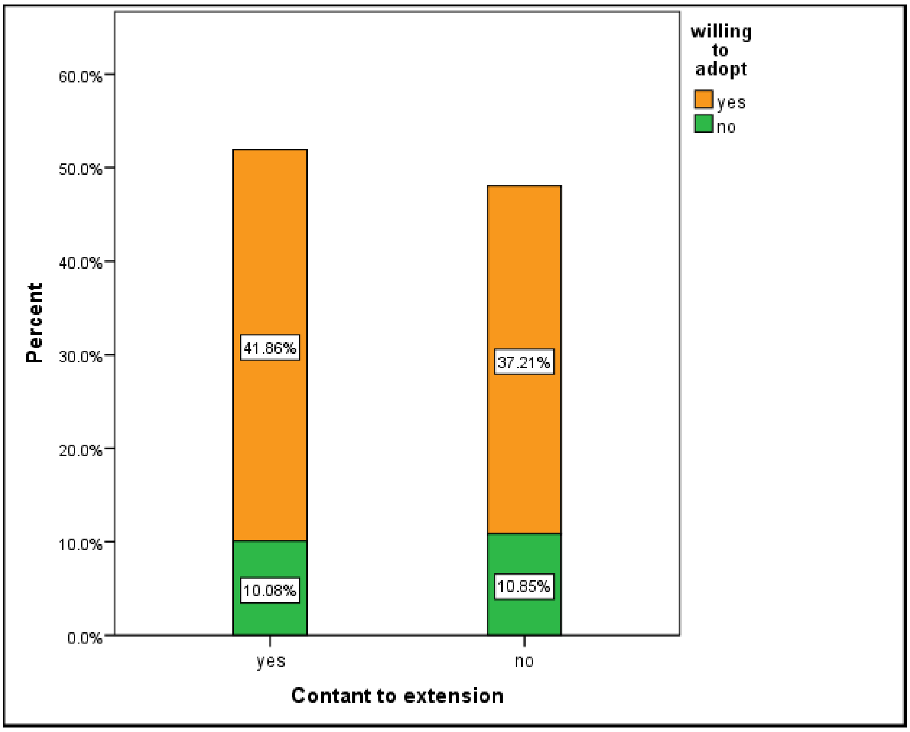


Figure 5.23: Contact to extension and willingness

5.4.14 Type of information received from extension services

Information is vital to any farmer. It can help smallholder farmers to increase their productivity or it can destroy them. In the study, it was found that more than 28 percent of respondents received information on soil preparation and fertiliser application, 12 percent received information on marketing, 10 percent received information on seeds and 9 percent on crop rotation. Respondents pointed out challenges with information received from extension officers. They stated that most of the information is not tailor made to suit certain areas, considering that physical characteristics of certain areas differ. The claim was that most extension officers offer the same information each year to different farmers, which does not help them in improving their productivity. Figure presents the results in Figure 5.24 .

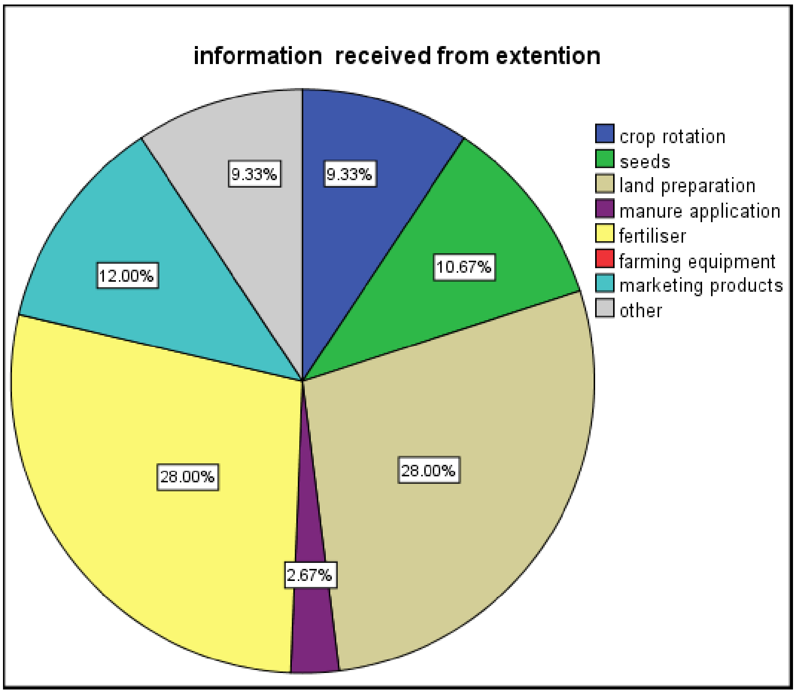


Figure 5.24: Type of information received from extension

5.4.15 Sources of information

Information acquisition is of prime importance to any farmer. It regulates the marketing output for the farmer. The results from the study reveal that 77 percent respondents received information through cell phones. The information was from social networks (Facebook, WhatsApp etc.) or general conversation with family members and friends. A total of 9 percent of respondents asked around to gather information on agricultural production and 3 percent got information through radio/television. It was shocking to note that only 3.95 percent of respondents sourced their information through extension services. When asked about why they do not rely on extension services, the respondents said that most extension officers do not have up to date information on a number of agricultural activities except general information on land preparation and fertilisers. This gap in information dissemination may prove to be a challenge in reaching out smallholder farmers targeted for the biofuel industry. The responses are shown in Figure 5.25 below.

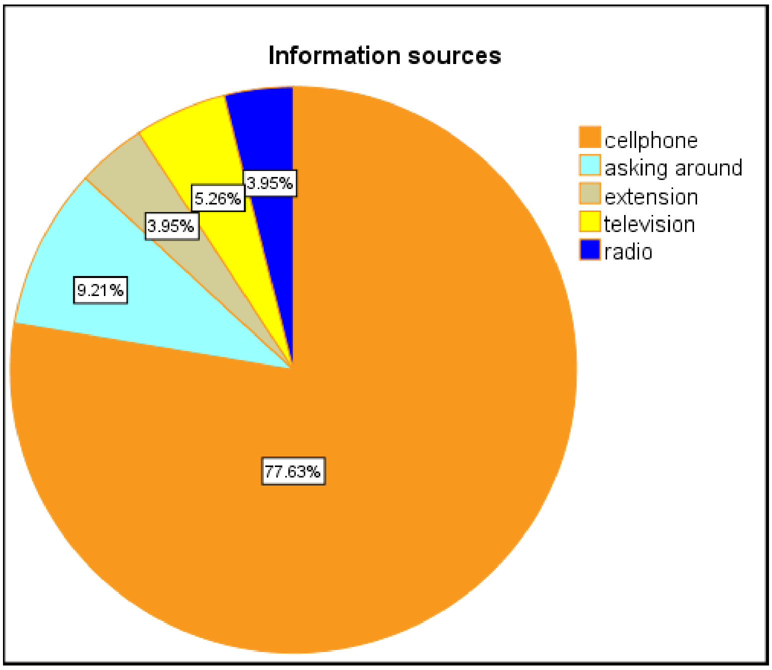


Figure 5.25: Communication Media

5.5 Awareness and adoption of biofuels

In order to understand why few farmers have not yet adopted biofuels for production, it was necessary to identify their awareness levels with regard to biofuels. A question was posed if they were aware of biofuel crops. A total of 51.94 percent of the respondents confirmed their awareness.

5.5.1 Biofuels known by respondents

Table 5.3 shows that most respondents knew sugarcane and soya bean. Overall, 64.3 percent of the respondents knew sugarcane as a biofuel crop. This is because many respondents were aware that ethanol is extracted from sugarcane. A total of 36.3 percent of respondents knew soya bean as a crop used for biofuels. In trying to understand how they knew of the crop, it was discovered that many respondents were aware that soya bean is used for biofuels through media channels like the television and radio.

Table 5.3 Biofuel crops known by respondents

Crops Grown	Percent
	(N=129)
Sugarcane	64.3
Canola	19.3
Sunflower	10.8
Sorghum	18.5
Wheat	7.4
Soyabean	36.3
Groundnuts	7.4
Maize	3.4

At least 18 percent respondents knew that sorghum can be used as biofuel crop although they usually used it for traditional brewing. It was surprising that only 3 percent of respondents knew that maize can be used as a biofuel crop. This was unexpected considering that the government has been emphasizing that maize not used for biofuels. Furthermore, this finding meant that the government was assuming that farmers knew that maize can be used for biofuels production, yet, the facts on ground point otherwise.

5.5.2 Willingness to adopt biofuel crops

In order to understand the challenges that may bear on the biofuel industry, responses of whether non-producing and producing farmers were willing replace the crops there are currently farming and adopt biofuels in their farming system were recorded. Figure 5.26 shows that 79.07 percent of the respondents stated that they were willing to adopt biofuel crops for farming and replace crops they are currently farming. In contrast, 20.93 percent stated that they are not willing to be part of the biofuel industry if there are to replace their current crops. The findings reveal that farmers maybe quick to embrace new technology that they believe would improve their productivity and income. However, as rational beings they can only do so after assessing the risks involved in managing biofuel crops production.

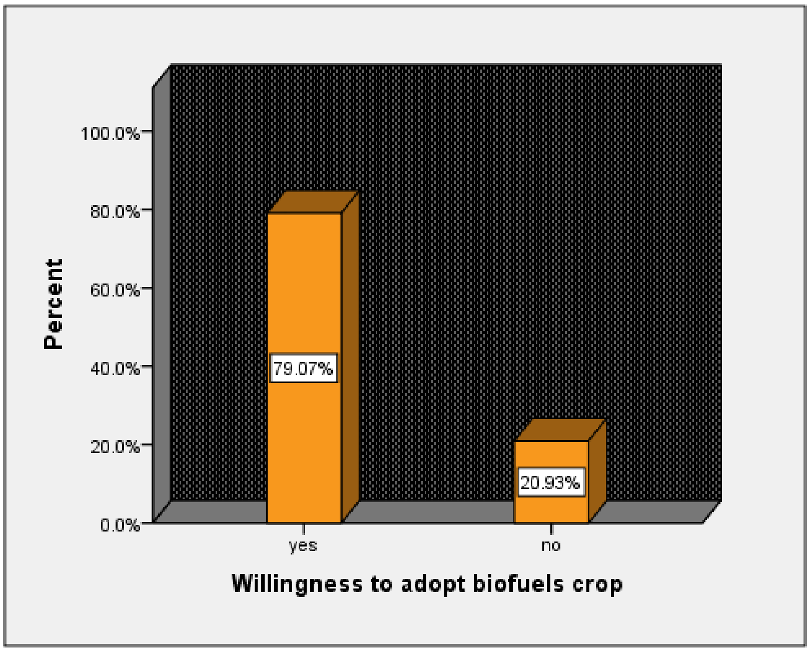


Figure 5.26: Willingness to adopt biofuel crops

5.5.3 Willingness to adopt with incentives

Respondents were given a question based on their willingness to adopt biofuel crops if given incentives in the form of government subsidies or price support for production of biofuels, inputs for biofuels production and access to markets. The percentage of farmers who were willing to adopt biofuels dropped from 79 percent to 65.12 percent and those not willing to adopt increased from 20 percent to 34.88 percent. The results in Figure 5.27 suggest that farmers may not be attracted to adopt biofuel crops depending on the type of incentives offered. The main problem identified by most farmers was that if they were offered government subsidies they would be forced to achieve a certain production target laid down by the government. They believed that would put them under unnecessary pressure if they failed to meet the targets. Hence, they was a decline of famers willing to adopt biofuel crops when offered incentives by the government compared to the status quo were they produce without any external factor. Moreover, they claimed that in cases were the government offers funding for biofuel crops production, they may need to pay back regardless of how much output is produced. Furthermore, they believed that anything offered by the government always comes with conditions that need to be satisfied regardless of the incentive type. Hence, placing themselves under supervision would not help them produce more. Lastly, some farmers suggested that in order for them to be influenced by incentives to produce biofuels crops, the government needs to address the current challenges they are facing in increasing productivity. This show in figure 5.27.

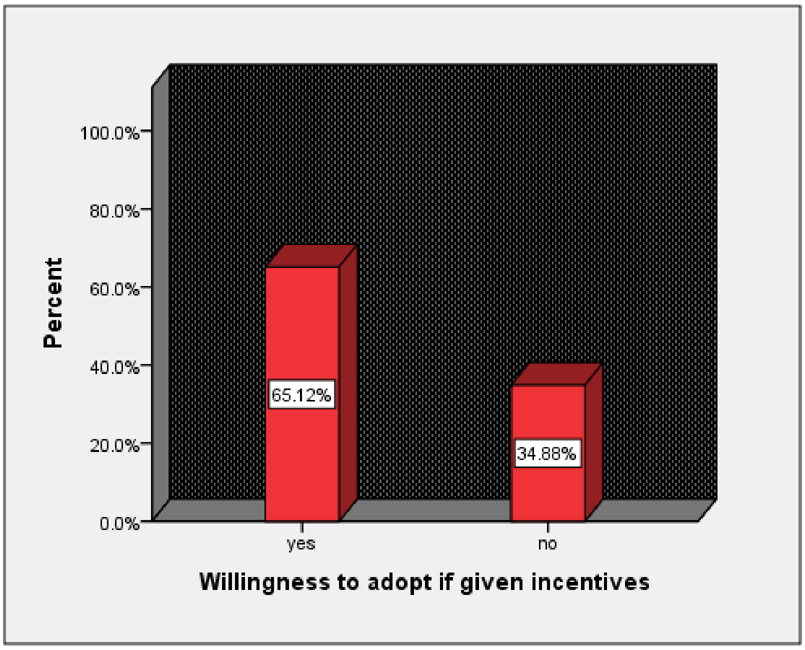


Figure 5.27: Willingness to adopt biofuels if given incentives

5.5.4 Awareness to Biofuels crops

To understand how respondents perceive the biofuel industry, a number of questions structured in a Likert scale were posed. The scale had **strongly disagree** as the most negative response and **strongly agrees** as the most positive response. Table 5.4 shows the responses to the questions that were posed on biofuels awareness.

Table 5.4 Biofuels awareness questions

Questions posed to respondents	Strong Disagree	Disagree	Neutral	Agree	Strongly Agree
The biofuels market is sustainable for small-scale farmers.	0.78	3.10	32.56	41.86	21.71
Participating in biofuel production would increase my farming output.	7.75	1.55	31.01	56.59	3.10
I have knowledge of the proposed crops for biofuel production by the Department of Energy.	32.56	3.10	15.50	46.51	2.33
Biofuels will create employment opportunities for small-scale farmers.	1.55	3.88	37.21	44.96	12.40
Biofuel production will increase productivity for small-scale farmers.	0	2.33	40.31	51.16	6.20
Producing biofuel crop will help small-scale farmers to access markets.	0	0	24.3	52.71	23.25

Figures in the table are in percentages.

5.6 Challenges faced by smallholder farmers

Table 5.5 shows a number of challenges faced by smallholder farmers in the study areas. A total of 98 percent stated that they had inadequate water for farming. This was also limiting their potential to farm a number of crops. Moreover, drought was prominent especially in Chris Hani Municipality. Overall, 85 percent of respondents had met drought before. Some of the respondents had problems in accessing farming equipment. Hence, pest and weeds destroyed their crops. At least 70 percent of respondents stated that they failed to secure a reliable market for their produce or output. Hence, this challenge was reducing their potential to grow in farming. At least 89 percent respondents identified arable land as a big obstacle. The respondents pointed that without arable land, they will keep struggling to increase their output. The problem of collateral security was evident in a number of respondents, 40 percent of the respondents identified finance as a challenge. Many lending houses or banks where not willing to help farmers without collateral security. This situation contributed to limited output.

Table 5.5 Challenges faced by respondents

Category	**Number of respondents %**
Water	98
Labour	68
Finance	40
Arable land	89
Farming equipment	80
Theft	75
Drought	85
Climate change	65
Reliable market	70
old age	10
Pipes	17
Pest and weeds	**82**

Reliable market and drought has been a obstacle to farmers for some time. Farmers stated that the distance they travelled to sell their produce was great and this affected their profits. Smallholder farmers usually struggle to access markets as compared to commercial farmers. Consequently, they stated that usually they sell the produce locally, in many cases through barter trade. Few farmers identified irrigation pipe shortages as a big problem, especially those staying close to water body sources. The problem they encounter most was fetching water for their farms. They stated that it was a costly exercise and tiresome because it requires a good deal of labour which is always scarce if not expensive.

5.7 Incentives for the adoption of biofuel crops

Farmers identified a number of incentives that they think would improve the adoption pace of biofuel crop production. Table 5.6 illustrates that a total of 93 percent of farmers identified knowledge as a key factor in adoption of biofuel crops. They stated that small scale farmers do not know biofuel crops; hence, one cannot adopt something that he/she does not know. A number of farmers sought more knowledge on a proper description of biofuel crops. Eighty seven (87) percent stated that if given equipment they would adopt biofuel crops. A number of farmers who borrow equipment for agriculture highlighted this. A total of 45 percent farmers identified arable land as the key to adoption of biofuel crops, because the current farmlands were not arable enough. Therefore, an incentive that would increase their land capacity or fertility would be welcome.

Table 5.6 Incentives identified by respondents

Category	Number of Respondents %
Equipment	87
Stable market	63
Arable land	45
Sponsor	67
Labour	50
None	5
Knowledge	93
Finance	73

About 67 percent stated that if they get someone to sponsor them, they would be more than willing to adopt the biofuel crops. They identified lack of resources as a serious obstacle affecting them in securing seeds and pesticides; therefore, any sponsorship would be welcome. At least 63 percent wanted a stable market for their produce in order to adopt biofuels. The grounds were that if the market was unstable, they run the risk of losing more since they are not sure how the crops will perform. At least 5 percent farmers wanted no incentive to adopt biofuel crops. Lastly, 50 percent identified labour as a motivator. The motion was that if they got labour, they might use the underutilised land to produce biofuel crops.

5.8 Conclusion

It can be concluded from descriptive statistics that smallholder farmers who were surveyed are generally old and rely on pensioners' grants. Moreover, it was observed that a number of respondents are unemployed. In addition, many farmers were underutilising their land due to a number of challenges such as water shortage, theft, lack of equipment and funding and these have led to a decline in productivity. Lastly, most farmers were aware of biofuel crops and they were willing to adopt biofuel crops for production if there is enough information. The next chapter presents the empirical model results.

CHAPTER 6

EMPIRICAL RESULTS AND DISCUSIONS

6.0 Introduction

A Heckman two-step model was used to examine demographic, socio-economic, farm specific and biofuel factors that influence the adoption of biofuel crops. Heteroscedasticity tests were conducted because in logistic regression heteroscedasticity can produce biased and misleading parameter estimates. Eight of the variables were identified to be statistically significant given their low *p value* that was less than 0.05. These include arable land, incentives to participate, challenges, labour source, gender, qualification and membership in association.

6.1 Heterescedasticity tests

In order to calculate the regression model, a heterescedatisticity test was conducted. The results from the White test showed that the Probability of the Chi-Square was well above the 0.05 significant levels and we accepted the null hypothesis that state that the variables are homoskedastic. This means that the error term is homoscedastic and we should not adjust any standard errors (Greene, 2012). The results are shown in Table 6.1 .

Table 6.1 Heterescedasticity

Heteroskedasticity Test: White			
F-statistic	1.336567	Prob. F(61,45)	0.1549
Obs*R-squared	68.94596	Prob. Chi-Square(61)	0.2266
Scaled explained SS	61.55970	Prob. Chi-Square(61)	0.4559

6.2 Model Fit

Table 6.2 shows that the model fit had the following specification: the estimated variance of residuals was at 0.27 with the Sum of Squared residuals at 6.945. Log likelihood was at -40.70 reporting the log likelihood of coefficients estimates assuming that there are normally distributed. The standard deviation of dependent variables was 0.427. The Akaik, Schwarz and Hannan-Quinn criterion all showed lower information criterion values for the Heckman two step model, suggesting that the model is robust and can measure what it intends to measure. Lower values especially on the Akaik info criterion are preferred (Greene, 2012). Furthermore, the Schwarz criterion that imposes a penalty for additional variables was at 1.167.

Table 6.2 Heckman two-step model

Dependent Variable: ADOPT **Method: Heckman Selection** **Sample: 1 129** **Selection Variable: AWAREBIO** **Estimation method: Heckman two-step**				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Selection Equation				
C	-0.418891	1.433957	-0.292122	0.7709
AGE	-0.070168	0.265638	-0.264149	0.7923
GENDER	0.858991	0.380165	2.259521	0.0262**
QUALIFICA	-1.393838	0.256512	-5.433810	0.0000***
MEMBERASS	0.935929	0.333940	2.802688	0.0062***
CONTACTEXT	0.340332	0.372853	0.912778	0.3638
FARMEXPERI	0.382349	0.209052	1.828970	0.0707*
FARMEQUIP	0.122361	0.084102	1.454915	0.1491
OCCUPATION	0.327695	0.216156	1.516010	0.1330
Outcome Equation				
C	0.308152	0.628281	0.490469	0.6250
HHS	0.081327	0.043241	1.880771	0.0632*
HINCOME	0.013285	0.057942	0.229273	0.8192
ARABLE	0.134692	0.054412	2.475421	0.0152***
INCENTIVESPART	0.342467	0.131541	2.603505	0.0108***
CHALLEN	0.027538	0.014278	1.928683	0.0569*
UTILISELAND	0.092340	0.298934	0.308899	0.7581
BORROWMONEY	-0.094266	0.111505	-0.845396	0.4001
LABSOURCE	0.382582	0.114837	3.331514	0.0012***
LANDACQUIRE	-0.074320	0.094449	-0.786875	0.4334
DISTANCE	-0.081809	0.064931	-1.259933	0.2109
Mean dependent var	0.234043	S.D. dependent var		0.427976
S.E. of regression	0.276261	Akaike info criterion		1.117695
Sum squared resid	6.945156	Schwarz criterion		1.669735
Log likelihood	-40.70862	Hannan-Quinn criter.		1.341737
Values marked with an asterisk *** represent significant at 1 percent, and the values marked ** represent significant at 5 percent level and values marked * represent significant at 10 percent level.				

6.2.1 Selection Equation

The selection equation was composed of the following variables; age, gender qualification, membership in association, contact with extension, farm equipment, farm experience and occupation. It was discovered that gender, qualification, contact with the extension and knowledge of biofuels were statistically significant.

Gender – the results suggest a positive and significant relationship between awareness of biofuel crops and gender of household (coefficient: 0.858991). The positive association of the coefficient meant that there was an increase in awareness to biofuel crops on females holding other things constant. Asfaw and Admassie (2004) noted that male-headed households tend to receive information more quickly about new technologies in agriculture as compared to female-headed households. Similarly, Diagne (2010) recorded a negative correlation between female and awareness of parboiled rice in Guinea.

Qualification or high level of education had a negative association with awareness of biofuels (co efficient: -1.393838). Education is believed to have an influence on agriculture production. This is quite true as educated people are usually associated with access to information on agricultural technology (Norris & Batie, 1987). Surveys conducted by Oyedele and Yahaya, (2009); Owuba, *et al.* (2001) identified that a high level of education contributes to the degree of agricultural productivity of the households. Hence, this improves awareness of farmers to innovations or new technology. The findings of this study contradict those of Daberkow & McBride (2003) who discovered that higher education level increased the likelihood of awareness in precision agriculture technologies. Although education has been highlighted in numerous studies as significant in adoption of technology, literature has been inconclusive on its effect on awareness of biofuel crops production.

Membership to association – membership and frequent participation in activities in line with agriculture has a positive (coefficient: 0.935929) influence on awareness of agricultural technology. As expected, participation or belonging to an agriculture society had an influence in the awareness of people of biofuel crops. This suggests that the more the individual attends or participates in an association, the higher the chances of the individual receiving the information that would influence his/her decision to adopt biofuel crops. A study conducted by Dandedjrohoun *et al.* (2012) recorded a positive association between membership in an association and awareness of new technology. The findings state that being involved in associations helps in the sharing of information through informal and formal discussions, which increases the level awareness.

Farm experience - the variable was hypothesised as having an influence in the awareness of biofuel crops. It was expected that most farmers with a number of years of experience in farming are likely to be aware of new technology or seed varieties due to well-established communication networks. The coefficient was positive (0.382349) and statistically significant at 0.10 percent level. The positive relationship between awareness and farm experience means that the more experience a farmer has, the higher the chances of being aware of biofuel crops.

6.2.2 Outcome Model

The second stage of the equation was to analyse the extent of potential adoption of the biofuels. The inverse Mills Ratio from the selection equation was then added to the outcome model to capture the selection bias effect.

Arable- this variable measures arable land size utilized during the last farming season. Farmers who utilized arable land are likely adopt new technology or crops in agriculture. This is influenced by the fact that they expect to earn higher profits if they adopt new technology or crops. The variable was found to be statistically significant (coefficient: 0.134692) in influencing adoption of biofuel crops. Ogada, Mwabu and Muchai (2014) noted that the size of land cultivated by the household was positively correlated with adoption of new technology. Furthermore, an increase of a household’s cultivated land area by one acre, on average, increased the probability of adoption of inorganic fertilizer and improved maize varieties by five per cent. Contrary, Dereje (2006) posited that farmers owning large amounts of arable land are in a better position to adopt new technology, compared to farmers who own small arable land because they face difficulties.

Incentives - this variable exhibited a positive relationship (coefficient: 0.342467) with adoption and was statistical significant. It should be noted that for incentives to improve the potential adoption rate of smallholder farmers, they should be in line with their expectations. In the survey, smallholder farmers were asked if they would adopt biofuel crops if they were offered price support, subsidized input and funding by the government. Many were sceptically and they claimed that the government would need payment regardless of the output they get. In which case, this would put pressure on them to increase output yet they will be starting to farm biofuel crops. However, it is particularly true that incentives may influence farmers in adopting new agriculture technology or crops. The chances of an individual adopting a certain technology without motivation are lower as long as they are risks involved in such adoption. It can be concluded that farmers are risk averse people and usually behave rationally. This means that given a choice to transfer the risks to someone, they will do so. In this case incentives would act as insurance for the risk they face in adopting new crops.

Challenges - this variable captures factors that hinder adoption to farmers. It has a positive and a significant coefficient of 0.027538. Farmers facing a number of challenges may be motivated to adopt biofuel crops in anticipation of improved productivity. This may depend on the challenges faced by the farmers. Although challenges may have an influence on farmers’ potential to adopt biofuel crops, it has not been documented in literature. Therefore, it can be assumed that farmers who are facing challenges such as, little rainfall maybe motivated to adopt biofuel crops that can survive in semi-arid regions and at the same time improving their soil fertility. Yet, on the other hand, farmers struggling with farming equipment may not be interested in trying new crops varieties because of insecurity or fear of the unknown.

Labour source - the coefficient (0.382582) of labour is positive and significant. This means that a unit increase in labour we can expect an increase in the propensity to adopt biofuels crops. Farmers who obtain labour from the community incur more costs than the ones who utilise family labour. It can be noted that from the challenges faced by farmers and incentives wanted in order to adopt biofuels, labour is a critical part of any adoption.

Household size - the coefficient for this variable was positive (0.081327) and statistically significant at 0.10 level. This coefficient means that for every unit increase in household size holding everything constant, chances of adoption are increased. A larger household may be expected to be interested in any venture or opportunity that would secure their livelihoods. As such, the higher the number of members of a household, the easier it may be to adopt biofuel crops. From the survey results, a number of households with a number of family members are struggling financially. Therefore, one-way of improving their household income maybe to produce biofuel crops and sell them.

6.3 Conclusion

This chapter provided empirical evidence on factors affecting or influencing the potential adoption of biofuel crops by smallholder farmers in selected areas in the Eastern Cape Province. The results on the selection equation pointed out that the variables: age, gender, qualification, membership in association and farm experience were statistically significant in influencing farmers' awareness to biofuel crops. Yet, the outcome model the variables arable, incentives, challenges, household size, and labour source were statistically significant.

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.0 Introduction

The main aim of the study was to identify factors affecting/influencing the potential adoption of biofuel crops by smallholder farmers in selected areas in the Eastern Cape Province. Specific objectives included the following: identifying the factors that influence or affect the potential adoption of biofuel crops; investigating if farmers are aware of biofuels crops in the Eastern Cape and estimating determinants of farmers' potential to adopt biofuel crops in the Eastern Cape.

A Heckman two-step model was used to determine the factors that influence adoption of biofuel crops, and descriptive statistics were used to answer the study objectives. By identifying the factors that influence the potential adoption of biofuel crops in selected areas in the Eastern Cape, the study provided valuable information that would help in making the Biofuels Industrial Strategy a success in eradication poverty to smallholder farmers and improving energy security in South Africa.

7.1 Summary

Subsistence farming has the potential of improving growth and eradicating poverty in communal areas. However, to unlock this potential the Biofuels Industrial Strategy Policy should try to cater for the smallholder farmers.

It can be inferred from literature that challenges facing smallholder farmers in South Africa include lack of access to market, lack of equipment, inadequate access to credit, pest and weeds, lack of seeds to name a few. These problems are practical and need effort from both the government and people on ground.

This study was conducted in selected areas in the Chris Hani District Municipality and Oliver Tambo District Municipality in Eastern Cape. A snowballing sampling technique was utilised in this study and the selection of respondents was based on availability and willingness of farmers to participate in the research. A total of 129 smallholder farmers were interviewed through face to face interviews using a questionnaire. Xhosa speaking students assisted in data capturing because Xhosa speaking people dominate the province. The data collected was then analysed using the SPSS 21 Software and EViews 8 software. SPPS was used to analyse descriptive statistics and Eviews was used to regress the Heckman two-step model.

The majority of the surveyed smallholder farmers were 35-50 years of age. Most of them had primary education and matriculation. The farmers produced a number of crops and vegetables for consumption, and in a few instances, they sold to the market. The most dominant gender from the study were males. Furthermore, low levels of income dominated the study areas. Most respondents survived on government grants for the upkeep of their families and the unemployment rate was high in the study areas. Only a few youths participated in agricultural activities.

Eight variables were statistically significant for the econometric model analysis. These are: in the selection model- gender, qualification, contact with extension and knowledge of biofuels were significant and in the outcome model - incentives to participate, arable land, challenges, labour were statistical significant at 5 percent level.

7.2 Conclusion

Smallholder farmers face a number of constraints in accessing markets and agricultural products. The most highlighted problems were water shortages, theft, pest and weeds, droughts to name a few. On the other hand, knowledge, access to arable land, labour, sponsorship, finance, among others were identified as incentives necessary in the adoption of biofuel crops. A number of respondents also cited lack of relevant information as a hindrance to the adoption of biofuel crops. Therefore, in order for smallholder farmers to adopt biofuels a collective effort by the government and the targeted beneficiaries is the key to the success of the biofuels strategy. Moreover, lack of knowledge from the targeted beneficiaries would further delay the achievements of the strategy even if it is redrafted. Hence, knowledge dissemination is seen as a key incentive to the success of the strategy.

7.3 Policy Recommendations

In order to achieve the targets of the Biofuel Industrial Strategy Policy, the government can help smallholder farmers by reducing the challenges faced, such as, lack of farming input like seeds. The government can gives incentives like farming inputs subsidies. In addition, a number of challenges pointed by respondents, such as, pest and weeds can be corrected by spraying the fields and surroundings areas harbouring such pests. The study findings pointed a problem with the extension services provided in study areas. In short, extension services should try to adapt to areas based on the geography and other factors and avoid using a one size fits all approach as pointed out by the respondents. This may help in educating farmers on how best they can benefit from biofuel crops production.

Another challenge pointed was the lack of access to credit facilities. The government can create a similar entity like the Land Bank that provides financial services to smallholder farmers, but with relaxed collateral requirements to target smallholder farmers.

Apart from these suggestions, the government can try to introduce incentives to smallholder farmers. The incentives can be in form of these:

- ✓ Payment per unit production - these payments are usually referred to as deficient payment, whereby producers receive payment direct from the government per unit of output produced. A similar system was used in the United States to support wheat farmers (Russo, 2007). Farmers receive a payment equal to the difference between a guarantee price and the market price. This form of payment structure can be used to pay smallholder farmers for the difference in guarantee price they incur. This may also help in improving output since farmers would be safeguarded from losing income due to price changes. This type of payment would reduce the risk factor exposed to farmers in an unpredictable market.
- ✓ Payment per hectare- this is a payment system based on historical or actual number of hectares on a farm. In this case, the amount of land occupied determines the payment received. Therefore, smallholder farmers who own large hectares of land would be motivated to put it into use if they are not already doing so. Moreover, this payment structure motivates smallholder farmers who wish to grow commercially, because they may be persuaded to acquire more land with the hope of getting more support from the government, hence, this may improve their productivity in the long run. In the European Union, a similar system was used to pay farmers based on the land owned and the number of animals on that land. This system was very successful in pushing farmers to utilise land.

- ✓ Payments per farm or farmer- this depends on how many farms a farmer owns or how many employees work for the farmer. In situations whereby the farmer has more labourers, payment from the government would reduce the wage costs that he/she suffers. As a result, the farmer can now divert the extra income to productive places with the farm. Thus, increasing the inputs needed to improve productivity. This is one way of reducing the labour payment bill for farmers, especially those who are struggling to pay hired labour, such as, smallholder farmers.

All direct income payment have an effect on agricultural production, but the effects differ according to the instruments used. For instance, the effect is high for deficiency payments as compared to hectare payments. Direct income payment offers more possibilities compared to price support because they can be differentiated. As such, they can be made conditional, for instance, in terms of number of hectares farmed. However, price support can also lead to direct higher production, thus leading to an increase in output in the long run. The only challenge in doing a price support scheme is that the government will need to draft a trade policy that will lead to a decline in supply (using import tariffs or supply quotas) and increasing demand (using export subsidies). The policy will be necessary to stimulate the price level so that both the producers and consumers do not lose from the price scheme.

Other recommendations to consider include:

Short-term policy recommendation

- ✓ The government should engage community leaders when disseminating information to farmers. This would make it easier for farmers to be aware of agricultural innovations.
- ✓ There is an urgent need for the government to engage lending houses to relax certain requirements for farmers to access credit facilities. lt is evident from the study that most

farmers struggle to access credit, .therefore, relaxing certain requirements on collateral security may improve the number of smallholder farmers benefiting from credit arrangements. This would in turn lead to improved output, as farmers will be able to afford inputs.

- ✓ There is a need for the provision of training to farmers willing to adopt biofuel crops. Training will help farmers in realising full potential in the production of biofuel crops and in turn motivate others to adopt the crops proposed.
- ✓ Re-evaluation of extension services is necessary to keep farmers interested in a number of agricultural programmes offered by the government.
- ✓ There is a need by the agriculture and energy departments to publish or publicise any new information pertaining biofuel crops and these efforts should be stepped up or intensified. This can be done by advertising through radio, television or any medium of communication that is utilised mostly by smallholder farmers.

Medium term policy Recommendation

- ✓ Identification of farmers with under-utilised land is necessary in tapping potential for adoption of biofuel crops. The government can try to confirm the number of farmers utilizing land through the Department of Agriculture. This will also help in planning for a support structure that best suits farmers.

Long Term policy recommendations

- ✓ Promotion of large-scale production of biofuel crops targeting every farmer with under utilised pieces of land. This can be done by increasing direct or indirect income payments. The payments can be linked to output or acreage. Incentivising farmers through a payment structure will also motivate a number of youths who are not participating in agriculture because they will get employment. Moreover, direct or indirect payment leads to the redistribution of income, hence, eradicating poverty in rural areas where smallholder farmers live.

- ✓ A mid-term review of the Biofuels Strategy is necessary in measuring the targets proposed, and necessary corrections should be implemented.

7.4 Areas of further research

Although the findings of the study indicate that smallholder farmers face many challenges, research that can quantify the extent of challenges faced by farmers is needed. This kind of research may reveal the untold story of a number of challenges that seem small yet they have a huge bearing on farmers' livelihood and adoption potential. A similar study on barriers and incentives to adoption of biofuels crops can be done at a national level to come up with an exhaustive list of barriers and incentives hindering the adoption of biofuel crops in South Africa. This study was done at a district level, therefore its findings should not be generalised to the whole of South Africa in principle, even though it may act as a guideline in making the Biofuels Industrial Strategy a success.

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APPENDIX

University of Fort Hare
Together in Excellence

Farmers Questionnaire

Title: Barriers and incentives to widespread adoption of bio fuels crops by smallholder farmers in selected areas in Chris Hani and OR Tambo District Municipalities, South Africa.

Introduction

In this interview schedule there is no wrong or correct answer. What is required is just your opinion on bio fuels crops production. This will assist in formulation of policies, research and extension programme that are appropriate to your area. Your cooperation will be therefore highly appreciated.

General information

Date..............................

Name of respondent...

Name of enumerator..

Name of village...

Section A – Demographic information

This section of the questionnaire refers to background or biographical information.

Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your co-operation is appreciated.

A1. What is your gender?

Male	1
Female	2

A2. What is your age?

A3. Your highest educational qualification?

Grade 11 or Lower	1
Grade 12 (Matrics, std 10)	2
Post Matric Diploma or certificate	3
Baccalaurete Degree (s)	4

Post Graduate Degree (s)	5

A4. Size of your household, i.e the number of people, including yourself, who live in your house/dwelling for at least three months of the year?

Live Alone	1
2	2
3	3
4	4
5 or 6	5
More than 6	6

A5. What is your occupation?...

A6. What are the sources of your income? State..

…………………………………………………………………………………………………….......

A7. Who is the household head of the family?...

A8. Who makes household decisions?...

A9.What is your household income per month?

R0-1000	1
R1001-2000	2
R2001-3000	3
R3001-4000	4
Over 4001	5

Section B - Farming information

B1. How much arable land (ha) do you have access to?

1. Less than 0.5 hectares	1
2. 0.5-1 hectares	2
3. 1-2 Hectares	3
4. 2 hectares or more	4

B2. Do you utilize the land?

1. Yes	1
2. No	2

B2b. If No why?..

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

B2c. If YES how much land is utilized?

1. Less than 0.5 hectares	1
2. 0.5-1 hectares	2
3. 1-2 Hectares	3
4. 2 hectares or more	4

B3.How much arable land in hectare did you use last season?...

B4. How did you acquire land?

Bought	1
Lease	2
Rent	3
Inherited	4
Other (Specify)	5

B5. In the last season, did this household grow food crops for sale or home consumption?

1. Yes	1
2. No	2

B5b.If Yes which crops did you produce?

Maize	1
Potatoes	2
Cabbages	3
Peas	4
Spinach	5
Onions	6
Other	7

5Bc. If other specify………………………………………………………………………………

…………………………………………………………………………………………………......

B6. How much produce did you consume, sell, donate, other: specify in kilograms (kg)

Crops	Quantity Produced	Quantity Consumed	Quantity sold	Quantity Donated	
					1
					2
					3
					4
					5
					6

B7.What are the sources of your food consumption?

Farm	1
Market	2
Other	3

B8 .Where do you get your farm inputs?...

B9.Where do you market your farm ouput?..

B10.What is the distance to market where you sell your output?

Less than 0.5 km	1
0.5-5km	2
6-10km	3
10km or more	4

B11.How do you get your market information?..

B12. Did you borrow any money for crop production last season?

1. Yes	1
2. No	2

B12b. If Yes from whom? And for what?..

....

....

B12c. If No why did you not seek credit?...

…………………………………………………………………………………………………

…………………………………………………………………………………………………

B13.What is the level of your farming experience?

0-5 years	1
6-10	2
11 and over	3

B14.What is the source of your labour for farming?

Family	1
Community	2
Other	3

B15. How much is your farm production costs?...

B16. How much Income do you get from farming ?...

B17. What kind of farming equipment do you have? State ....

……………………………………………………………………………………………………

……………………………………………………………………………………………………

B18a. Are you a member of any farmers' membership association?

1. Yes	1
2. No	2

B18b.If Yes name the organisation?..................................

…………………………………………………………………………………………………….

B18c. If No why?...

B19. Are you in contact with Agriculture extension agents?

1. Yes	1
2. No	2

B19b. If Yes how many times do you visit them per month?..

B19c.What kind of information do you get from them?...

…………………………………………………………………………………………………….

……………………………………………………………………………………………….....

B20. What challenges are you facing as a farmer?..

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

Section C

This section explores your attitude and perceptions regarding awareness and adoption of biofuels crops.

C1. Are you aware of biofuels crops?

1. Yes	1
2. No	2

C1b. If Yes what do you know about biofuels?...

……………………………………………………………………………………………………

…………………………………………………………………………………………………..

C2. From the list below can you tick biofuels crops that you are aware of .

Sugarcane	1
Canola	2
Sunflower	3
Sorghum	4
Wheat	5
Soybean	6

Groundnuts	7
Maize	8
Other	9

C2b. If Other can you name the crops………………………………………………………

C3. What is your view about biofuels?...

………………………………………………………………………………………………

……………………………………………………………………………………………….

C4. Are you willing to participate in biofuels production?

1. Yes	1
2. No	2

C4b. If No why are you not willing?...

………………………………………………………………………………………………

……………………………………………………………………………………………….

C5. What kind of incentives would make you participate in biofuel productions?............................

………………………………………………………………………………………………

……………………………………………………………………………………………….

C6. If offered incentives are willing to let go the crops you are currently farming?

1. Yes	1
2. No	2

C6b. If No why are not you willing to let go the crops you are farming?..

……………………………………………………………………………………………………

……………………………………………………………………………………………………

To what extent do you agree with each of the following statements. Please indicate your answer using the following 5-point scale where:

1. = Strongly disagree **(SD)**
2. = Disagree **(D)**
3. = Neutral **(N)**
4. = Agree **(A)**
5. = Strongly Agree **(SA)**

	SD	**D**	**N**	**A**	**SA**
C7. The biofuels market is sustainable for small-scale farmers	1	2	3	4	5
C8. Participating in biofuels production would increase my farming output	1	2	3	4	5
C9. I have knowledge of the proposed crops for biofuels production by the Department of Energy	1	2	3	4	5
C10. Biofuels will create employment opportunities for small scale farmers	1	2	3	4	5

C11. Biofuels production will increase productivity for small scale farmers	1	2	3	4	5
C12. Producing biofuels crop will help small scale farmers to access markets	1	2	3	4	5

C13. Please enter your perception regarding any other beneficial or detrimental effects of adopting bio fuels crops in the space provided below

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Thank you for your co-operation in completing this questionnaire.