AN ANALYSIS OF PERCEPTIONS AMONGST FARMERS ON THE ADOPTION OF GM TECHNOLOGY IN PAARL, WESTERN CAPE-SOUTH AFRICA.

by

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Declaration

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I declare that the dissertation entitled: **AN ANALYSIS OF PERCEPTPIONS AMONGST FARMERS ON THE ADOPTION OF GM TECHNOLOGY IN PAARL, WESTERN CAPE, SOUTH AFRICA,** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete reference

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FESTUS OWUSU **DATE**

Dedication

This study is dedicated to the following persons from whom I draw strength and inspiration:

- My uncle, Mr. Yaw Amoako Amoako
- My friend, Leticia Ayensu
- My grandfather, Mr. Yaw Nkensah

Acknowledgments

I would like to express my deepest appreciation to my supervisor, Prof. Derica Kotze. This study would not have been possible without her support: Thank you for taking me through the rudiments of study. Thank you for being a guiding light and for the constructive and insightful ideas for my dissertation. Your modest nature, support and encouragement saw me through to the accomplishment of my goal. Your contribution will have a lasting influence on my career.

Abstract

In early 2003, a persistent drought threatened about 15 million people in the Southern African region (SADC) with starvation as farmers in this region were not able to produce enough food. A similar threat was experienced in the United States of America (USA). The Americans responded by introducing GM technology, which thankfully stabilised corn production and food security. It was against this backdrop that the South African government legalised and supported GM technology in the farming industry. However, the technology became a contentious issue amongst scholars, politicians and policy makers as well as farmers. Therefore, this study analysed the perceptions of small-scale and large-scale farmers, located in Paarl, Western Cape, South Africa, on the adoption of GM technology. This qualitative study, using a case study design, collected primary data from thirty (30) farmers: fifteen (15) small-scale and fifteen (15) large-scale farmers. The findings revealed complex factors influencing farmers' adoption decisions and that Adopter perception (AP) and Consumer perception (CP) play a key role in their adoption of GM technology. These commercially and profit-driven farmers avoid using GM technology because public opinion and the markets weigh heavily against it. It was concluded that the farmers regarded GM technology as just one of many agricultural technologies and not as an exception. It was also considered unaffordable and detrimental to the environment, the economy and their livelihoods. The study recommends that the government should fully investigate public perceptions with regard to the adoption of any new agricultural innovation prior to making policy decisions.

Keywords: Adoption, climate change, farmers, GM, Paarl, perceptions

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LIST OF ACRONYMS

AP	Adopter Perceptions
BT	Bacterium Thuringiensis
CIDA	Canadian International Development Agency
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussion
GHG	Global Greenhouse Gas
GM	Genetically Modified
IFPRI	International Food Policy Research Institute
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
MDGs	Millennium Development Goals
R & D	Research and Development
SDGS	Sustainable Development Goals
SLF	Sustainable Livelihood Framework
SA	South Africa
UN	United Nations
US	United States
USA	United State of America

UNCCD	United Nation Convention to Combat Desertification
WCED	World Commission on Environment and Development's
WEMA	Water Efficient Maize for Africa

CHAPTER 1: INTRODUCTION

1.1 Introduction

This study undertook an analysis of perceptions amongst large-scale farmers and smallholder or small-scale farmers concerning the adoption of genetically modified (GM) technology and how it influences their decisions to accept or reject GM technology. The study was conducted in Paarl in the Western Cape Province, South Africa. This chapter examines the background to the research study, the research problem and the objectives of the study as well as presenting a brief outline of the research methodology and the chapters.

1.2 Background to the Study

GM technology is a term used to describe a plant or crop that has been modified by scientists to alter its genetic material. Genetic modification (GM) technology allows scientists to introduce desirable traits from certain species into crops through genetic engineering (National Academy of Science 2010:1). According to Oluwambe and Oluduasi (2017), GM technology produces crops that are more pest, disease and drought resistant than unmodified crops. Climate change affects agricultural production, particularly in developing countries. Moreover, conventional agricultural practices makes a substantial contribution to climate change, accounting for 18% of greenhouse gasses, whilst also being a prime cause of water pollution and unsustainable environmental waves (Linquist, Groenigen, Maria & Kessel 2012). As a result of unsustainable environmental waves agricultural production has been very low, particularly in Africa. Thus, agricultural production systems need to be transformed to meet food demands, otherwise there will be serious consequences for people and agricultural development (Linquist et al. 2012). Because of this, an innovation, known as GM technology or Genetic engineering has been introduced into agriculture. According to Chavas (2001:265) the process of food production has changed over time. These changes were determined by the interactions between the human population and technologies. By this 21st century, the production of food has evolved from simple forms of food gathering to complex biotechnology (e.g. genetic engineering or GM technology). The end of 20th century saw genetic applications being introduced into agriculture as a result of the said climate change and diminishing resources of agricultural inputs (Trewavas 2002:668). Since agriculture inputs, such as land and water are diminishing resources, there is no option but to produce more food and other agricultural commodities from less land that is arable and scarcer water. Consequently, the need for more food has to be met through higher yields per unit of land, water, energy and time. According to Tonukari and Omotor (2010), technology can be used to increase the productivity ceiling without associated environmental harm. Agriculture technologies represent a unique opportunity to address food security in the world. Amongst other things, farmers require crops that provide higher yields per hectare, make better use of less water and are less dependent on pesticides and fertilisers as they, the farmers, need to be able to feed the growing population (www.greenbiotic.eu 2012). According to Mohammad and Lee (2014), the increase in population, dry and arid lands, drought and low yield crops as well as economic imbalances are the main causes of low agriculture production in most countries. Thus, agriculture as a necessity for life should be established to liberate people from going to bed hungry every night, but it raises questions of how to achieve this. Will realising this be possible without the application of new technologies and new methods, which have the ability to increase agricultural production?

With this in mind, scientists have introduced GM technology into agricultural operations. The said technology has the ability to increase yields and withstand unfavourable climate conditions. A new scientific discipline has emerged which has the capacity to change agriculture trends in the world and improve the capability of crops to resist environmental pressures (e.g. extreme heat), thus enabling farmers to cultivate crops in those parts of the world presently unsuitable for crop production (Mohammad & Lee 2014:96). Agricultural biotechnology, particularly genetically modified (GM) technology, has been promoted to increase food production in the world. It is perceived as being able to help address global food insecurity through the development of plants that are resilient to changing climate conditions. Since the introduction of this technology in 1996, the use of GM crops has increased at a rapid rate and accounts for over 80 percent of soybean, corn (maize), and cotton acreage in the United States (National Academy of Science 2010).

According to Mohammad and Lee (2014:95), the main manufactures of GM seeds are US firms Monsanto, DuPont, Dow Chemical and Syngenta of Switzerland. GM products dominate agriculture in the USA and hold a large share of the food products that are found on Americans' plates. Additionally, studies suggested that GM technology started in the United States of America and, in 2009, a record number of small- and large-scale farmers planted GM crops in 25 countries (Masehela, Terrapon, Winker, & Maphisa 2016). The following countries have commercialised GM crops: USA, Brazil, Argentina, India, Canada, China, Paraguay, South Africa, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Spain, Mexico, Chile, Columbia, Honduras, Czech Republic, Portugal, Romania, Poland, Costa Rica, Egypt and Slovak Republic (Masehela, Terrapon, Winker, & Maphisa 2016).

However, since the introduction of GM technology into global agricultural operations an intellectual debate has arisen as to whether GM technology is acceptable or not. This emergent debate has led to two schools of thought. The first school of thought suggested that GM technology is good for all farmers (McFarlane, Phipps & Ceddia 2011; Eicher et al. 2006; Becerril & Abdulai 2009). This argument is backed by various literature sources (Bennett et al. 2004; Brookes & Barfoot 2012; James 2013; Thritle et al. 2003) highlighting the positive impact of GM technology in terms of increasing yields and farming income, reducing pesticides and improving quality of life. Furthermore, the world's economy and development has been faced with two major challenges: global climate changes and rapid population growth. As the world's population is growing rapidly, transgenic crops are promoted as one critical instrument that can help alleviate global food insecurity (Julian, McFarlane, Phipps & Ceddia 2011:2). Studies have suggested that GM technology can resolve some of the elementary efficiency problems that afflict farmers and hinder the development of successful agricultural systems. As Bailey, Willoughby and Grzywacz (2014:2) argue, accumulating agricultural products and adjusting agriculture to climate change are essential to Africa's development prospects.

It is a fact that many African countries import food from developed countries. According to Onyeiwu, Pallant and Hanlon (2007:1), African farmers face severe food shortages arising from drought, desertification and lack of expertise. In Africa, the losses of food production are caused by pests and diseases while environmental degradation are exacerbated by climate conditions. This situation has caused low food production, making food very expensive, resulting in food insecurity. The problem of food insecurity has become life-threatening in many parts of the world. Achieving food security is vital and a growing challenge in the world, especially in the developing countries (Tonukari & Omotor 2010). According to Wambugu (2001:2), in order to reduce the cost of food and achieve security, Africa needs to use science and technology to reduce production losses and increase production. An effective tool is needed to be able to increase food production where crop yields are significantly lower than those obtained in developed countries (Herrera-Estrella 1999). Herrera-Estrella (1999) further said that transgenic crops would help all farmers to increase food production. A transgenic crop is the product of the application of scientific knowledge to a natural crop. To feed the growing populations living on this earth, the production of quality food must upsurge with limited inputs; accomplishing this is particularly challenging in the face of worldwide environmental change (Tonukari & Omotor 2010). There are many prospects to boost harvests and upsurge agricultural production through the adaptation of developed crop varieties (Tester & Langridge 2010:818), and in some cases, GM technology offers advantages over conventional plant-breeding approaches (De Groote, James & Bett 2010; Jacobsen et al. 2013; Bailey et al. 2014). Data from 2011 reveal a global trend of GM cultivation described by an area of 160 million hectares in 29 countries and involving over 15 million farmers of which half of them manage small farms. These farmers have benefitted a great deal from GM technology through an increase in production and lower production costs (www.greenbiotech.eu 2012).

On the other hand, the second school of thought is of the view that although GM technology is seen by some as a way forward for increasing agricultural production, it presents serious problems. GM technology has become an embodiment of evils of industrial agriculture which claims massive environmental distraction (Herrera-Estrella & Alvarez-Morales 2001:256). For some people, GM technology has become the new manifestation of 'evil technology', which sacrifices human health and environment for the sake of money for few companies. Furthermore, advantages of genetically modified crops have sometimes been overstated since, in the view held by the second school of thought, they have the abilities to cause well-being problems and unsustainable ecological effects. For example, they may give birth to allergens and poisons, spread harmful traits to weeds and non-GM crops or damage creatures that consume those (Arthur & Yobo 2014:21). One main ecological influence of GM crops that has got to critical magnitudes is the abuse of herbicide-tolerant GM crops that have fortified a rise in herbicide use and an epidemic of herbicide-resistant "super weeds". In addition, it is possible that herbicide resistant varieties can become severe weeds in other crops (Altieri & Rosset 1999).

According to this (second) view, developments in agricultural biotechnology are profit-driven rather than need-driven, arguing that the actual push of the genetic engineering industry is not to make Third World farming more fruitful, but rather to make profits (Altieri & Rosset 1999). They furthermore argue that, multifaceted problems, such as poverty cannot be solved with a single "magic bullet" in the form of GM technology (Morse et al. 2007; Sarich 2005). GM technology may worsen the problem of poverty among rural poor farmers, for example, the intellectual property rights of GM technology would subject farmers to substantial fines for cultivating anything that has been patented (Horne et al. 2008). The intention is to force growers to buy seeds for every planting season. Across the world, farmers could get into dangerous levels of debt at the hands of companies that manufacture GM seeds. These companies will eventually control the world's seeds as well as food. According to Walker (2014) the source of food is seed, therefore whoever controls the seed, control the entire food chains.

Agricultural biotechnology has been notable in its production increase but the fear of ultimate human control over nature by this technology poses social, economic and environmental risks as well as risk to our world view and culture (Levidow 1998:214). The unintended and unexpected effects that could emerge directly or indirectly from GM technology may have adverse effects on the economic wellbeing of poor farmers and the environment. According to Cellini et al. (2004:1090), the potential occurrence of unintended and unexpected effects is the concern currently being raised regarding the application of recombinant of DNA technique in the production of foods. This unknown effect is a serious concern of many people around the world.

Even though the environmental risks issue has received some discussion in scientific and academic spheres, this debate has frequently been presented from a narrow viewpoint that has restrained the gravity of the risks (Altieri & Rosset 1999). It has been established that procedures for risk valuation of GM crops are not well established and there is reasonable anxiety that present field biosafety assessments express little about possible ecological risks related to large-scale production of GM crops. The dominant fear is that global forces to gain markets and profits are resulting in companies discharging GM crops too fast, without proper consideration for the long-term impacts on the ecosystem (Altieri & Rosset 1999).

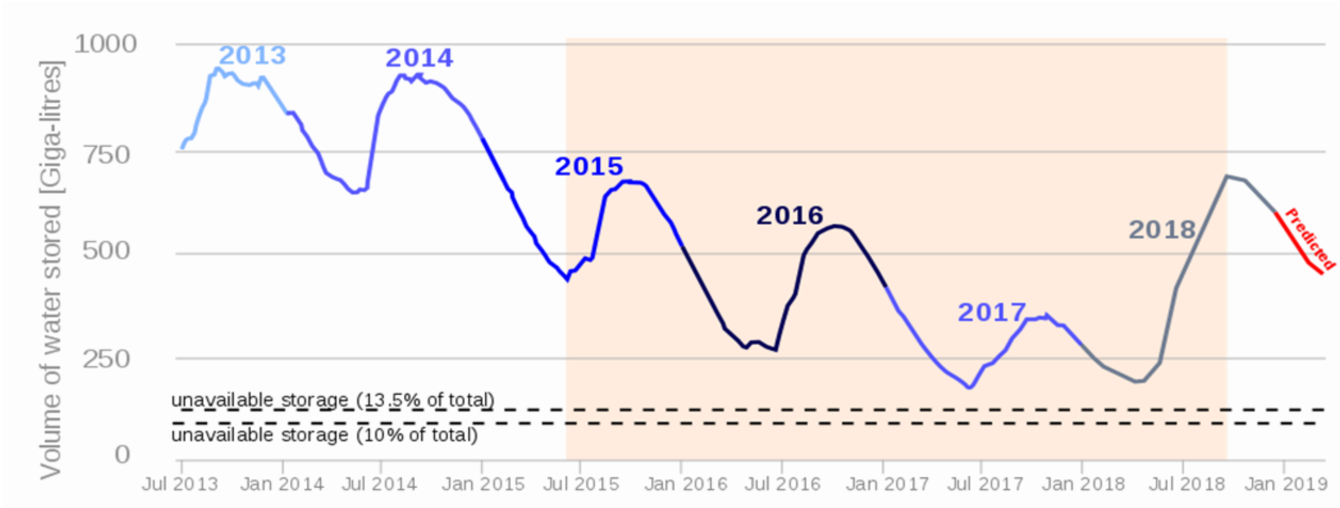
1.3 Background to the problem: South Africa and GM technology

Farming plays a vital role in every society. In less developed societies, agriculture is more geared toward the provision of food and social security. The role of agriculture systems in South Africa (SA) is to enhance productivity, ensure food security and also increase the living standards of small-scale and large-scale farmers. A FAO report (2004) highlighted that farming is vital to food safety in South Africa. The report specifies that farming contributes to poverty alleviation by decreasing food prices, generating jobs, improving farm income and increasing wages. Additionally, the incorporated food safety policy document for South Africa (July 2002) serves to guide the efforts of the Department of Agriculture, Forestry and Fisheries to contribute towards addressing food (in)security in South Africa (Du Toit et al. 2011). However, the present food safety challenge in South Africa comprises of two sizes: the first attempts to preserve and upsurge South Africa's capability to meet national food necessities and the second pursues to eradicate scarcity among farmers (www.agis.agric.za). Food security is important for every person, household, society and state. In less developed countries, food security could be significantly improved by broadened investment and policy reforms (Tonukari & Omotor 2010). The right to food is preserved in global and nationwide law. In South Africa, food security was especially acknowledged after 1994 when South Africa became a democratic country. The right to have adequate food was entrenched in Sections 26 and 27 of the South African Constitutional law of 1996. The constitution specifies that every South African citizen has a right to sufficient food and water (Du Toit et al. 2011:1). In this regard, the government of South Africa has, by law, put in place GM technology that enhances food security for all people in South Africa.

However, farming practices must protect the land efficiency and carrying capacity in order to harvest adequate food to feed a rising populace. Declining agriculture production and water scarcity due to drought and declining rainfall has left South Africa with less than two–thirds of the number of farms it had in the early 1990s (Plessis 2003). Temperature variation intensifies the possibility of life-threatening weather actions such as heat waves and droughts as well as additional steady vicissitudes in temperature and rainfall.

According to Taylor (2009), climate change as experienced in South Africa, demonstrates how temperature impacts on crops (crop burn, drought). Farmers would be in danger if drought continuously affects the crops. The Western Cape Province for example, is at jeopardy from climate-induced heating and variations in rainfall variability (Mukheibir & Ziervogel 2007:143). Figure 1.1 below, shows the rainfall pattern in the Western Cape. The Area's regular dam levels in 2018 was at 22.6%, compared to 34.7% at the previous year (Taylor 2019). This has led to low supplies of water in key areas of agricultural production, which is worsened by agriculture having to compete with urban (industrial and residential) water usage. Water distribution to the agrarian segment has been reduced by more than 60%, and in some cases, by up to 86% (Western Cape Government 2017). The drought may have intermediate to lengthier hostile impacts on certain crops, putting agrarian industries at danger even after the predictable end of the drought. Certainly, a study done in 2017 in the Western Cape established that 6% of all growers specified that they would not be able to endure farming if water allocations were cut by 60% (Western Cape Government 2017). Agriculture management and food security has become challenging and there is an increasing need to adopt other agricultural practices in order to increase food production.

Figure 1.1: Graph of entire reservoir water stowed in the Western Cape's largest six dams from 30 June 2013 to 31 March 2019



Source: Western Cape Government 2017

The agrarian segment in the Western Cape consisted of around 6 653 large-scale farmers and 9 480 small-scale farmers, whilst another 50 000 poorer households are reliant on irrigated courtyard gardening for their survival (Plessis 2003). The last are frequently dependent on public water and it is anticipated that the majority of these families will not be able to yield sufficient crops during drought periods, which will influence negatively their food safety. Farmers in Western Cape are looking for alternative crops to grow because of hot and drier conditions (Taylor 2009:4). In this regard, the South African Government has learned from developed countries like USA and recognises the potential benefits from using GM technology and has therefore introduced GM crops to be used on South Africa farms. GM technology helps farmers to tackle insects, diseases and weeds as well as changes in the climate, such as drought, that results in food insecurity.

The anticipated effects of climate change as referred to above, pose serious constraints and challenges for sustainable food supplies. Referring once again to Taylor (2009:2), agricultural production is at high risk due to climate changes and South Africa's agriculture sector is no exemption, especially in the Western Cape areas as mentioned above. Weather is one of the production factors in farming and it can cause uncertainty in food production. The question that needs to be asked is what strategies do farmers have to adopt to cope with this change? As Hassan (2010:77) stated, it will need considerable municipal and individual investment in the growth of crop varieties that are able to withstand the stresses of heat, drought and low fertility. According to Mushunje, Muchaonuyerwa, Mandikiana and Taruvinga (2011:5918), the South African Government as a major stakeholder in the economy, is in support of GM technology and has therefore put in place an Act to control the wise and responsible use of GM technology. The Genetically Modified Organism Act (No 15 of 1997) seeks to enhance agricultural productivity so as to improve food security, especially in the light of global environmental changes (www.un.org.esa/.../agriculture.pdf). In this regard, with agriculture as an important sector, SA has embarked on a strategy that improves food production among all farmers. South Africa has been planting GM crops commercially since 1999 and has become the first African country to have commercialised GM crops (Masehela, Terrapon, Winker, & Maphisa 2016).

In this regard, the Republic of South Africa was the first upper-middle income nation to cultivate genetically modified crops and has been the testing place for possible wellbeing improvements for the rest of Africa and the developing world (Gouse et al. 2005:28). South Africa introduced genetically modified white maize, the first GM food crop in a developing country (Fakuda-Paar 2007), and studies have shown that GM white maize, developed in the USA is now being used by Zulu smallholder farmers in SA. The genetically modified crops that are grown by small- and large-scale farmers are insect resistant cotton, herbicide tolerant cotton, herbicide tolerant soybean, insect resistant white maize and insect resistance yellow maize (Masehela, Terrapon, Winker, & Maphisa 2016). According to Gouse, Kirsten and Jenkins (2003:15) there is great potential for improved yields and increased revenue for both seed companies and farmers alike. In essence, smallholder and large- scale farmers may benefit equally from the adoption of GM technology through increased production, but with lower production costs. The overall assessment of the outline of genetically modified crops in SA indicated that the use of GM technology has decreased pest destruction and insecticide applications while increasing gross income for all farmers (Gouse et al. 2016). However, not all farmers in South Africa have adopted GM technology. A study conducted in South Africa by Mulaudzi and Oyekale (2015:105) observed that farmers' perceptions of technology play an imperative role in the use of GM technology. A different study, conducted in China, observed that farmers' perceptions of the perceived benefits and risks associated with GM technology influence their decision to adopt or not to adopt GM technology. Against this background it was important to examine the extent to which small-scale and large-scale farmers' perceptions of GM technology influence their decision to adopt or reject the new technology. This study focuses specifically on the views of small- and large-scale farmers in Paarl, Western Cape Province.

1.4 **Problem statement**

Studies exposed that insights can be used to differentiate between users and non-users of GM technology. Individual perceptions influence farmers' behaviour. According to Ajzen (2006), a person's insights about the likely result of behaviour influences their decision to adopt or reject the said behaviour. Human behaviour is guided by certain principles; one such principle is perceptions or philosophies about the possible results of the said behaviour (Ajzen 2006:1). In essence, the perceived outcome of behaviour influences people to accept or reject the behaviour. It can be reasoned that the perceived risks and benefits related to GM technology may influence a farmer's decision to accept or reject it. Keelan et al. (2009:1) observed that technological adoption is influenced by many factors, but farmers' perceptions on a given agricultural technology influence their decisions to adopt new technologies (Adesina & Baidu-Forson 1995:3). Farmers' subjective thinking or their assessment of new technology as compared to the old technology, may influence their adoption decision.

According to Sanchez (2015:3), the assumption is that personal philosophies and perceptions heavily influence opinions and subsequently the adoption of new technologies including GM technology. In an essay on GM technology, Kershen (1999) contended that endorsement or refusal of GM technology would not be grounded on information about or understanding of the science and technology but rather upon the ideological beliefs, perceptions and cultural values of the individual. Kagai (2011:166) also argued that although consumers play a major role in the success or failure of GM crops, the perceptions of producers (who are themselves consumers) play the most essential role in accepting or rejecting GM technology. However, more qualitative research is needed in order to explore farmers' perceptions of biotechnology and GM crops and to analyse the relationships between those perceptions and choices regarding the adoption and implementation of GM technology and the use of genetically modified crops. It is against this background that this study investigates how large-scale and small-scale farmers' perceptions impact on their decisions and willingness to adopt and experiment with GM technology and crops in Paarl.

Rainfall patterns are becoming unpredictable as temperature variation takes its toll, intimidating the production of staple and cash crops in the Paarl, Western Cape (Taylor 2009). According to the Western Cape Government (2017), Paarl farmers face many problems and climate change will apply its influence in the situation of numerous interrelating drivers. Climate change for Paarl is predicted to be very severe in the coming years. According to Engelbrecht, Landma, Reasons, Lutjeharms, Piketh, Rautenbach and Hewitson (2006), the future of the Western Cape is likely to be one that is warmer and drier than at the present time. It is vivid from recurrent proceedings that the occurrence and harshness of climate-induced catastrophes are growing. Experts have cautioned that the Western Cape is set to become comparatively warmer and will experience reasonable to strong warming in the next 100 years (Western Cape Government 2017). These realisms are gradually placing weight on the agrarian area to continue to grow and to generate much needed jobs, especially in Paarl where limited forms of other employment exist. Following the trend of climate conditions and as a major production factor in farming and a major cause of uncertainty in agriculture, farmers in Paarl are already experiencing crop failures. There is a decline in the volume of crops (especially wine grapes) harvested in Paarl due to shortages of rainfall. A crisis likewise awaits agriculture in the Western Cape, especially in Paarl (where it is very dry and hot); farm dams are currently at very low levels and farmers have no available water to use on their crops (www.farmersweekly.co.za 2017). According to Taylor (2009), uncertain climatic conditions cause uncertainty in agriculture manifesting in low crop yields, pest invasions or crop failures and also has an effect on the type of crop grown in a given area. Climate change such as drought in Paarl poses serious constraints and challenges for farmers. The normal expected rainfall in Paarl failed in 2018, resulting in the total accessible storage water level dropping. This situation has called for restrictions which have been imposed on agricultural irrigation water use in water schemes (Araujo et al. 2014:117). In summary, it can be said that profitable farming as well as survival farming will be seriously impacted by these conditions.

A research done in South Africa by Gouse et al. (2003:16) cited that 95% of BT cotton is produced by large scale farmers in South Africa, while only 5% is produced by smallholder farmers. The question emerged as to why some farmers adopted GM technology and others do not? There is a gap in literature regarding the reasons for not adopting GM technology. The researcher has identified this as a problem. Despite decades of agricultural biotechnology policy followed by the SA Government that promoted the adoption of GM technology as a way of improving productivity in the agricultural sector, there has been a low rate of adoption of GM technology among farmers in Paarl. Emerging technologies that will transform agricultural practices in Paarl will be related to water-management and related technologies such as smart farming, precision farming and GM technology, however the acceptance of these technologies will depend on the perceptions of the farmers (Western Cape Government 2017). A Study conducted in Paarl suggested that acceptance or rejection of any agricultural technologies depend on farmers perceptions (https://farmingfirst.org/sdg-toolkit#home 2015). Researchers recognized that if a crop plant is genetically engineered to be resistant to a broad spectrum herbicide, weed management could be simplified and safer chemicals could be used, however adoption of this technology will depend on the perceptions of the users (Western Cape Government 2017). In light of the fact that GM technology can create strategies such as genetically engineering virus resistance and insect resistance as well as heat and drought tolerance traits, one would therefore have expected the ready acceptance of this technology to address the major agricultural problems in Paarl. The study thus aimed to identify and analyse the Paarl farmers' perceptions which influence their decision to accept or reject GM technology.

1.5 Research questions

In line with the above objectives, the research questions includes:

1. Can the adopter-perception model approach be presented as theoretical foundation to explain farmer's perceptions on GM technology adoption?
2. What perceptions do small and large-scale farmers have on GM technology which may influence their decision to accept or reject it?
3. What impact GM technology adoption may has on the environment, economy and social aspects which may influence farmers' decision to accept or reject it?
4. What policy actions can be used to shape farmers perception in order to increase GM technology adoption?

1.6 Study objectives

With regard to the above, the following primary and secondary research objectives were set:

1.6.1. Primary objective

The main aim of this research study is to analyse the perceptions among large-scale and small-scale farmers in Paarl on the adoption of GM technology.

1.6.2. Secondary objectives

In order to achieve the primary objective, the following secondary objectives are set:

1. To present the Adopter-perception model as theoretical framework to study perceptions of farmers on adoption of GM technology.
2. To investigate the perceptions of large-scale and small-scale farmers concerning the adoption of GM technology and the effects thereof.

3. To examine factors as well as conceptual model in terms of environmental, economic and social aspects that impacts on the farmers' decision to adopt GM technology.
4. To propose guidelines addressing the perception of farmers and to encourage an increase in adoption of GM technology.

1.7 Adopter-perception model

This section briefly presents the Adopter-perception model as a theoretical framework to study the perceptions of farmers concerning the adoption of GM technology. This model is one of three models that can be applied to explain adoption decisions. The three models are as follows: Economic-constraints model, Innovation-diffusion model and the Adopter-perception model. The Economic-constraints and Innovation-diffusion models were developed by Roger in 1962, while the Adopter- perception model was developed by Kivlin and Fliegel in 1966. The Economic-constraints model reflects the assertion that the distribution pattern of the major economic resources (land and capital) are the major factors determining adoption behavior. The lack of these resources may deter a farmer from adopting an innovation, irrespective of his or her perception of the innovation in question. The Innovation-diffusion model on the other hand, holds that access to information about an innovation is the key factor that determines adoption decisions. As a wise saying goes "information is powerful" because it create an awareness which influences behaviour. Access to information on GM technology may create awareness that GM technology exists and again this information may influence adoption decisions. Meanwhile, the Adopter-perception model, also known as the User-perception model, suggests that the perceived attributes of innovation determine adoption decisions. In essence, the perception of the user concerning the attributes or the characteristics of the technology in question influences adoption decisions. For example, a farmer may have economic resources (land and capital) in terms of the Economic-constraints model, and may also have information regarding technology use (Innovation-diffusion model), but the farmer's subjective thinking or assessment concerning the attributes of technology may determines his/her adoption behaviour. This study is based on the Adopter-perception model because it explains how farmers' perceptions of technology attributes determine adoption behaviour. Small-holder and large-scale farmers do not have the same objectives and this may be reflected in their perceptions of the use of GM technology. The meaning of the objective measure of the characteristics is subjective, that is in the mind of the perceiver. For example the cost of GM seeds is evaluated by the potential adopters (large-scale and small-scale farmers) relative to his or her financial background. The cost of GM seeds may seem cheap for a large-scale farmer, but expensive for a small-scale farmer. The Adopter-perception model clearly measures the perception of the potential adopter regarding the characteristics of the new technology, which the Economic-constraints model and Innovation-diffusion model failed to do. It was therefore essential to use this model to ascertain the perceptions of large-scale and small-scale farmers which influences their decision to accept or reject GM technology. Details of this are given in Chapter 3.

1.8 Importance of the study

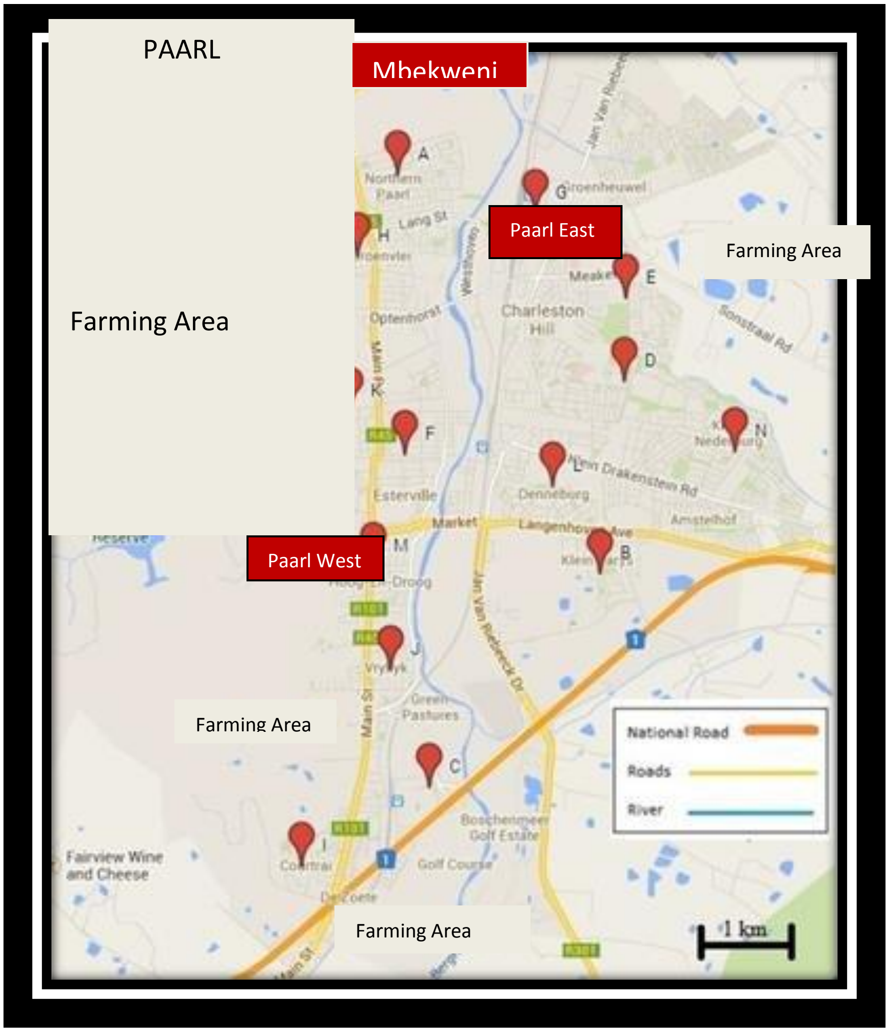
GM technology is crucial to agricultural development due to climate conditions, coupled with population growth and limited agricultural inputs. It is therefore necessary to understand perceptions held by smallholder and large-scale farmers on the adoption and implementation of GM technology to create awareness in the agriculture sector and food security statues. Agriculture, as the backbone of the economy, plays a crucial role in improving livelihoods and reducing the vulnerability of poor rural and urban households to food insecurity. For this reason, it is necessary for all stakeholders, policy makers and consumers to grasp the reasons why some farmers accept GM technology and other reject it. Understanding these perceptions will reshape adoption behaviour and food security status in the country. The findings of this study could influence the adoption and implementation of GM technology in the study area. In general, this study could give an indication to policy makers on farmers' perception on GM technology and provide answers to adoption and non-adoption of GM technology in South Africa. Policy makers may also use the recommendations from the study's findings to advise farmers about GM technology. Furthermore, the findings can contribute to the existing body of knowledge on issues pertaining to GM technology in Western Cape.

1.9 **Scope of the study**

The study was carried out in the farming communities of Paarl (see Map 1). Paarl is one of the oldest settlements in the Western Cape and is the largest town in the Cape winelands area. Established in 1678, it is well-known for its fruit farming activities.

Paarl farming communities are unique in that they are characterised by formal and informal settlements. Formal settlements describe the areas where most large-scale farmers can be found while informal settlements describe the areas where most of the smallholder farmers are settled. The populace from which the sample was drawn comprises of both small-scale and large-scale farmers within the Paarl farming communities. The map below illustrates Paarl farming communities.

Map 1: Paarl farming communities



Source: Google map of Paarl (2020)

1.10 Research design and methodology

This research study applied a qualitative research methodology in order to obtain in-depth knowledge about the perceptions of farmers on the adoption of GM technology. A case study design was used to explore these perceptions among large-scale and small- scale farmers in Paarl.

Both primary and secondary research methods were employed. The primary research method included personal interviews with respondents which were conducted using an interview schedule with open- and close-ended questions. The secondary research method included a literature review and content analysis to study recorded information about the topic in general and, more specifically, GM technology, models on adoption decision and context of the case study area. A focus group discussion (FGD) was also conducted for the purpose of triangulation and to ensure validity and reliability of primary data. The sampling frame comprised of all the farmers in Paarl. The random sampling method was used to select farmers for the collection of primary data through personal interviews. Details of the methodology used are presented and discussed in Chapter 4.

1.11 Ethical considerations

As a researcher, I confirm that the research respondents contributed on a voluntary basis. Their participation in the interviews was a function of their informed consent to participant in the study after being informed of its objectives and process. The research participants were assured of total confidentiality and that the information gathered was to be used solely for the purpose of the study. They were informed about the importance of the study and how it could help future farmers and policy makers as well as stakeholders with regard to sustainable food security. There was no discrimination against, nor favouritism shown to any research participant in the study; all participants were treated with dignity and integrity regardless of sex and ethnic group.

1.12 Outline of dissertation

This chapter presented the background of the problem that prompted the study and provided an overview of sections to be discussed in more detail in the following chapters. It also outlined the primary and secondary objectives of the study, the significance of the study and the research methodology it followed. Chapter 2 dealt with the explanation of concepts, the origin of GM technology and the debate on GM technology. It further explored the impact of GM technology on the economy, livelihood and environment. The Adopter-perception model as theoretical framework was presented in Chapter 3 to provide a framework to explore the various perceptions held by Paarl farmers concerning GM technology and the relationships between these perceptions were analysed with regard to decision making pertaining to GM technology adoption. Chapter 4 dealt with the research design and methodology. The study opted for a qualitative research paradigm as the overall methodological approach to guide the study. Chapter 5 presented the research findings according to the themes that emerged from the empirical results. The last chapter provides conclusions based on the findings of the study. The chapter also gives recommendations

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter first focuses on the explanation of concepts and deals with the origins of and the debate on GM technology. Secondly, it focuses on the perceptions and adoption of GM technology, followed by farmers' perceptions of GM technology.

2.2 Explanation of concepts

2.2.1 GM technology

GM technology is an agricultural technology developed by scientists, whereby a natural crop can be modified to an artificial crop known as a GM crop (Adenle 2014:243). According to Stojanovic (2015: 6) genetically modified GM technology is an improvement in farming technology, whereby crops have been genetically transformed by the inserted genes, borrowed from other species in order to make them demonstrate behaviours such as resistance to pests or herbicide tolerance. James (2010) also explained GM technology as a scientific approach to producing genetically modified food crops that are more resilient to pests, diseases and drought and which have short maturity periods. This technology has been perceived as being able to solve the problem of food insecurity in the world. Given the cumulative effect of world population growth, agriculture production and greenhouse gas emissions, it is essential to revolutionise farming in order to sustainably hasten crop efficiency. According to Stojanovic (2015:2), GM crops are the suggested answer to these concerns, with a growing number of countries benefitting from the new technology. However, the concept of GM technology has led to debate. This debate has in turn led to two schools of thought. The first school is in favour of the concept and the second school is against the concept. This debate impacts on people's perceptions concerning GM technology and farmers decision to adopt or reject GM crops.

2.2.2 Perception

In natural science perception denotes to the sanities that any living thing uses to gather information about its surroundings. Wade and Travis (1987) suggested that the sanities corresponding to the human sense organs have been categorised, at least since Aristotle's time, as: vision (our eyes), hearing (our ears), taste (our tongues), touch (our skin) and smell (our noses). Tacca (2011) also explained perception from a biological point of view by saying that perception is a process through which an individual understands their sensory impressions in order to give meaning to their environment.

While there are many descriptions in writings clarifying perception from a farmer's viewpoint, the one used by Walters et al. (1989:333) delivers a precise definition: "The entire process by which an individual becomes aware of the environment and interprets it so that it will fit into his or her conditions". This definition is accepted for this study. Furthermore, perception can be regarded as a variable that influences decision making and behaviour. It can be reasoned that since perception influences individual behaviour, it affects a farmer's decision to adopt or reject new agricultural technology. Rogers (2003) views perception as an antecedent to the decision to adopt new innovations.

2.2.3 Adoption

Adoption simply means that an individual organises something in a different way to the way in which they had done so previously (i.e. in this context, using GM technology to increase crop yields). "It is a completion of a decision-making procedure frequently influenced by a thoughtful plan or tactics made by others and affected by personality and creative ability, basic wants and so on" (Zaltman & Lin 1985:653). The adoption of new technology by an individual, family, community or state represents one-half of the dynamic core of social change. Acceptance of an innovation does not happen at the same time for everyone in a social system; rather, it is a process whereby some are quicker to adopt the innovation than others. In general, acceptance of a new technology is influenced by many factors. According to Rogers (2003) these factors include the socio-economic characteristics of the household (education, perception, and societal pressure and resources endowments) and its objective, together with the characteristics of the technology. Many writers have explained the significance of these factors in adoption decisions, especially in the area of agriculture (Adesina & Zinnah 1993, Kikulwe et al 2011). The literature identified the following three groups of models for explaining adoption decisions: the Innovation-diffusion, Economic-constraints and the Adopter-perception models (Adesina & Zinnah 1993). These models are discussed in detail in chapter 3.

2.3 Origin of GM technology

There has been concern over the anomaly of the simultaneous increase in population and decrease in food production. Malthus (1798) cited in Trewavas (2002: 668) predicted a continuously underfed and starving human population. A growing population drives the need to increase agriculture efficacy. Worldwide however, agriculture faces pronounced problems in terms of production size and ecological influence. The situation is further complicated by climatic conditions. It has been recognised that insecticides have the capacity to decrease harvest losses but their possible undesirable effects on communal well-being and the atmosphere is extensive. The agrarian business' response to this is to reduce the rate of the application of undesirable insecticides by substituting ones that are less poisonous and efficient. Nevertheless, with a growing world population, and a decline in crop development through orthodox methods as well as a dwindling zone of land available for farming, there is a need for new technology to produce more food in an ecologically satisfactory and sustainable way. It is against this background that scientists have developed the technology known as GM technology in agricultural operations. According to Trewavas (2002), the 20th century was the epoch of plant modification and this idea stabilised agricultural food production: for example, corn production in the USA. For the first time the hereditary base crop production could be controlled and easily adjusted to accommodate the different climates found on that continent. The use of GM technology in food production is regarded as problematic by some and as an important part of the solution to the world's food crisis by others. The diverse views or opinions on GM technology among scholars, experts, consumers and farmers have brought about the debate concerning this subject.

2.4 Debates on GM Technology

The debate on GM technology has emerged reflecting different views within the intellectual landscape and even farming communities. The debate may be seen as a solid indicator of movement towards farmers' and consumers' engagement in agriculture policies in a democratic country. The role of farmers' voices as well as the public and consumers' voices in agricultural decision making has become an important element in good agricultural policies. In practical terms, this development seems to be the best way to solve a number of perceived potential problems and difficulties associated with new agricultural practices. A new agriculture practice and its adoption and implementation in particular cases has the potential to cause problems where the new practice is related to some amount of disagreement. The following section addresses the themes underpinning the GM technology debate.

2.4.1 Western versus Indigenous Knowledge

All societies, primitive and modern, attempt to make sense of how the ordinary world performs and how to use this wisdom to guide practices of operating the surroundings (Madhav, Fikret & Carl 1993). Thus, decision-making is an outcome of knowledge about the working of the usual world. The current GM crop debate centers on Indigenous Knowledge systems (IKS) versus Western knowledge systems within a sustainable development framework. These two knowledge systems represent two different ways of looking at development. Before the development of modern technology's scientific understanding of the natural world, primitive societies had their way of interpreting their natural environment. The primitive wisdom was qualitative and grounded on observations on a limited physical scale.

Moreover, modern knowledge systems (Western sciences), and IKS view world development issues from the different knowledge systems. They differ in terms of their respective backgrounds and standards, established philosophies, expressions of thought, services and actions as well as how the knowledge is used (Tinnaluck 2004). These two knowledge systems are used for reasonable interpretations and also to conduct investigations, resolve anomalies, make assessments, disapprove of behaviours, and guide our thoughts about how we should act and to reach an understanding of ourselves, other people, and the world. However, IK is considered as being inferior and looked down upon in developmental theories. According to Semali and Kincheloe (1999:3), cited in Grange (2004: 82-83), indigenous wisdom reveals the dynamic methods in which the local people of a zone have come to know themselves in relationship to their surroundings and how they shape themselves. It is the common wisdom and philosophies of indigenous peoples about their ordinary truths of life. This knowledge comprises customs, standards, principles, and worldviews of native peoples as distinct from Western scientific knowledge. Such indigenous wisdom is the creation of native publics' uninterrupted involvement of the workings of nature and its relationship with the social world (Dei 1993:1050). It is also a general form of knowledge that has accumulated through a long series of observations conveyed from one group of people to another (Madhav, Fikret & Carl 1993). Native knowledge endeavours to comprehend the usual world in a universal way by detecting the relationships between all the system parts.

In contrast, Western knowledge attempts to comprehend the natural biosphere by learning separate parts. A more inclusive talk of differences as presented by Apffel-Marglin and Marglin (1990) cited in Agrawal (1995:2-3), teaches that the unique features of native knowledge (which they call traditional wisdom) are located in the truths that: 1) it is entrenched in its precise community; 2) it is contextually bound; 3) it does not trust in nonconformist morals; 4) it does not generate a subject object dichotomy; and 5) it needs a commitment to the indigenous setting, unlike Western knowledge which believes in flexibility and ignores resident origins. Overall, traditional knowledge systems assume a more holistic approach and, unlike Western knowledge systems, do not separate observations into different disciplines. Indigenous people established a means by which to develop and use their resources that guaranteed their preservation for future use. However, Western knowledge systems are constructed on the paradigm of positivism which is the belief that the most reliable source of knowledge is information developed by logical scientific testing knowledge. Knowledge that does not come from this source is considered as unreliable. In this regard, native knowledge has been shelved or looked down upon.

2.4.2 **Indigenous knowledge and development**

Since the Second World War, development strategies have progressed through numerous phases, concentrating on economic development, development with fairness, basic needs, participatory progress and, currently, sustainable development (Bates 1988; Black 1993; Daly 1991 cited in Argawal 1995:3). In the past, development practitioners used a top-down approach to carry out development ideas. Developing countries, especially African, mainly depend on the use of Western science (Western ideas) to carry out developmental strategies. This implies that development does not come from within communities themselves and the voices of the local people are excluded. According to Tinnaluck (2004:70) IK was seen as an obstacle to development. Briggs (2005:100) agreed that in the past, philosophers of development saw traditional knowledge as incompetent, mediocre, and an obstacle to development. On the other hand, Western knowledge (science based knowledge) was seen as a way forward to carry out development strategies. In essence, Western knowledge became a silver bullet to solve all developmental problems. Contemporary knowledge of science and technology for development tends to ignore and weaken other knowledge systems for developing countries, which are frequently considered as non-scientific (Tinnaluck 2004:70). According to Briggs and Sharp (2014:662), by the close of the 20^{th} century, development had become an extremely difficult concept that had lost much of its original promise. Pieterse (2009:339) expressed it as follows: "development is the management of promise - and what if the management does not deliver? For those living in Chiapas or other oppressed and poor areas, the chances are that development is a bad joke". Characteristically, growth specialists from the West are brought in to analyse growth anomalies and to offer solutions grounded on scientific methods. Just as in the colonial era, the dominant assumption is that both Western science and rationality are more advanced (Briggs & Sharp 2004). According to Escobar (1995), and other post development thinkers development is Westernization, an external method grounded on the concept of the industrialized world. What are needed instead, they argue, are local methods and discourses. Development, in this interpretation, is a successor to colonialism (Pieterse 2009:340).

Recently, efforts have been made towards knowledge built societies, and the significance of local wisdom for growth strategies has been progressively recognised as essential. The Second Knowledge for Development Conference, prepared by the World Bank and other administrations in March 2000, Kuala Lumpur, Malaysia, and the final plan of action endorsed IK in development strategies. It calls for development plans for using native wisdom in development (Tinnaluck 2004:71). Many countries have been encouraged to incorporate IK in their development strategies; for example, South Africa has given recognition to IK in its developmental plan. According to Briggs (2005), the call for native wisdom in development has become essential, representing one likely means of negotiating the so-called "development impasse". One of the more progressive expressions that have now begun to take possession of the dictionary of development experts and philosophers alike is IK. Everywhere western social science, technological might, and institutional models seem to have failed; local knowledge and indigenous wisdom are increasingly viewed as the modern and the greatest approach in the old contest against starvation, poverty and underdevelopment (Atte 1992; Richards 1985). IK has become essential in developmental themes for many reasons. As Brokensha et al. (1980:74) stated: *''Development from below is for many reasons, a more productive approach than that from above, and ... an essential ingredient is indigenous knowledge. To incorporate indigenous knowledge in developmental planning: is a courtesy to the people concerned; is an essential first step to successful development; emphasises human needs and resources, rather than material ones alone; makes p ossible the adaptation of technology to local needs; is the most efficient way of using western 'Research and Development' in developing countries; preserves valuable local knowledge; encourages community self-diagnosis and heightens awareness; leads to a healthy local pride; can use local skills in monitoring and early warning systems; involves the users in feedback systems*". For example, farmers can use their local knowledge to give feedback on the positive and negative effects of GM seeds. The positive feedback, together with the negative feedback, such as the possibility of disappointment without using IK, establishes a robust situation for integrating this knowledge in development programmes. Without considering IK, technology transfer such as GM technology may fail because this new innovation may be incompatible with the needs, values and the lifestyles of agricultural practices of the local people. The focus on indigenous knowledge, according to Agrawal (1995:1), "represents a shift away from the preoccupation with the centralized, technically oriented solutions of past decades, which failed to improve the prospects of most of the world's peasants and small farmers".

IK has played a very prominent role in agricultural practices and has been well-defined to comprise of standards and activities that describe practices, allocate roles and guide interactions among the people and their natural environment. IK provides a context for actions and decision-making in communal, monetary and ecological activities among rural people (Clinton & David 2007:118). Local knowledge therefore shapes actions and facilitates information critical in decision-making. "It is knowledge which is developed and used over time by local people and is influenced by environmental and socio-economic realities" (Clinton & David 2007:118). Native wisdom, and its related skills, has been established outside the formal educational system and is entrenched in philosophy and immersed in custom. It is the foundation for decision-making in rural societies with respect to food security, human and animal health as well as natural resource management (Scoones & Thompson 1994).

In response to Modernization theorists and Marxists, supporters of native wisdom highlight the potential it embraces for agrarian production schemes and sustainable development (Clinton & David 2007). Western knowledge, with its associated world view of humans as being apart from and superior to the natural world, has been surprisingly effective in promoting human understanding and influence of simpler systems. Nevertheless, scientific knowledge has been mostly unsuccessful when confronted with multifaceted environmental systems. Science-based civilizations have tended to overuse and simplify the complex nature of ecological systems, resulting in a whole series of problems of resource exhaustion and environmental degradation (Madhav, Fikret & Carl 1993). It is against this background that the knowledge of local people accrued over historical time, is of meaning. The attention to local knowledge and production systems heralds a long overdue move. It signifies a change from the obsession with the centralised, technically oriented answers of the past decades that failed to adjust life prospects for a majority of the peasants and small farmers in the world. IK forms the capstone of numerous convergent tendencies in social science thought and development of administration practice. In previous years, with the disappointment of the impressive models of development, the attention in most of the social sciences has shifted focus to favour IK. Post-development authors argued that local knowledge characterises a potential substitute for development among the rural poor. According to Escobar (1992:98), "…the problem with development is that it is external, based on the model of the industrialized world, and what is needed instead are more endogenous discourses". Development should begin by examining local cultures, because it is the life and history of the people that is the condition for and of change. According to Kotze and Kotze (1993), "…as more and more problems emerge on a global scale, the need for holistic solutions increases". In this 21st century humankind has to face problems such as drought, environmental destruction and famine as well as sustainable development. However, holistic solutions are needed to tackle these problems. Native knowledge that calls for the presence of indigenous opinions and priorities could be the way forward for development.

Within the context of this study, GM technology is regarded as Western knowledge which may not favour most developing countries. As in the case of scientific knowledge, GM technology follows linear 'cause and effect' concepts and does not embrace holistic solutions. GM technology is considered as being based on Western ideology, with huge promise to improve agricultural production of the South and enhance food security. As discussed in Chapter 1, proponents of GM technology argue that, in this twenty-first century, agricultural practices must match with the prevailing contradictory objectives of food security and environmentally sustainable farming. They see GM technology as a key element for achieving these goals. Trawavas (2002) argued that agricultural biotechnology is a win-win answer for the challenges of 21st century agriculture. However, Treurnicht et al. (2011:9) are of the opinion that GM crops pose more questions than answers with regard to sustainable development. According to Fig (2007:108), technological choices are not neutral and GM technology adoption has specific economic, environmental and social consequences. The following section discusses the debate on GM technology in relation to sustainable development.

2.5 Impact of GM technology's on the environment

Within the context of global environmental unsustainability, human activities have degraded farm lands (Tester & Langridde 2010:818). It is thought that the current agricultural practices in Africa have a detrimental impact on the environment. While farming is the main source of food, rigorous farming in general is a problem for the environment, causing pollution of portable water, soil dilapidation, and destruction as well as decreasing biodiversity (Frison et al. 2011, cited in Jacobsen et al. 2013:651). Population growth has caused more rigorous agricultural practices and the intensification of farming systems leads to systematic degradation (Haung, Pray and Rozelle 2002:679). Brindal (2012:713) added that growing forces for food safety and sustainability as well as the need to stop ecological dilapidation have focused the attention on improving the effective use of farm resources. The expanding population and the slow rate of crop development through orthodox farming methods along with the declining areas of land accessible for food making, increase the need to use new technologies to produce more food in an environmentally acceptable manner.

Crusaders of GM technology argue that one answer to the above problems is the use of GM technology. Bennett, Shankar and Morse (2008:2489) highlighted that biotechnology may deliver responses to agricultural glitches that orthodox plant breeding approaches have not been able to address sufficiently in the developing countries. According to Zechendorf (1999), the detrimental impact of conventional farm practices on the environment cannot be denied, therefore there is a need to use farm practices that can protect the environment. Biotechnology applications, especially transgenic crops, hold the most promise in increasing food production whilst protecting the environment (Herrera-Estrella 1999). An analysis of the USA experience with genetically engineered crops shows that GM technology offers substantial net environmental benefits compared to conventional crops production (National Academy of Science 2010:1). The proponents of GM technology, speaking in favour of this new technology, have in particular, raised the following concerns associated with conventional crop production, as discussed in sections 2.5.1 and 2.5.2

2.5.1 Effects of pesticides on the environment

It has been recognised that conventional methods of farming involve the regular use of pesticides and herbicides. Insecticides used in farming can cause unwanted effects on living organisms and the natural surroundings (Jensen et al. 1995; Werf 1996). According to Phipps and Park (2002:2) insecticide use has been accountable for killing large numbers of birds. Agriculture pesticides are normally applied as liquids sprayed on the crop or soil. The pesticides most often run off into sources of surface water and groundwater. The presence of pesticides in surface water and groundwater is harmful to aquatic organisms (Werf 1996:83). Moreover, the regular use of pesticides also causes greenhouse gas emissions. GM technology is considered to be one of the best tools that can be used to solve the problems mentioned above and at the same time increase food production. With the introduction of GM technology, global greenhouse gas (GHG) emissions have been reduced as a result of changes in pesticide usage (Phipps & Park, 2002:1; Julian et al. 2010). Furthermore, the toxic load delivered to the environment by conventional methods of farming can be reduced by introducing technology such as biotechnology (Morse et al. 2006). This new technology has the ability to reduce pesticide use and improve the reliability and quality of the world food supply (Jan-Peter, Metz, Escaler & Conner 2003:2).

2.5.2 Deforestation

One of the most extensive changes affecting the earth is forest transformation for farming, resulting in ecological degradation and climate change. Transforming forest into agricultural land has ecological consequences and these effects outweigh the potential gain in food production (Herrera-Estrella 1999: 5979). Despite these consequences, hectares of forest are cleared every year to be used as agricultural land. This activity has been recognised by international organisations and therefore measures have been put into place to fight against deforestation. For example, the United Nations Convention to Combat Desertification in those countries experiencing drought or deforestation, particularly in Africa, was established (UNCCD 2008). The aim of this convention is to combat desertification to mitigate the effects of climate change (Julian et al. 2010). According to the proponents of GM technology, using it in agriculture can slow deforestation. Herrera-

Estrella (1999) expressed the view that GM technology could facilitate the conversion of low productive acid savannas into productive crop land. For example, Brazil and Asia have successfully developed areas of acid grassland into fruitful land for the growing of sugarcane and soybean.

2.5.3 Critics of GM crops

Despite the abovementioned merits of GM technology, critics of GM technology have raised concerns that GM technology may have negative effects on the environment. Currently there has been increasing attention paid to how vicissitudes in agricultural practices connected with the introduction of genetically modified (GM) crops might directly or indirectly impact on the environment (Dale et al. 2002). The debates on the commercialisation of GM crops in some parts of the world have led to questions about their possible impact on the environment (James 2010). Do they benefit or harm the environment and specifically, to what amount could they profit the environment by including certain chemical inputs into agriculture (Dale et al. 2002)? Concerns regarding the environmental release of GM crops include the fear of gene flow by pollination to weeds and domestic plants (Jan-peter, Metz, Escaler & Conner 2002). Wolfenbarger and Phifer (2002) highlighted that GM crops can generate variations that develop an organism's capability to become an invasive species. Invasive species spread widely in their non-native ecosystem, causing unintended degradation and unnatural changes in ecosystem functions and structure. For example, a study conducted in USA on GM maize observed that GM technology has harmed the caterpillar of the Monarch butterfly as well as Ice Wings and insects (Azida & Ho 2010). According to Adams (2000) transgenic crops may cross-pollinate with their extremely productive weed relatives, which means that in the succeeding generation the new weed plants will be found to be herbicide tolerant. Farmers fear that GM seeds will create a 'super weed' over time which will become resistant to GM seeds and crops and to other herbicides and pesticides (Kruft 2001). According to Riffins (1999), the long-term accumulative negative impact of the introduction of genetically modified organisms could well surpass the harm that has resulted from the release of petro-chemical products into the earth's ecosystems.

2.6 Economic impact of GM technology

One of the aims of the United Nations Millennium Development Goals (UN 2009), was to eliminate life-threatening poverty and starvation. Amongst the important message of MDGs report was “high per capita growth driven by agricultural productivity” (Hahne, Horn & Reski 2011:245). This was singled out as one of the key elements to decrease poverty in the world. Recently, international communities have introduced Sustainable Development Goals (SDGs); the aim of SDGs is to strengthen the weaknesses of MDGs. Sustainable development embraces the unfinished trade of the MDGs but goes well beyond poverty abolition, breaking substantial new ground. It is a worldwide, cohesive and human rights-based programme for sustainable development. It poises development, community fairness and ecological stewardship and underscores the relations between concord, progress and human rights (World Bank 2013:1). The World Commission on Environment and Development (WCED) defined 'sustainable development' as "…development that meets the needs of the present without compromising the needs of future generations to meet their own needs.” The sentiment of the sustainable development notion is the acceptance that social, economic and environmental goals should be balancing and codependent in the development process. The first two goals of the SDGs tackle issues of poverty reduction, food safety and sustainable agriculture practices. Both the MDGs and SDGs have put poverty reduction and hunger at the forefront of their agendas. This indicates that agriculture is very important and is the way forward to fight against poverty and hunger. Within this framework, agricultural interventions should be introduced to improve food security and to reduce hunger and poverty; thus improving economic and social wellbeing of farmers. Capitalising in the agrarian sector can solve not only starvation and under- and malnutrition but also other challenges such as poverty, water scarcity, energy use, climate change and unsustainable production and consumption (https://farmingfirst.org/sdg-toolkit#home 2015:1). Food and farming are currently positioned at an intersection. Although, developments in agricultural yield have been noted over recent decades to please the food demand of a growing global population, it has frequently come with social and environmental costs, including water scarcities, soil dilapidation, ecology stress, biodiversity loss and declining fish stocks and forest cover as well as high levels of greenhouse gas emissions. The industrious prospective of our natural resources base has been damaged in many places around the world, compromising the future productiveness of the planet (FAO 2018:4). It is against this background that scientific methods are needed to address these challenges. With the introduction of GM technology, concerns have been raised as to whether this new technology can achieve sustainable development and at the same time improve the economic conditions of all farmers. The following sub-sections examine the perceived advantages and disadvantages of GM technology with regard to the economic conditions of farmers.

2.6.1 Economic advantages of GM technology

The main reason for the widespread adoption of GM crops is the perception of its economic benefits (Mabaya et al. 2015). Every farmer's aim is to use a technology that will enhance crop yields while at the same time reducing the cost of inputs. According to Julian et al. (2010), farm profits in the world have been reduced by the increasing input costs and volatile commodity prices. Consequently, some farmers are prudently assessing GM crops to reduce input costs while increasing production. Essentially, farmers consider GM technology as a way forward to increase their profit margins due to the use of less pesticides and an increase in yield. The introduction of transgenic crops with insect resistance (BT) aimed at preventing pests and weeds have in many circumstances brought an increase in harvests when compared to conventional crops (Julian et al. 2010:4). However, the question arises whether GM technology benefits all farmers or not? According to Bently and Theile (1999), small-scale farmers are resource-poor and therefore have a lower tolerance to crop pest infestation; making the use of measures able to solve pest problems a high priority. A study conducted in Northern China by Yang et al. (2005:230) observed that resource-poor farmers have reduced the costs of pesticides and labour by adopting GM technology. A similar study conducted in South Africa by Gouse et al. (2005) showed that BT maize has potential to upsurge harvests and in turn, to rise income for farmers. Cost-benefit analysis by Brookes and Barfoot (2005) revealed that employing GM technology in farm operations increased net income. A lesson drawn from these studies is that GM technology holds the potential to improve the economic conditions of farmers, influencing them to support and implement GM technology.

The unprecedentedly rapid adoption of transgenic crops that were first introduced reflects the significant multiple economic benefits realised by large and smallholder farmers who have grown transgenic crops (James 2003). Gains in agricultural productivity have been on the increase as a result of the use of the new technology (Bennet, Ismael, & Morse 2002:44). As mentioned above, GM technology is regarded as able to improve the management of crops through pest resistance and weed control, consequently having the potential to increase profit. Qaim (2005) indicated that the adoption of GM crops in developing countries have helped farmers to save from 33% to 77% on costs for pesticides. In essence, GM technology allows farmers to decrease pesticide use and yet have an increase in productivity. In line with this reasoning, it can be said that adopters of GM technology have improved their economic conditions by cutting down on expenses for pesticides and herbicides.

Furthermore, literature on GM technology acceptance have been conducted for BT cotton in Argentina, China, India, Mexico and South Africa (Huesing & English 2004:85). Unarguably, the developing world needs better cotton insect control because traditional pesticides are not always the paramount answer due to their lack of obtainability and their high cost. BT cotton has melodramatically decreased the use of orthodox insecticides by an average of 60–70%, positively affecting farmer profits (Thomas, Burke, Gale, Lipton, & Weale 2003, cited in Huesing & English 2004:86). GM crops are also engineered to increase yield, to reduce the use of pesticides and herbicides, increase nutritional content in food and provide economic benefit to farmers (Sanchez 2015). Similarly, the potential of GM technology is significant for improved yields and increased revenue, for seed companies and farmers alike. In this context, it can be argued that biotechnology does not discriminate, hence it helps every farmer, small or big. According to Cloete et al. (2006), biotechnology is recognised as an income making development that can contribute to economic growth and the establishment of new small, medium and micro–enterprises that can provide employment opportunities at different levels of expertise, thereby contributing to job creation and poverty alleviation.

2.6.2 Economic disadvantages of GM technology

GM technology is seen as one of the most contentious modern approaches to eradicate poverty in Africa. Mendola (2007:372) states that the acceptance of new technology by farmers will be determined by whether farmers choose to increase their revenue and reject the tendency to fall below the poverty line or not. According to Dowd-Uribe (2014:161), this controversy centres on whether or not this agricultural innovation can improve yields, reduce risk and increase profit for many smallholder farmers in Africa who face enduring poverty and comparatively low agricultural production. The question that has emerged within the controversy of the GM debate is whether GM technology can benefit poor, resource based farmers. Kropiwnicka (2005:45) argues that within the current structure, where technology is motivated by revenue, rather than by need-oriented research and development, the GM technology uprising can have an adverse effect on small farmers. Biotechnology innovations and development are owned by private companies or individuals, whose aim is for profit, frequently at the expense of the poor; therefore, biotechnology may not necessarily help the poor farmers. According to Makanya (2004), GM technology promises rich rewards to GM seed manufacturing companies and commercial farmers, but it spells doom for small-scale farmers in particular. The locus of agriculture has shifted dramatically from the public to private multinational sector, at the expense of the small farmers (Tripp 2002).

Smallholder farmers may be at a disadvantage since GM technology is designed to destroy the traditional practice of seed saving. According to Kruft (2001:4), seed companies have invested huge amounts of funds in the research and development of GM seeds and they protect this investment through setting up contracts with farmers. The contract between a farmer and a biotech company contains a provision of ‘no seed saving’. This provision prohibits farmers from saving seed or reusing GM seeds. This contract gives Biotechnology Companies the right to own GM seeds and therefore, farmers are required to buy seeds every planting season, thereby disadvantaging the poor resource-based farmer who only produces food to feed the family. A study carried out in South Africa by Mannes (2010) confirmed that economic benefits gained from adoption of genetically modified maize by large-scale and small-scale farmers are not equal; large-scale farmers have greater gains than small-scale farmers who produce mainly for household consumption. Small-scale farmers tend to save seeds or borrow seeds from friends or relatives. As mentioned earlier, GM seeds contracts force farmers to buy seeds every year, which can be too expensive for the said resource poor farmers. Another study conducted in South Africa by Mushunje et al. (2011), found that small-scale farmers are forced to buy BT maize seeds on a yearly basis. This discourages prospective adopters based on the potential cost of procuring seeds every year. It can thus be argued that the cost of GM seeds may be too expensive for resource poor farmers, compared to commercial farmers who are in the business of producing and selling for profit.

2.7 Impact of GM technology on sustainable livelihood

Learning how people are able to make a living or seepage poverty is an essential issue of development theories. According to Scoones (2015), sustainable livelihood (SL) is explained as the capabilities, assets and activities required for a means of living. It is projected that 75% of the global population work and live in rural areas and projections propose that most of these people are poor. These are good reasons to put effort in poverty reduction research and also to find ways and means to increase agricultural development. Sustainable livelihood is of supreme significance in the SDGs, particularly linking to well-being, schooling, poverty reduction and control of human diseases. According to Julian et al. (2010) the original GM crops were not made to have direct effects on these factors; however, their use has had indirect effects on these factors and those yet to be manufactured may prevent disease. In section 2.6, it was discussed that GM crops have the potential to increase profits and thus ease poverty. Literature suggests that as incomes rise, people are able to access better education and health care, which have impacts on their livelihood.

In Africa, farming is a common choice for overcoming poverty and enhancing food security. The population of Africa is expanding rapidly, depending largely on agriculture for its livelihood. Upgrading production, and increasing profitability and sustainability of agriculture is the main passage out of poverty (Solomon, Bekele, Franklin & Leslie 2012). Agrarian development is also important for nurturing economic development and feeding growing populations in most of the less developed countries (Datt & Ravallion 1996). However, since agriculture growth and irrigation have already become a negligible source of output growth at a world scale, farming development will depend more and more on yield-increasing agricultural technological change (Hossain 1989 cited in Mendola 2007:373).

It is the view of that accomplishing agrarian development and higher productivity will not be conceivable without innovating technology to increase yield output because it is no longer likely to meets the needs of the increasing population simply by increasing the zone under farming. Agricultural technology improvement is therefore crucial for improving productivity and reducing poverty, thereby meeting the demand for food. The role of change and innovation in agricultural technology for reducing poverty and improved livelihood is recognised worldwide (Abdulai 2009:1024), but there is considerable debate among scholars as to whether technology such as GM technology can alleviate poverty and improved livelihood among all farmers or not. The following section investigates the positive and negative impacts of GM technology SL.

2.7.1 Positive impact of GM technology on livelihood

Knowledge, science and technology in agriculture are central to meeting the SDGs' predominant issues related to poverty and livelihood (Julian et al. 2010). As many people in Africa depend on agriculture for survival there is a need for innovation. Innovation is a process of using new ideas or methods to improve agricultural productivity. According to Rogers (2003:12), innovation is a knowledge or practice that is perceived as new to the users. An innovation would be adopted and used forever just if that innovation was able to improve the livelihood of the users. Innovation-decision processes can lead to either the adoption or rejection of a concept and this decision can be changed at a later stage (Tully 2015:56). For example, a farmer could initially use GM technology for some time and later stop using it; this occurring when the farmer realises that the new technology is not helping to improve his or her standard of living.

Agricultural development and sustainable livelihood are not feasible without yield-enhancing technological options (Kassie, Shiferaw & Muricho 2011), and technological change is fundamental to agricultural transformation (Langyintuo & Mungoma 2008). Research has demonstrated that technology concerning GM crops has the ability to make a contribution to rural poverty reduction in many Africa countries (Shankar, Bennett & Morse 2008:2489). Technological improvements are crucial to increase agricultural productivity and reducing poverty while sustaining the environment that supports sustainable livelihoods. SL investigates the capital (physical, financial and others) that countries have available to them, how these are contributing to livelihood and how vulnerable they are to shocks and stress (Carney 1998). Food production for instance, may be a source of livelihood that depends on having the necessary capital (land, labour and finance) but which is also potentially vulnerable to shocks (attack by pests/disease and drought). Conventional methods of farming are regarded as more vulnerable to the abovementioned shocks, which make it difficult for farmers to produce enough food. GM technology on the other hand, is perceived to be less vulnerable to shocks. The assumption is that sustainability is achieved by having a larger range of livelihood options which are less vulnerable to shock (Castro 2002). It can be argued that since GM technology is less vulnerable to shocks, it can achieve sustainable livelihood and maintain the environment.

Many producers of maize, soybeans and cotton in the United States, Brazil, China, Argentina, South Africa and Kenya have embraced genetically modified (GM) varieties of these commodities. Typically, this technology has conferred direct and indirect benefits to farmers through cheap inputs costs and improved management flexibility, as well as benefits to consumers via lower food prices. Becerril and Abdulia (2010) concur with the idea that GM technology is perceived to aid in decreasing poverty through direct and indirect effects. The direct effects of GM technology on poverty reduction include productivity gains and lower cost per unit of production, which can raise the incomes of producers who adopt it (Kassie, Shiferaw & Muricho 2011). GM crops increase incomes, thus alleviating poverty. Higher incomes make it possible for people to access better education and health care which has a direct impact on the social dimension of sustainability (Julian et al. 2010).

A study conducted in Mexico by Traxler and Godoy-Avila (2001) found that 85% of the total benefits of GM cotton went to farmers, thus improving their lives; while 15% went to seed suppliers and technology providers. A similar study conducted in China by Pray et al. (2002) indicated that the major share of benefits from the adoption of GM technology was retained by farmers with little accruing to the technology providers. According to Morse, Bennet and Ismael (2012:24), there are distinct livelihood benefits from GM technology adoption for resource-poor famers in South Africa. Illustrations from current literature indicate that profits from developed agricultural technologies have influenced the poor directly by raising incomes of small farm households. Therefore, it can be argued that GM technology has improved the lives of farmers who have adopted it.

2.7.2 Negative impact of GM technology on livelihood

According to Morse and Bennet (2012), the impact of agricultural technology on food production and economic growth in developing countries is well established, but there is still a debate about the extent to which these productivity increases have been translated into a reduction in poverty and improved livelihoods. There is a positive perception that GM technology can increase crop yields, but there is a negative perception that GM technology may improve the life of farmers. According to Chandrasehkaran and Machendra (2009), research in biotechnology is mainly in the hands of few multinational companies which focus on crops and traits that are important to the developed countries and not to the resource-poor farmers in developing countries. Research carried out in South Africa observed that GM technology, which is supposed to be helping resource poor farmers, seems to serve the needs of large-scale farmers and the promoters of GM technology (Witt, Patel & Schnurr 2006).

It can be argued that since GM technology scientists have invested so much money; they will promote the technology to serve their interests, but not that of the resource poor farmers. Other scholars are of the view that the extension of proprietary science and shrinking of public goods may lead to a condition where the technology of the future remains in the hands of a few transnational corporations. It can be reasoned that only resource-rich farmers might have access to these, thereby further widening the gap between the rich and the poor. Swaminathan (2001:39) argued that the problem could become worse if corporations integrate genetic use restriction mechanisms known as ‘terminator’. Small farmers may experience genetic enslavement since their agricultural destiny could be in the hands of a few companies if they have to purchase new seeds every farm season. In other words, farmers have to depend on a biotech company for GM seeds every year before cultivation can take place. Farmers will lose their independence since they will have minimal control over their own production. Hence, according to this view, GM technology may not improve the livelihood of the majority of farmers and small-scale farmers would be even worse off if GM seeds become too expensive for them to buy.

2.8 Perceptions and adoption of GM technology

GM crops are considered one of the possible ways forward with the aim of combining higher yields and improved food in an environmentally friendly agronomic practice (Sanchez 2015:3). Studies have shown that GM technology is widely recognised as a contemporary stratagem that holds the potential to improve agricultural production (Eicher et al. 2006; Julian et al. 2010; Aerni, 2005; Ammann 2005; Zechendorf 1999). One of the reasons for the interest in new food technology is the anticipated range of benefits they can bring to farmers and the food industry (Mendola 2007). As mentioned previously, the perception held is that with the introduction of new technologies, like GM technology, farmers spend less on pesticides and herbicides, while at the same time increasing productivity. Due to these benefits, genetic modification has influenced the food industry worldwide and it has permeated the global agriculture domain as the fastest adopted agricultural technology in history (Klerck & Sweeney 2007:172; Khush 2012).

This rapid adoption has happened due to the fact that conventional methods of farming cannot produce enough food to feed the growing population coupled with climate change such as drought which constrains production. However, initial adoption in 1996 was limited to commercial farmers (Falck-Zepeda 2016). Studies have shown that GM technology has only been introduced and adopted by small-scale farmers at a much latter stage due to their perception of the technology (Schnurr, Patel & Harald 2006; Kruger, Van Rensburg, Van den Berg 2009; Shankar, Bennet & Morse 2008). Within the agricultural sector large scale cultivation of GM crops began in the US in 1996 and has since expanded rapidly. Today, GM crops cover about 11% of the world’s cultivation area with some crops dominating; for example 76% of the world soybean crop, 70% of all cotton, 32% of all maize and 24% of the oilseed grape (James, 2013). Despite these high adoption rates, the cultivation of GM crops is far from being widely accepted by all farmers because of the different perceptions (Almeida et al. 2015). Bett, Ouma and De Groote (2010), highlighted that farmers will adopt or reject GM technology based on their perceptions of the technological characteristics and the related perceived social, economic, health and environmental impacts.

Despite the possible advantages of GM technology, numerous individuals are still cautious of it due to their perceptions and the supposed possible ecological and health risks which could indicate a substantial challenge to the adoption of the GM crops. For example, Kilkulwe, Wesseler and Falck-Zepada (2011), after analysing farmers' and the public's perceptions toward the possible adoption of GM bananas in Uganda, established that the perceived unknown health risk from consuming GM food is still a serious concern among farmers and consumers. According to Mushunje (2011:5919), perceptions could be used to distinguish between adopters and non-adopters of GM crops. Traill et al. (2004:176) agreed that the stated benefits and the perceived risks of GM technology may variously affect farmers' acceptance.

According to Costa-Font, Gil and Traill (2008:99) there is little understanding on the demand side effects of this new agricultural innovation. The demand side is influenced by the perception of people leaning either towards acceptance or rejection. In other words, public perceptions of GM technology influence the decision of whether to accept or reject GM food. A study conducted in Kenya by Kagai (2011:165), indicated that adoption of GM crops can be negatively or positively affected by public perception. It can be argued that within the public domain there are certain dimensions which can be classified into two groups regarding perception on GM foods; optimistic and pessimistic.

A major challenge of this new innovation is the understanding of what drives the farming communities' behaviours and decision making processes in view of the limited adoption of the technology that has been proven to increase yields (Halbrendt, Gray, Chan-Halbrendt & Tamang

2014:20). Innovation in this context is explained as a new agriculture practice that seems to have positive change on production. Zaltman and Wallendorf (1983) defined innovation as [an] "...idea, practice or object that people see as different". From a marketing perspective, the description needs to be more focused: thus, new technology is defined as a product which is perceived by the consumer as new. This perceived newness may be due to change(s) in just one attribute of the product.

While researchers, marketers and other institutions promoting GM technology suggest that it is one of the best modern agricultural methods that should be used by all farmers, they however fail to consider the local farmers' perceptions which influence their adoption decisions. A study carried out in the USA concluded that insight of GM corn by growers will decide its acceptance or rate of adoption, within the farming society (Clinton, Rice, Higgins, Steffey, Hellmich, Witkowski, Calvin, Ostlie & Gray 2002). Fliegel (1993) projected that a new technology would disseminated along an expected pathway of awareness, interest, evaluation, trial and adoption. Evidence has shown that new agricultural innovations introduced by government or other agencies are frequently neglected for traditional practices after the development intervention project has been accomplished (Prager & Posthumus 2010). This occurs due to the promoters of such innovations failing to consider the user's perception of the innovation. To sustain new technology there is a need to measure and evaluate farmers' perceptions regarding the new technology.

Evaluating perceptions on the practice of an innovation is important for the growth strategy to withstand the new technology (Yang et al. 2005:230); in other words there is a need to understand the user's personal perception. Wossink and Boosaeng (2003) observed that many agricultural technologies have failed because they were inappropriate for farmers' need and perceptions as the sustainability of agricultural innovation is largely dependent on the perceptions of the farmers. Alonge and Martin (1995) found that farmers' perceptions regarding the possibility of sustainably substituting one farming practice for another is a predictor of the adoption of such a practice; in other words the compatibility of the new practice with the existing practice. Compatibility of a new practice is the degree to which a practice is perceived as consistent with the existing values, past experiences and needs of the receiver (Robinson 2009). If farmers are to adopt sustainable agricultural practices, they should believe that the new practices are important. Understanding farmers' attitudes towards GM crops is central to understanding how the adoption of GM technology might develop among farmers (Chimmiri, Tudor & Spaulding 2006).

A collective theme fundamental to the numerous paradigms that illuminate technology acceptance, includes perceptions of an innovation known as 'Adopter-perception' (Agarwal & Prasad 1997:1). Studies investigating farmers' adoption behaviour have shown that technology characteristics and farmers' perceptions are perceived to influence the said adoption behaviour. However, there are different factors which shape the perceptions of small-scale and large-scale farmers towards GM crops. This is explained in greater detail in chapter 3. According to Costa-Font and Mossialos (2005) individual perceptions of a new technology differs because of the way each individual forms his/her perception. As argued by Adesina and Baidu-Forson (1995:1), farmers' personal assessments of agricultural innovations influence adoption behaviour and a study conducted by Zakaria (2014:1191) witnessed that 'farmers have different perceptions' about GM crops which has impacted on their intention to adopt its cultivation. Results revealed that farmers' perceptions toward the possible benefits and risks of GM crops are mixed and differ within and across countries (Kagia 2011:165). Their perceptions of perceived benefits and risks or expected harm determine adoption of GM technology (Costa-Font & Mossialos 2005).

Despite the likely merits of GM technology numerous individuals are still suspicious of GM technology due to a lack of understanding and perceptions concerning environmental and health jeopardies which could represent a major problem to acceptance of GM crops (Adenle 2013:242). Regardless of scientific confirmation to the contrary, there are still perceptions that the primer of genetically modified crops in the food cable will damage the surroundings and human well-being and will seriously disturb the livelihoods of farmers; in particular, those in developing countries. Additionally, it is hard to comprehend why some farmers choose to practice and continue to plant varieties of GM crops, while some decide not to experiment and others try do them but are disgruntled and abandon the technology (Mulaudzi & Oyekale 2015). Farmers' debate on the merits and demerits of GM crops are diverse within and across countries (Kilkulwe, Wesseler & Falck-Zepada 2011:241). A research done in the USA in the state of Illinois by Chimmiri, Tudor and Spaulding 2006 (2006) observed that farmers' perceptions of GM crops were positive as productivity increases were reported as one of the benefits of BT maize; thus influencing adoption behaviour. A similar study conducted in Kenya observed that BT maize has benefitted smallholder farmers through higher yields and less use of pesticides and herbicides (Owuor, Smale & De Groote 2004:2). A study conducted in China by Yang et al. (2004:7) indicated that farmers' reasons for adopting BT cotton were to save on labour, reduce pesticide application, obtain higher yields and grow the cotton more profitably.

As discussed earlier, large scale and small-scale farmers hold different views on the adoption of GM technology (Mushunje et al. 2011). According to the literature, the aim of small-holder farmers is to produce food to feed the family, therefore their perception regarding new agricultural technology may be different from large-scale farmers whose aim is to produce to sell and make a profit. For example, GM technology may be viewed as being expensive for small-scale farmers since their farming activities are not geared towards profit making as in the case of large-scale farmers. According to Moore and Benbasat (1991), the importance of innovation attributes suggest that individual behaviours determine how innovation characteristics are perceived and potential adopters perceive these characteristics in different ways, subsequently leading to varied adoption behaviours.

2.9 **Conclusion**

In conclusion, the introduction of GM technology has elicited different views within the intellectual and the farming communities. The intellectual debates on GM technology centered on Western knowledge and Indigenous knowledge. GM technology was designed using Western knowledge and this has led to two schools of thought. The first school argues that GM technology is good for all people and has the ability to increase agricultural production, especially in Africa, since conventional farming methods, coupled with climate change, cannot produce enough food to feed the growing population. On the other hand, the second school of thought is of the view that

GM technology may not help agricultural development of developing countries as GM technology has negative effects on the environment, economic and livelihood.

Moreover, farmers have formed perceptions regarding adoption and use of GM technology. Farmers' perceptions of GM technology determine adoption decisions. Since perception is contextually variable, small-scale and large-scale farmers may not have the same perception; this may led to different adoption decisions.

The theoretical framework underpinning this study is discussed in the next chapter.

CHAPTER THREE: THEORETICAL FRAMEWORK

3.1 **Introduction**

In this chapter the theoretical framework for the study is outlined by paying attention to adoption behaviour, stages of adoption and the innovation-decision process model. The chapter also presents the three main adoption models that are applied to explain the decision to adopt new agricultural technology.

3.2 **Adoption behaviour**

Individual adoption behaviour depends on multiple interrelated personal, cultural, social and situational factors. Individual decisions to adopt a behaviour or a new agricultural practice involve a complex procedure. "Adoption is a process. Irrespective of whether a person is an early or a late adopter he is likely to go through an extended period of deliberation before trying a new idea or practice"(Lionberger 1962:161). In other words, an adoption decision is not a single, unsupported act, but a continuous process that can be scrutinised, simplified and endorsed. What the individual farmer will decide about an innovation is essentially determined by his or her personal circumstances, the institutional structures of their society as well as the perceptions of the potential adopter. Lionberger (1962:161) argues that adoption of new ideas and practices may require special skills, inputs, services, information and other essentials (like credit). The accessibility of all these depend on the institutional structures for supplying and for coordinating such a system in order to meet the needs of individuals (Lionberger 1962; Darlington & Lyudmyla 2015). According to Neels and Kris (2005:2), the adoption process …"is a method of decision-making by a person that needs cognition-that is, it entails the use of an individual's skills to understand, perceive and interact with their surroundings in an intelligent means". It can be argued that personal perception and the environment play a role in an adoption process. When an individual farmer's adoption conditions are met, they will then decide whether to accept or reject the technology. Moreover, adoption behaviour has become one of the central zones in information technology that has been comprehensively investigated in order to decide the major factors influencing decisions taken by potential adopters to accept technologies and implement them in their activities. According to Conley and Udry (2010) cited in Silva and Broekel (2016: 379), adoption of new technology remains a critical prerequisite for the optimistic transformation of the agriculture segment; thus, scholars have concentrated on the individual adoption behavior of new technology.

While technology adoption decisions involve complex procedures, nevertheless, successful new technologies have emerged and expanded in scope, especially in the agricultural sector. The concept of improved agriculture technology is increasingly being integrated into national development strategies, forcing farmers to adopt certain levels of technology (Lionberger 1962; Taylor & Cayford 2004; Wambugu 2001). In order for these new technologies to be more productive, they need to be accepted and used (Heman & Regina 2007). For example, as mentioned in Chapter 1 (see section 1.3), the South Africa government has integrated GM technology in their agricultural policy thereby imposing a certain amount of pressure on all farmers to accept it. However, it is ultimately the individual's adoption behaviour and decision that results in fruitful implementation or not. According to Sobia and Shahrina (2014:1380), adoption will only occur if innovations are driven by farmers' needs. It is therefore important to understand the processes individuals undergo to accept or resist new practices. What motivates one person to decide to adopt a technology whereas another repels? What encouragement within the community setting has bearing on the pronouncement to accept? These queries are addressed in the framework of adoption behaviour. The literature indicated that adoption behaviour depends on the person and the selections a person makes to receive or discard a specific innovation. In attempting to understand why an individual chooses to accept or reject a particular innovation, Chimmiri, Tudor and Spaulding (2006) propose that individuals shape exceptional insights of technology that influence the adoption behaviour.

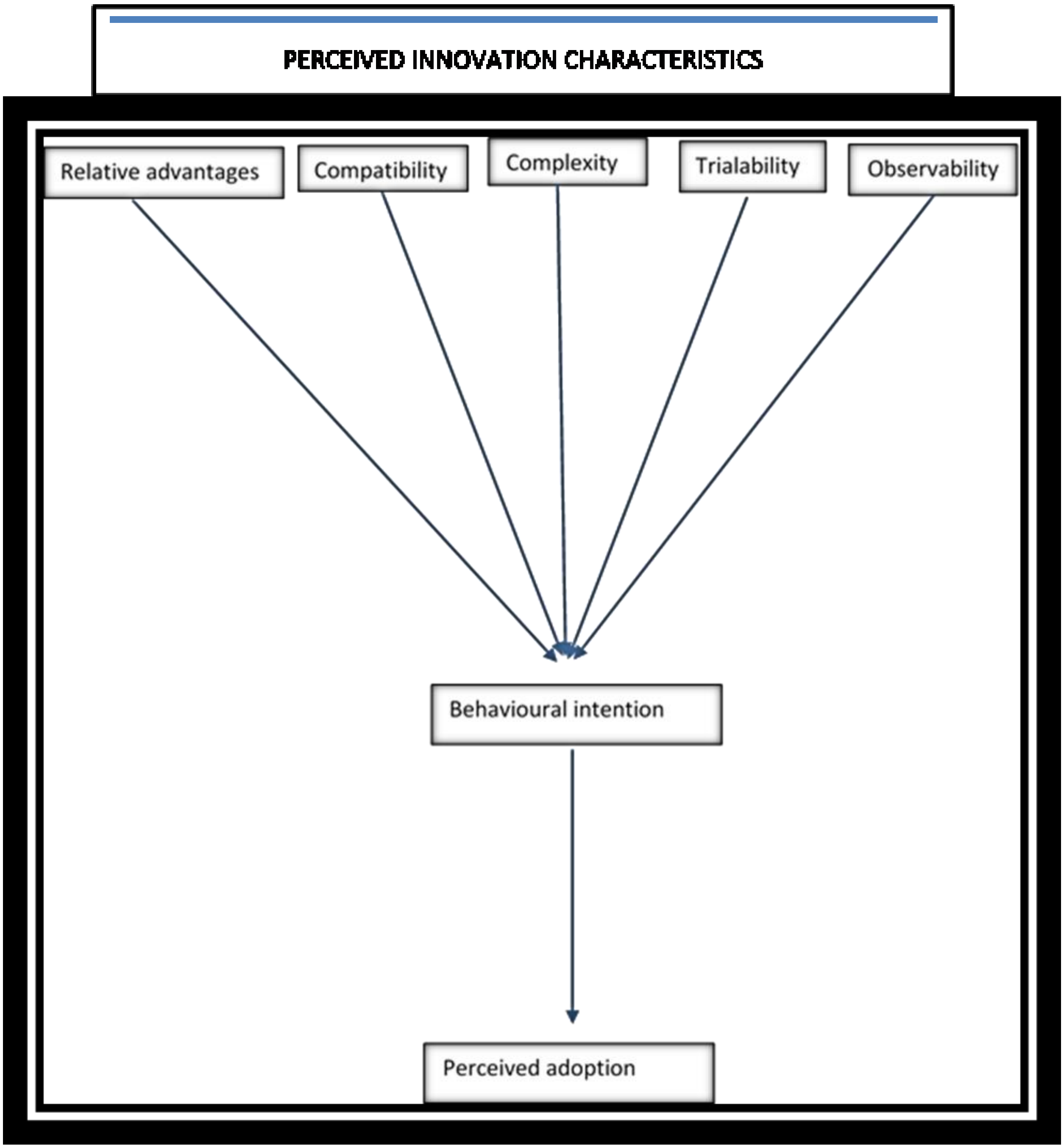
In promoting agricultural technologies, three main models are used to explain the decision to adopt new technology. As stated in Chapter 1 section 1.6, these models are known as the Adopter-perception model, the Innovation-diffusion model and the Economic-constraints model. These are discussed in more detail in section 3.5 of this chapter. Most research on this topic considers farmers' socio-economic characteristics as the main factors affecting adoption behaviour. However, although these factors are essential, they failed to include a farmer's subjective perception of the characteristics of the new innovation (Adesina & Baidu 1995:2). Communication is necessary for the diffusion of an idea, therefore investigating the concept of communicative performance may be helpful (Bahar & Zehra 2008). At a minimum, examining the communicative act must include the communicator, the message, the media, the target individual and the social context in which the message is received as well as the perception of the receiver (Lionberger 1962). When potential adopters consider an innovation, information is communicated to them in order to examine the characteristics of the innovation. Based on these factors, a potential adopter will then decide to accept or reject the innovation (Flight, Allaway, Kim & Souza 2011:110; Moore & Benbasat 1991). According to Lionberger (1962:158), communication alone is not enough: "It is often said that our problem is one of communication– the implication being that a good communications program would provide the answer to problems of promoting change. This isn't always true for example communication certainly may not remove social conditions which serve as barriers to change- particularly if target individuals regard them as essential to their welfare- nor will communication alone provide the physical needs for adoption" (Lionberger 1962:158). Communication is necessary for the diffusion of ideas, but adoption of new practices depends on multiple factors. For Rogers (2003:5), communication is a process whereby members generate and share information with one another in order to reach a common understanding. While it can be argued that communication is necessary, perceptions of potential adopters will however determine the intention whether to accept or reject a new practice.

Drawing from prevailing writings, the Theory of Reasoned Action can provide a foundation for research on adoption behaviour (Neels & Kris 2005:9). The theory is grounded on individuals' action being strongly connected with their view towards that action. People form perceptions by analytically reflecting on any information that they have about the behaviour being considered (Fazio 1990 cited in Parminter & Wilson 2003). Sequentially, perception results from an individual's views about the outcomes of a precise behaviour and their assessment of those views. The more a person anticipates that a specific behaviour will have good consequences for him/

herself, the more that individual will have a positive perception towards that behaviour. Likewise, the more an individual expects a behaviour to have undesirable consequences, the more he or she will have a negative perception towards it. For instance, if individual farmers believe that GM technology has desirable consequences they will form a positive perception towards it and therefore adopt it. People's perceptions influence their behaviour based on the information they receive. This is similar to the Theory of Planned Behaviour in which cognitive self–perception plays an important part in human behaviour. Ajzen and Madden (1986) indicate that a person's perceptions are a good interpreter of their actions. The stronger the perception to perform a particular behaviour, the more likely it is that the person will perform that behaviour. The predictive power of perception to actual behaviour is supported by empirical studies (Mathieson 1999). In essence, a farmer's perception is an effective predictor and explanation of their adoption behaviour.

It can be argued that perceived innovation characteristics play a key role in adoption behaviour. It is particularly imperative to understand that it is a potential adopter's perceptions of these characteristics that influence adoption rather than some expert's assessment of the factors (Rogers 1995:216; Van Slyke, Belanger and Communale 2004:33). Over the past years, ample studies have been focused toward identifying salient perceptions concerning the personality characteristics that influence technology adoption decisions (Yi & Fiedler 2006:394). Rogers (1995) defined the relationship between five perceived attributes of an innovation: compatibility, relative advantage, trial-ability, observability, and complexity. Perceived innovation characteristics lead to behaviour intention and finally, adoption. However, adoption behaviour does not happen all of a sudden, but rather, it passes through some stages before adoption and utilisation of innovations in various organisations, disciplines and socioeconomic classes take place. Figure 3.1 below, illustrates how perceived innovation characteristics lead to adoption behaviour. In the next section attention is paid to the stages of adoption.

Figure 3.1: Perceived innovation characteristics and adoption behaviour



Source: Kawaljeet, Yogesh and Michael (2017)

3.3 **Stages of adoption**

Acceptance of new agriculture technologies takes some time to spread in farming communities. Rogers and Shoemaker (1971), and Rogers and Beal (1957) suggested the following five stages through which an innovation passes before an individual takes it into use:

- The awareness stage: at this point an individual become aware of the innovation. The first requirement for an individual farmer to apply a new technology is to become aware of the presence of the new technology.
- The interest stage: in this phase a person commences gathering evidence about the new technology.
- The evaluation stage: in this phase potential adopter assesses the new technology and decides whether to try it or not.
- The trial stage: at this point an individual takes the new technology into trial or applies it on a smaller scale.
- The adoption stage: in this phase the innovation is taken into frequent full scale use and is given a satisfactory approval by the individual.

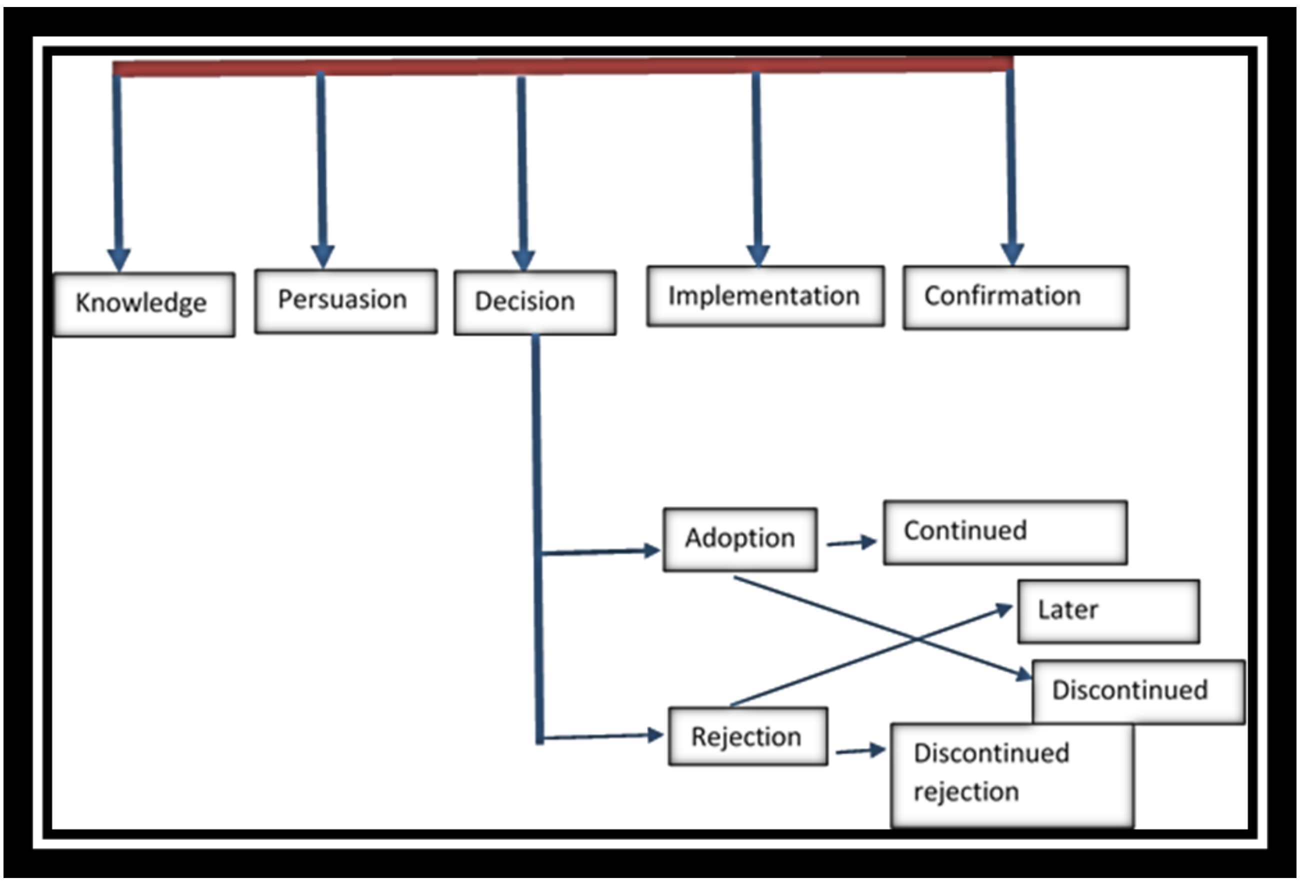
Rogers (1983) however proposed a better-quality model to illustrate the phases of adoption which he called the Innovation-decision Process Model. Innovation-decision process is basically an information-seeking and information-processing activity in which a person is inspired to decrease ambiguity about the merits and demerits of the new technology.

3.4 **The Innovation-decision Process Model**

The innovation-decision process (see Figure 3.2) is a rational procedure through which an individual farmer passes from first getting knowledge of GM technology to form a perception about GM technology and to make a decision to adopt or reject. During this process, an individual engages in multiple ways before adopting a new technology. Before adoption takes place a person is likely to go through some stages before trying a new idea or practice (Rogers 1995; Lionberger 1962; Behar & Zehra 2008). The different stages of the innovation-decision process are the knowledge stage, persuasion stage, decision stage, implementation stage and confirmation stage. These are briefly outlined in sections 3.4.1 to 3.4.5. Figure 3.2 below is a schematic representation of the Innovation-decision Process Model.

Figure 3.2 Innovation decision process

INNOVATION DECISION PROCESS



Source: Ali and Wani (2015)

3.4.1 **Knowledge stage**

The initial phase of an innovation-decision process starts with the knowledge phase (Ismail 2006:16). In this phase individual farmers come to recognise the presence of new agricultural technology. The existence of the new technology becomes known to individuals through communication networks. The individual farmers begin to ask questions about the innovation such as how, what, why and when to use (Ali & Wani 2015:111). Throughout this stage, the farmer tries to decide "what the innovation is and how and why it works" (Rogers 2003:21). The queries posed by a farmer relate to three types of knowledge formation: "Awareness-knowledge: Awareness knowledge represents the knowledge of the innovation's existence. How-to knowledge: The how-to-knowledge, contains information about how to use an innovation correctly. Principles-knowledge: The last knowledge type is principles-knowledge. This knowledge includes the functioning principles describing how and why an innovation works" (Ismail 2006 cited in Ali & Wani 2015:111).

Awareness about a particular innovation might be nearly comprehensive in some areas; such as GM technology in the USA, but may be very low in other areas, like in South Africa and Ghana (Barnerd, Isabel, Roel & Miet 2014). The frequency of awareness about an innovation possibly differs with the kind of innovation, the particular environment, farm size and the characteristics of the farmer. The supply and dissemination of information enhances the type and intensity of information campaigns and extension activities are critical for growing awareness rates. Some farmers may be more enthusiastic to study than others and become more vigorously involved in the quest for information about new farming technologies. Moreover, the expense of searching for valid information might be lower for well-educated and more experienced farmers, and farmers with a larger social network and more capital. On the other hand, it may be very expensive for smallholder farmers and farmers with less capital and smaller networking channels. Diffusion and adoption of new innovations depend on awareness, which is an essential first step in the exploration of technology adoption. Additionally, it is the commencement of the adoption process which determines sustained adoption or rejection. In order for agricultural innovations to flourish, their characteristics should be made known to potential users. Adesina and Zinnah (1993) suggested that information through extension services affected farmers' decisions to adopt a new variety of rice in Sierra Leone. Another example of the adoption is awareness creation through participatory learning programmes that enhanced the adoption of Sawah rice production technology in Nigeria (Fashola et al. 2006). A different example is that from the study of Oladele and Adekoya (2006) who reported that information provided through extension visits helps farmers to sustain the adoption of improved varieties of Downy mildew-resistant varieties of maize and early maturing cowpea varieties in south western Nigeria. Furthermore, disregarding the importance of the awareness stage may result in bias in evaluations of adoption rates, programme impact and the determinants of adoption (Diagne & Demont 2007). For example, particularly when farmers with an advanced prospect of adopting an innovation are more intensively targeted by extension programmes or search more actively for information themselves, adoption rates and it effects may be overvalued and lead to imprudent conclusions. In revisions on the adoption of new rice varieties in Cote d'Ivoire and Ghana, the findings of Diagne and Demont (2007), and Asuming-Brempong et al. (2011) revealed that adoption rates increased strongly when the awareness stage was first completed.

3.4.2 **Persuasion stage**

The persuasion stage follows the knowledge stage. It is in this phase that the ambiguity surrounding the introduction of an innovation may increase or decrease (Ali & Wani 2015:107). Persuasion occurs when an individual farmer forms a positive or negative perception toward the innovation. However, a farmer can only form a perception of an innovation when he is aware of its existence. Information again plays a very significant role as more wisdom and concrete knowledge about innovation is required for farmers to be able to reduce or increase ambiguity. According to Adegbenga and Oladimeji (2008), certain technological information required for GM technology, needs more than mere distribution, due to the attributes of the innovation and the extent to which it interferes with traditional beliefs and characteristics of some people. The degree of difficulty of a new innovation may require knowledgeable individuals and representatives to give a detailed view of the new technology and to also discuss the concerns of the potential adopter. Furthermore, to judge expected returns in order for farmers to reduce uncertainties, farmers require information on the innovation characteristics, such as harvest effects, risk and capital intensity. This is particularly important with regard to GM technology, which is a knowledge-intensive technology. Ambiguity and hazards connected to innovation attributes may reduce farmers' anticipated efficacy, particularly for risk averse farmers. A misleading conversation or erroneous advertising may escalate the levels of ambiguity while a constructive response from close friends, peers or family members will significantly reduce the levels of ambiguity. Sherry (1997) details that individuals usually trust information from close friends and family members about an innovation while they filter the information coming from outside; thus, the persuasion phase is a critical element in the innovation-decision process.

3.4.3 **Decision stage**

A decision occurs when individual farmers are involved in actions that lead to acceptance or rejection of an innovation (Rogers 1983). Whereas the term 'adoption-decision' refers to "full use of an innovation as the best course of action available," a 'rejection-decision' means "not to adopt an innovation" (Rogers 2003 cited in Ali & Wani 2015:111). Rogers expressed the view that it is important for a new technology to be tested first on a smaller scale or in a trial as it then has a greater chance to be considered (in this instance, by farmers) (Ali & Wani 2015:112). During a trial or testing period, farmers depend on their own evidence and experience to choose whether or not the suitability and success of the technology is sufficient to further continue using it. However the acceptance or dismissal may not be sustained and the individual may later change his/her decision. Consequently Rogers (2003) cited in Ali and Wani (2015:112) projected four outcomes of this phase:

- Continued Adoption: an individual discovers a favourable new technology and embraces it permanently.
- Later Adoption: an individual observes that the new technology is favourable and anticipates accepting it in the near future. The delay may be because of monetary or other social issues.
- Discontinuance: an individual approves an innovation but discards it afterwards.

- Continued Rejection: the individual discards the new technology from the outset and continues to do so.

3.4.4 Implementation stage

In this phase the new idea or technology is functional or one can say the new technology is put into use. Up to the implementation phase, the results of the new technology process has been a strictly mental exercise. But implementation comprises obvious behavioural modification, as the new technology is actually put into practice (Rogers 1983). The implementation phase can be a challenging task for the operator. The originality of an innovation and prevailing fears can impede the implementation process of an innovation by the individual. Ambiguity about the consequences of the new idea still can be a problem at this level. Thus, the user may need technical assistance from change agents and others to decrease the degree of ambiguity about the consequences. Moreover, the innovation-decision process will end, since the new technology loses its distinctive quality as the separate identity of the new idea disappears (Rogers 2003). In other words, since the innovation has reached the implementation stage, it loses its originality; thus the innovation is not new to the potential adopter. After the implementation stage, the last stage, the confirmation stage, follows.

3.4.5 Confirmation stage

At this stage the individual confirms his or her decision to receive or reject the new idea, as individual farmer searches for support for his or her decision. Rogers (2003:189) stated that this decision might be reversed if the individual is "exposed to conflicting messages about the innovation". However, individual farmers tend to stay away from these messages and seek supportive messages that approve of his or her choice. Thus, positive perception becomes more vital during this phase. Depending on the supportive information and the perception of the individual, later adoption or discontinuance happens during this phase.

Discontinuance may occur during this phase in two ways: "First, the individual rejects the innovation to adopt a better innovation replacing it. This type of discontinuance decision is called replacement discontinuance. The other type of discontinuance decision is disenchantment discontinuance. In the latter, the individual rejects the innovation because he or she is not satisfied with its performance. Another reason for this type of discontinuance decision may be that the innovation does not meet the needs of the individual. So, it does not provide a perceived relative advantage, which is the first attribute of innovations and affects the rate of adoption" (Ismail 2006:17).

3.5 **Adoption Models**

Table 3.1 below illustrates the three models previously mentioned by Adesina and Zinnah (1993:298): the Innovation-diffusion model, the Economic-constraints model and the Adopter-perception model.

Table 3.1 Mainstream theoretical models on adoption of an agricultural innovation

THEORETICAL MODEL	ASSUMPTION BEHAVIOUR	DECISIVE FACTORS IN ADOPTION
Economic constraints model	Adoption defined by utility maximization behaviour of farmers	-Access to natural resources -Access to capital -Learning/investment cost -Risk
Innovation-diffusion model	Adoption defined by dissemination of information	-Access to information
Adopter-perception model	Adoption defined by the characteristics of the innovation in addition to information in utility maximization	-Access to information -Innovation characteristics; cost, relative advantage, complexity, compatibility

Source: Prager & Posthumus (2010)

3.5.1 Innovation-diffusion model.

The Innovation-diffusion model was developed in 1962 by Rogers (Wani & Ali 2015:103; Omolehin et al. 2007). Innovation-diffusion pays attention to understanding how, why and how frequently new thoughts and innovations are spread in a community (Rogers 1962 cited in Wani & Ali, 2015:103). This model suggests that exposure to evidence related to a specific technology is the chief factor affecting acceptance decisions or spreading innovation in a social system. Access to information sources speed up the acceptance procedure due to the fact that people become aware of the possible profits related to the new technology (Hooks, Napier & Carter 1983:309). Acquisition of information about an innovation enables farmers to familiarise themselves with it as well as with the actual use of innovation. According to Rogers (2003), diffusion is the process whereby new idea is transmitted through certain networks over time among the members of a community. This description identifies the following features: (1) an innovation that symbolises the new idea, preparation or object are being communicated; (2) communication channels which indicate the way information about an innovation moves from the change agents (technology suppliers) to end operators (e.g. farmer); (3) the time period over which a social system adopts a technology; and (4) the social system. 'Social system' denotes to a set of unified elements that share mutual problems and are involved in joint problem solving to accomplish a common goal (Rogers 1983). A social system comprises individuals, an organisation or agency and their adopting plans (Ismail 2006). Belonging to a social group enhances social capital, allowing trust to develop, ideas and information exchange (Robinson 2009). In recent times, an influential body of literature on technology acceptance has concentrated on the effect of social learning on acceptance decisions. The basic concept presented in the literature is the idea that a farmer in a village observes the behaviour of neighbouring farmers, including their experiment with an innovation. Once the year's yield is harvested, the farmer then informs himself/herself concerning the innovation which may increase his possibility of accepting the new technology in the following year. Uaiene et al. (2009) cited in Mudzonga (2010) proposes that community network effects are imperative for individual decisions and that in the particular context of agricultural innovation farmers share information and learn from each other. Studying the effects of community-based organisations in the adoption of new technology in Uganda, Katungi and Akankwasa (2010) found that those farmers who participated most in community-based organisations were more likely to engage in social learning about the technology; hence, raising their likelihood to adopt the technology. Bandiera and Rasul (2002) observed social systems and technology acceptance in Northern Mozambique and established that the likelihood of acceptance is higher amongst farmers who discussed the technology with other farmers.

In addition, Dearing (2009:506) also argues that diffusion occurs through a combination of (a) the need for individuals to decrease personal doubt when presented with a new idea; (b) the requirement for individuals to explain their observations of precisely what reliable sources are thinking and doing; and (c) overall social pressure experienced to do as others have done. Ambiguity is an essential hindrance to the acceptance of new technology (Lia 2017). Ambiguity in answers about new technology leads to a search for information and the potential adopter only considers adoption if he/she believes that the information in question comes from a trustworthy person. Searching for evaluative decisions of trusted and respected opinion leaders or change agents is crucial to overcoming doubt. Moreover, an innovation's outcomes may create insecurity. Access to information decreases doubts about the performance of the new technology and may alter an individual's evaluation from being purely personal to objective over time (Caswell et al. 2011; Bonaban & Wabbi 2002).

However, access to information about agricultural innovation does not automatically mean it will be implemented by all farmers. This suggests that farmers may consider other factors after receiving information about innovation before accepting or rejecting it (Uaiene et al. 2009 cited in Mudzonga 2010). Access to information may result in non-adoption of the technology. Innovation-diffusion model asserts that it is imperative to certify that information on technology given to potential adopters is dependable, constant and truthful. Adopters first need to recognise the beneficial attributes of the technology and its usefulness, for them to adopt it. The notion of dissemination of information about innovations usually refers to the spread of ideas from one place to another (Rogers 1962). The gift of the innovation-diffusion concept is that it respects diffusion as a process that includes collecting information about new technology. This process helps potential users to form positive or negative perceptions towards the innovation in question. It however, ignores individual perceptions on the characteristics of an innovation as well as an individual's economic resources. The Innovation-diffusion model just considers access to information of an innovation as the main factor affecting adoption decisions. Although this factor is important in adoption decisions, the model fails to take into consideration the adopter's subjective assessment of the characteristics of the new technology. Again, the model fails to consider economic resources (capital and land). It is believed that capital and land are prerequisite resources for farming, which is not possible without these resources. This model therefore can be biased when it comes to factors affecting a farmer's decision to adopt new technology.

Furthermore, during the innovation-diffusion process, a farmer goes through a series of choices and actions evaluating a new idea over a period of time and making an informed decision of whether to accept or not. The process a farmer goes through from learning about GM technology to decision making may be described as an innovation-diffusion process in which the final stage is confirmed potential adopters. During each phase of the decision-making process, the individual tries to obtain information from various sources that may reduce the risk and uncertainty associated with GM seeds to help them in making an informed decision. For the purpose of this discussion, the innovation-diffusion process is defined as "an information seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (Rogers 2003:172). The procedure contains a certain amount of uncertainty because the individual has to modify his/her behaviour while deciding to adopt the new alternative to replace the idea that is already in existence and therefore, the innovation-diffusion process was described by Rogers (2003:232) as "an uncertainty reduction process". Rogers (1995 cited in Lia 2017) explains that according to the innovation-diffusion model, the adoption of the innovation occurs after going through several stages. Rogers (1995) called this the S-shaped adoption curve (see Figure 3.3). He labeled individuals and organisations according to different adopter categories: innovators, early adopters, early majority, late majority and laggards.

3.5.1.1 Adopters categorization

Rogers (2003) categorised individuals based on their innovativeness or the extent to which they demonstrate an attraction for a particular new technology in contrast to other members of the community (Figure 3.3). An individual's innovativeness depends on both the individual's involvement with their community and the community in which the individual is an affiliate. Scholars consider that a population can be broken down into five different categories in terms of innovation decisions and their willingness to accept a particular innovation: innovators, early adopters, early majorities, late majorities and laggards (Robinson 2009:4). Each respective cluster has its own characteristics based on its view of a particular innovation. According to Robison (2009:4), "when thinking about these groups, don't imagine it's your job to shift people from one segment to another. It doesn't work that way. It's best to think of the membership of each segment as static. Innovations spread when they evolve to meet the needs of successive segments". For example, some farmers may adopt GM technology earlier while others will wait and see the empirical benefits before adopting it. Thereafter, the adoptions of innovations spread when they change to meet the requirements of successive sectors. The different clusters are described as follows:

Innovators: According to Ali and Wani (2015:105), innovators have a tendency to take risk, they are eager to devote their time and the energy required to learn new idea. Moreover, they often spend more time, energy and imagination on developing new technologies and apparatuses and love to talk about their new idea. They are ready to persist with non-paying and unproductive innovations and a certain level of doubt about the innovation (Ismail 2006:19). Likewise, Rogers (2003) supplemented this concept stating that modernisers are the gatekeepers bringing the new technology in from outside of the community. Unfortunately their one-eyed fixation on a new performance can make them seem dangerous to the practical majority. Yet no change or innovation programme can thrive without their energy and commitment (Robinson 2009).

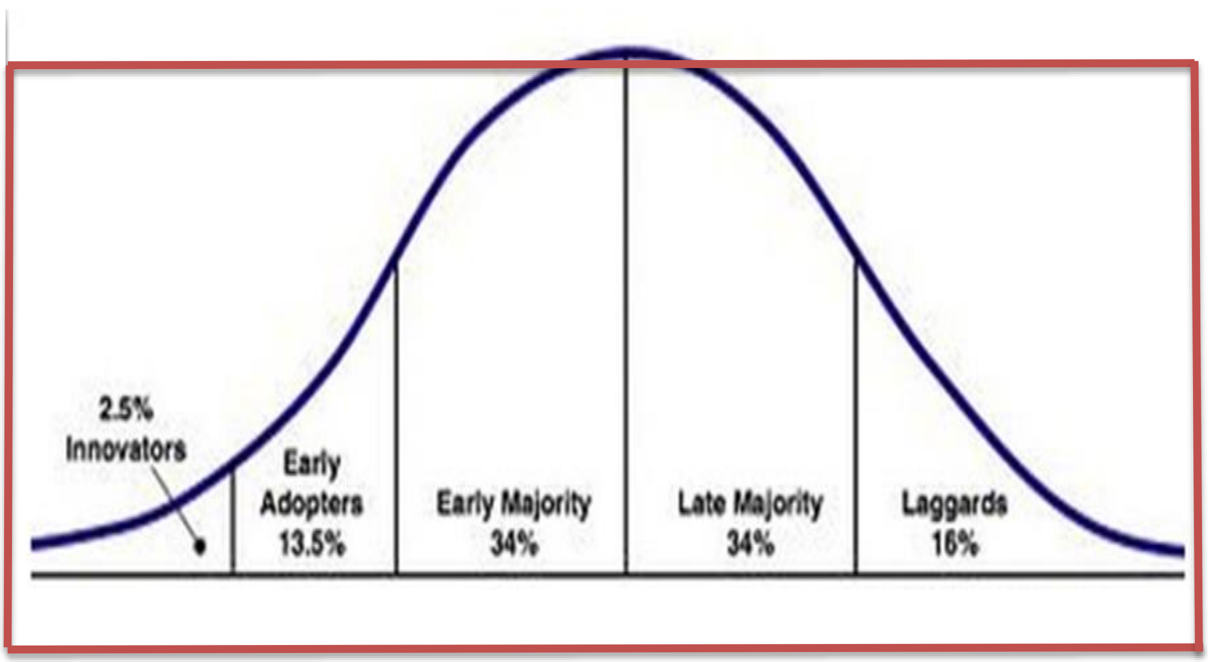
Early adopter: these are the people who adopt or use new technology first within the social system. Once the benefits are identified, these adopters jump in. They are on the vantage point for a strategy to improve their lives or productions and are quick to recognise the connection between ingenious innovations and their personal desires (Robinson 2009). Rogers (2003) contended that since initial adopters are more likely to embrace management roles in the community, other members come to them to get advice or information about the new technology. Early adopters (also known as first adopters) are inclined to be more economically fruitful, well associated and well knowledgeable and henceforth more socially respected. Indeed, leaders play an essential role at almost every step of the innovation-diffusion process, from commencement to enactment; predominantly in organising the funds that carry innovation forward (Light 1998 cited in Ismail 2006:19). Consequently, as protagonist, initial adopters' perceptions toward the new technologies are the most imperative. Their personal assessments about the new technology influence other members of the community through their interpersonal networks. First adopters' acceptance of the innovation decreases doubt about the innovation in the diffusion process. Lastly, "early adopters put their stamp of approval on a new idea by adopting it" (Rogers 2003: 283).

Early majority: According to Robinson (2009:5), "assuming a new product or behaviour leaps the chasm, it may eventually reach majority audiences". Initial majorities are practical people, happy with reasonably open-minded ideas, but won't act without concrete evidence of profits (Robinson 2009:5). This group has the ability to relate to technology but is ultimately motivated by a logic of realism. This means that the early majority are content to delay and see how early adopters benefit. They are watching for simple, unquestionable, improved methods of doing what they already do. They need guaranteed off-the-shelf performance; minimum disruption, commitment of time and learning and either cost neutrality or rapid payback periods

Late majority: These are traditional practical people who dislike risk and are not happy with new ideas. Basically their only driver is the fear of not fitting in; therefore they will follow conventional methods and established social morals. They are frequently motivated by the fears and views of laggards (Robinson 2009). Though they are doubtful about the new technology and its consequences, economic stipulation and peer pressure may lead them to the acceptance of the new technology. To lessen the ambiguity of the innovation, interpersonal networks of close peers should persuade the late majority to adopt it, [then] "the late majority feel that it is safe to adopt" (Rogers 2003:284).

Laggards: According to Rogers (2003), laggards are very old-fashioned and they are even more cynical about new technology and change agents than the late majority. Laggards are the indigenous cluster of the community and their interactive links mainly comprise from the same group in the social system they belong to. According to Kaasinen (2005) cited in Ali and Wani (2015:106), the last to embrace innovations are the laggards, who base their decisions on the past rather than the future. Roger regrets the selection of the term 'laggard' and emphasises that it would be a mistake to imply that laggards would be somehow at fault for being late to adopt. They may resist change because of inadequate resources and the lack of awareness-knowledge of innovations. They are people who see a high risk in adopting a particular new practice. Therefore, laggards have a tendency to wait and see whether the innovation has been productively adopted by other members of the social system and whether it is successful (Ali & Wani 2015). Due to all these features, laggards' innovation-diffusion stage is quite long.

Figure 3.3: Adopters categorization



Source: Ali and Wani (2015)

3.5.2 **Economic-constraints model**

This model has been offered as an alternative explanatory thesis for the innovation-diffusion model and is primarily grounded on the supposition that economic obstacles exist that prevent an innovation-diffusion model from operating effectively (Hooks, Napier & Carter 1983). The Economic constraints model was proposed by Aikens et al. (1975), and asserts that dissemination patterns of resources are the major predictor of adoption behaviour. In other words, land and capital determine adoption decisions. Lack of capital and land will exclude farmers from adopting technologies due to their inability to access the necessary input prerequisites. According to Hook et al. (1983:310), farmers who do not have access to sufficient credit and land cannot adopt the technologies regardless of the perceptions they have of the new technology. Access to loans has been mentioned as motivating technology acceptance (Mohamed & Temu 2008). It is alleged that access to credit encourages the acceptance of uncertain technology through lessening of the liquidity constraints as well as through boosting households risk bearing ability (Simtowe & Zeller 2006). Hypothetical and practical writings have revealed that risk and uncertainty play an imperative vital role in the acceptance of new agricultural technologies (Marra et al. 2003; Mercer 2004). This is specifically true for marginal farmers in Africa, who have to manage risks on an everyday basis to protect their livelihoods. It is therefore important to make access to credit easier for all farmers in order to speed up adoption processes.

The Economic-constraints model accepts that farmers make every effort for profit but resources are unevenly dispersed amongst individuals, consequently shaping the forms of adoption (Adesina & Zinnah 1993; Negatu & Parikh 1999). A farmer's conclusion to approve will be grounded on resources, and the cost and merits related to the technology as economic constraints frequently prevent individuals from acting. A person may have a strong desire to adopt something once he or she is made aware of the advantages of adoption, but be unable to do so due to their economic constraints. A farmer's judgement to accept new technology is however based upon countless procedural, economic and social factors that are related to the technology in terms of prices and profits (Mudzonga 2010). In this model, a farmer accepts GM technology in order to maximize profit. The model is based on the premise that the decision to accept a new technology depends upon its relative performance. It presumes that a farmer uses rational thinking to estimate expenses and profits of adopting the new technology in terms of its material values and that he/she has taken into consideration the actual value of the costs and the benefits which they could have obtained with an alternative choice. Kari and Bauer (2004) argued that the economic potential in terms of harvests, costs and profits of the technology are very imperative elements in adoption decisions.

The strength of the economic-constraints model is that it recognises the significance of profitability and economic factors (land and capital). However, it overlooks the role played by personal perception or inspiration in persuading a farmer to adopt an innovation. Another weakness is that data on innovation is hardly accessible in realism. For example, there is no certainty of the economic effects of the technology, especially in the early phases when the technology is new. Furthermore, technology varies over time and is often linked with high costs. The theory furthermore overlooks the communal effects on a farmer's choice making process and it is presumed that farmers are solitary and sovereign and make decisions based just on their own valuations of the return on the innovation. In reality, however, farmers are influenced by relations, perceptions, social connections and economic and environmental conditions in society as well as the attributes of technology.

3.5.3 Adopter-perception model

Kivlin and Fliegel (1966) proposed a third model known as "Adopter perception" (AP). This model asserts that perceived attributes of technologies condition adoption behaviour. The model assumed that potential adopters embrace or discard a new technology grounded on its technological attributes. According to Klein and Tornatzky (1982), examples of these attributes are: relative advantage, complexity, observability, trail-ability, perceived risk, compatibility, ease of use, usefulness, and cost. As discussed in section 3.2, this study is based on this model to analyse perceptions among small- and large-scale farmers which are vital in influencing the adoption decision. The intent of this research was to obtain respondents' perceptions of and consequent reactions to the adoption of GM technology where the individual adoption decision is voluntary.

A lesson learned from the literature suggested that farmers' perceptions on technology attributes are the key driving forces that induce farmers to adopt or reject such technology. According to Moore and Benbasat (1999:193), assessing prospective adopters' perceptions of new technology has been termed as a classic issue in the innovation literature and is a likely key for understanding diffusion and adoption of technology. Adesina and Zinnah (1993) stated that this concept has now become essential and is present in agricultural economics literature. According to Fliegel and Kivlin (1966), decisions to reject or adopt technology are not based on single technology attributes. There are many attributes associated with technologies that need to be considered during an adoption process. However, the question which emerged is: How do farmers' perceptions of GM technology's attributes condition the adoption of a new technological innovation? Farmers need to be aware of GM technology's attributes and its perceived potential benefits and risks. Rogers (1995) developed a theoretical framework that describes the relationship between perceived innovation characteristics and the adoption of an innovation. The relationship of innovation characteristics to the adoption of an innovation point to the significance of the adopter's perception and its influence on adoption decisions.

Ashby and Sperling (1992) stated that farmers might be subjective in their thinking regarding technology characteristics and this could play a crucial role in technology adoption decisions. Subjective thinking stimulates all kinds of behaviour, including rational decisions (Shari & Dorit 2018), therefore it can be argued that individual subjective thinking influences behaviour. Sarker et al. (2008) cited in Mudzonga (2010:9) posit that adopter perception is the degree to which farmers are expected to embrace particular perceptions concerning the effects of new technology and these personal assessments can be important factors in their decision making. Accordingly, as soon as the prospective consumers are exposed to new technology, they will search for information about the characteristics of this technology. The primary stage in the adopter perception model is the perception of the need to adopt (Mudzonga 2010). Such perception is dependent on the individual features of the prospective adopter, such as education, understanding and human values. Individual access to information regarding new technology is based on education, extension officers, exposure to the media and experience, which may aid in forming positive or negative perceptions towards the new technology, thus conditioning adoption behaviour. An individual's decision to approve new technology is not instantaneous, but follows a process made up of a series of actions and decisions which occur over time. As discussed in section 3.3 (stages of adoption), Sarker et al. (2008) cited in Mudzonga (2010:9) describe "…this process (adoption) as a mental process whereby farmers go through a stage of being aware or acquiring knowledge about a new technology to form a positive or negative perception towards the technology and ultimately decide whether or not to adopt". This study argues that there are various factors influencing this process and these include, amongst others, household factors (socioeconomic and resource based) and economic factors (access to market and credit). However, an individual farmer's perceptions of technology attributes are the most essential factor. For instance, a farmer may have sufficient funds and information about GM technology, yet he/she may decide not to adopt GM technology due to his or her perceptions of the characteristics of the said technology. Prager and Posthumus (2010:3) agree with this notion, saying that the model supports the idea that adoption also depends on personal factors (human values, education and experience) as well as physical factors of land and institutional factors. This is explained in greater detail in the following paragraph.

Adoption or rejection of technology by farmers may depend on their rational decision making based upon their perceptions of the appropriateness of the characteristics of the technologies in question (Adesina & Zinnah 1993:298). According to the AP model, a farmer can be made aware of potential benefits of GM technology (Innovation-diffusion model) and have economic resources (land and capital) which are required inputs for farming (Economic-constraints model), but these however may not be sufficient to explain the adoption decision made by a farmer. The AP model gives recognition to the farmer's need to assess the attributes of the new technology compared to the existing technology. Erz (1985) cited in Posthumus and Prager (2010:4), recognises that there are several level of discrepancies between hearing and acceptance, "…said does not mean it's heard-heard does not mean it's understood-understood does not mean it's agreed–agreed does not mean applied-applied does not mean retained". Individuals hear information about a new innovation and need to have the perception that others in their community support the innovation; and they also need to think they can manage their behaviours to adopt the innovation. A potential adopter needs to evaluate the characteristics of a new technology from his or her own subjective point of view and thinking and decide whether to accept or reject it. The most important aspect in adoption behaviour is that the farmers have to understand and know the characteristics of the new technology.

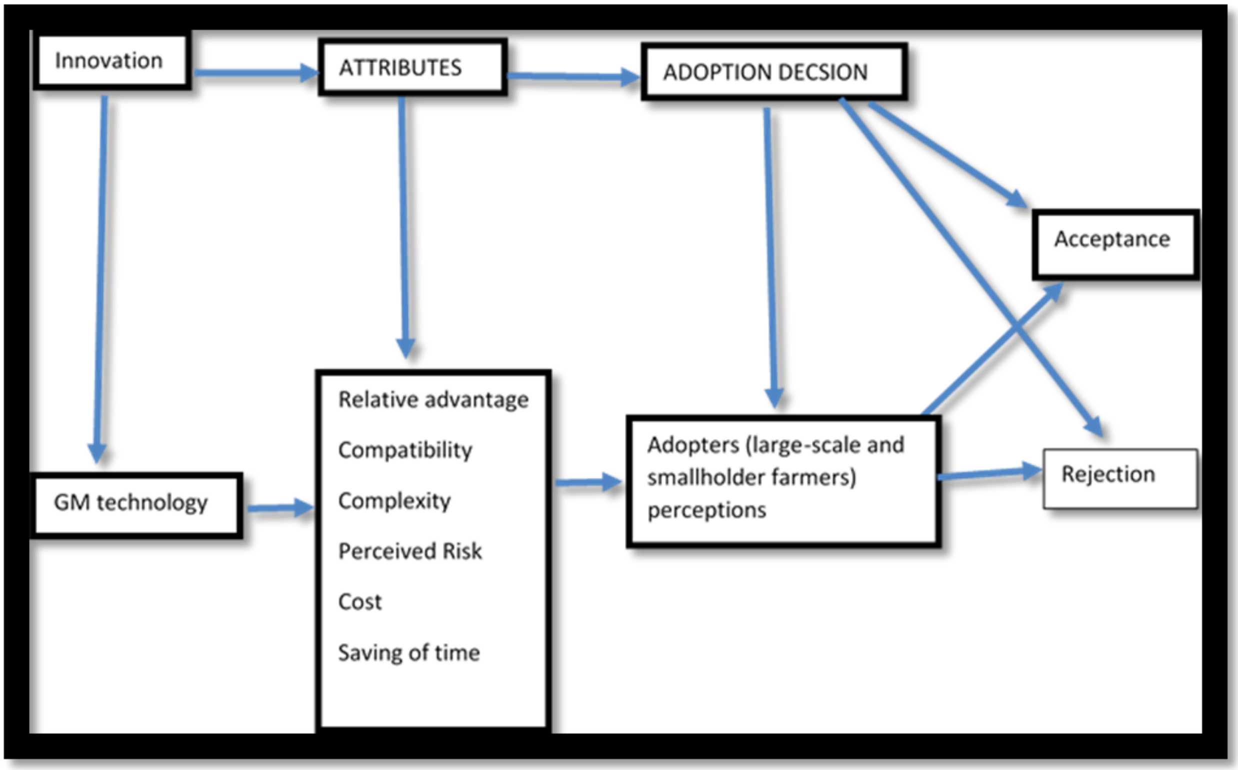
As mentioned in section 1.6 in this study, potential adopters perceive innovation characteristics differently which may lead to varied adoption behaviours. Even if a given innovation's attributes appear attractive and acceptable to others, individuals may not adopt the innovation due to his or her perception. The action of individuals, however, is established by how they perceive GM technology attributes. Because different adopters might perceive these characteristics in different ways, their eventual actions might differ (Moore & Benbasat 1991:194). It can therefore be argued that smallholder and large-scale famers may perceive the attributes of agricultural technology differently, which may result in varied behaviours in GM technology adoption. Take for example, the innovation attribute 'complexity' it is unlikely to have the same kind of relationship to innovation adoption and implementation across a large array of organisations. Likewise, it may not be possible for small-scale and large-scale farmers to have the same relationship with this attribute. An innovation may be perceived as complex for a small-scale famer, but may be straightforward for large-scale farmers to implement. Furthermore, the cost attribute of innovation is evaluated by the potential adopter's financial resources. The innovation cost may seem inexpensive to one, but exorbitant to another, such as the cost of GM seeds. Perceptions are always evaluated in reference to some internalised system of values and the result is a subjective rating of the importance of the relevant attribute (Posthumus & Prager 2010).

Argawal and Prasad (1997) emphasise that innovation that is not used, provides little value and that new technology must be acknowledged and used correctly by its potential user cluster in order to understand projected productivity gains. The perception framework in Innovation-diffusion theory has been expanded and refined to include seven characteristics relating to using an innovation (Moore & Benbasat 1991). In this paper, as stated, the focus is on adopters' (large-scale and small-scale farmers) perception about the characteristics of the GM technology as explanatory and predictive variables for the acceptance and implementation of GM technology adoption behaviour. Many other factors, as discussed in this dissertation have been proposed as having influence on adoption behaviour. However, adopter perception of an innovation deserves consideration for several reasons. Firstly, the construct is a recurring theme in technology adoption models. Secondly, given several attributes it would be valuable to verify whether all the attributes indeed predict adoption behaviour; and finally, considering perception as a contextual variable, it is essential to verify the relationship between large-scale and small-scale farmers' perception, which influences acceptance and rejection behaviour.

The attributes of new technology as perceived by farmers determines whether the farmer may accept or reject it (Ram 1987). It is therefore essential to understand the relationship between perceived GM technology characteristics and adoption decisions. Rogers (2003) identified five characteristics of an innovation that are key influences on adoption behaviour. These characteristics include: trial-ability, compatibility, relative advantage, observability and complexity. In addition, perceived risk of an innovation is also found to be an important element negatively associated with innovation adoption (Keelan, Flanagan, Newman, & Mullins 2009). Further concepts recognised in the literature include cost and saving of time (Fliegel & Kivlin 1966); communicability, divisibility, perceived cost, social approval and profitability (Tornatzky & Klien 1982); perceived usefulness and perceived ease of use (Davis 1986). Among the various characteristics some are viewed as inherently positive which leads to accelerated adoption, whereas other slow down such outcomes. However, Tornatzky and Klein (1982) cited only three innovation characteristics that impact on adoption behaviour: relative advantage, compatibility and complexity.

For the purpose of this study, I have focused on the following innovation characteristics: perceived relative advantage, perceived complexity, perceived compatibility, perceived risk, perceived saving of time and perceived cost (as depicted in Figure 3.4 below) to determine adoption behaviour amongst small-scale and large-scale farmers in Paarl, in Western Cape. These characteristics are discussed in the following sections.

Figure 3.4 Innovation attributes leading to adoption or rejection



Source: Adopted from Lai (2017)

3.5.3.1 **Relative advantage**

Relative advantage determines the degree to which a possible adopter will benefit or profit from the acceptance of a new technology compared to the previous one. The relative advantage of new technology can be in the form of monetary benefit or in the form of cost savings. The costs can be either monetary, such as properties or societal, such as mockery, shunning or exclusion from peer groups (Robinson 2009). The new technology might also deliver better recital at comparatively lesser costs - in other words, 'higher value.' If the innovation delivers a low comparative benefit over prevailing alternatives or, in fact delivers greater comparative disadvantages, then adopters are more likely to reject it. The individual needs to know that a high cost hindrance could cause for example consumer resistance, compared to a low cost advantage. Furthermore, Benbasat and Moore (1991) appealed that this concept, relative advantage, is comparable to the notion of usefulness, in which usefulness is defined as the user's subjective assessment that using a precise technology will increase his or her work performance. Relative advantage in the adoption study, is frequently mentioned as the most important in terms of influencing the rate of adoption (Zhu & He 2002). Relative advantage attributes exist if an innovation offers greater recital relative to the old one. For example, a farmer may adopt GM technology because he or she may be of the view that this new technology performs very well in terms of production compared to the conventional methods. According to Batz et al. (1999:124) a farmer will adopt a new technology if it promises higher utility than the traditional technology. Utility in this context means the gains or benefits a farmer may get from adopting new agricultural technology. An empirical study conducted in Sierra Leone by Adesina and Zinnah (1993) demonstrated that farmer's adoption decisions on modern mangrove rice varieties are based on utility maximisation. Sierra Leon farmers' decision to adopt modern mangrove rice is based on maximizing profit. A farmer practices rational thinking to assess costs and benefits of adopting an innovation in terms of its material values, which could be obtained from an alternative choice. In this case, Sierra Leone farmers compared the old technology with the new innovation and adopted the new one which has given them a relative advantage over the old technology. A similar study was conducted in Brazil to find out why small-scale farmers plant GM crops. In an interview which was conducted, one farmer said this:

"For someone like me planting crops, I am thinking about the profits and the money I will make. The trouble is that we are not thinking ahead for the next 15 or 20 years. I plant and say to myself, this is wrong all wrong ----- this is not right, we are planting something that has been genetically modified"(Almeida et al. 2015).

It can be argued that profit is the main rationale behind adoption of a new technology. As discussed earlier, farmers adopted GM technology because it helped to reduce the cost of pesticides and labour and hence was profitable. This suggests that farmers adopt new technology due to the relative advantage it has over the old technology. However, introduction of an innovation comprises of two stages. In the first stage the new technology is introduced, for example, through demonstration or by giving free seeds to farmers, resulting in the new technology being adopted when found to be more beneficial than the old technology. The second stage is characterised by a decline in the use of an innovation over time, until desertion (Dinar &Yaron 1992). Desertion (discontinued use) of an innovation is a reflection of either loss of profitability due to falling yields; no longer being tolerant to drought; being susceptible to diseases and incompatibility with the type of soil farmers are dealing with. In this case, a farmer may switch back to the old technology or to a more profitable technology.

3.5.3.2 **Complexity**

Complexity is presumed to be negatively linked to innovation acceptance and operation (Agarwal & Prasad 1997). Complexity is the extent to which new technology is perceived as difficult to comprehend and practice. The more difficult a new practice is, the slower the rate of adoption. Research has indicated that perception of complexity conditions adoption behaviour. 'Complex' denotes to perceptions of how difficult an innovation is to practice or understand (Tully, 2015). According to Rogers (2003:257) "Any new idea may be classified on the complex-simplicity continuum". Some innovations are clear in their meaning to possible operators while others are not. New technologies that are easy to understand or use are more likely to be adopted quickly than the difficult ones. Ease of use is similar to the notion of complexity and encapsulates that degree to which a prospective adopter views usage of the innovation to be relatively free of effort. An empirical study conducted in Ghana by Asiedu-Darko (2014:14) demonstrated that new agricultural technologies that are complicated make adoption difficult for non-literate farmers; farmers must understand the new farming techniques before they can adopt and successfully use them. Carpenter and Gianessi (1999) cited in Chimmiri et al. (2006:152) concluded that farmers adopted herbicide-tolerant soy-beans in the late 1990s because of the simplicity and flexibility of Roundup Ready weed control and the notion that conventional management weed system cannot control weeds.

3.5.3.3 **Compatibility**

Compatibility is a complex notion that encourages the perception that an innovation is consistent with the present principles, previous experience and the needs of potential adopters (Roger 2003:240). Compatibility denotes the level to which a possible adopter may perceive an innovation as being consistent with the existing standards, prerequisites and historical practices. According to Fliegel and Kivlin (1962:204), compatibility is important in that if there are no conflicting values between the old and new practices, this may encourage acceptance of the new technology. However, in order for the new technology to be accepted, some elements of the old may need to be perceived as having negative values. Innovations that are perceived as compatible with ethics and opinions are more likely to be adopted than innovations that are perceived as incompatible with these. 'Compatible' describes what the farmers feel or think about the new technology and whether or not they accept the new technology. For example, a farmer will adopt the new technology if he or she feels it is compatible with his or her existing social values and needs. An empirical study conducted in the United States found that incompatibility with existing practices was a barrier to adoption (Rodriguez et al. 2008). A similar empirical compatibility study provided by Tornatzky and Klein (1982) showed that the farming innovation of hybrid sorghum was most compatible for those farmers who had previously adopted hybrid corn. Negatu and Parikh (1999) concluded that non-compatibility of new technology with the farmers' ecological and other resources, constrains its acceptance.

Moreover, Rogers's description of compatibility which quotes uniformity with values or norms, desires and previous practices is generally repeated in other reviews of innovation characteristics research (Ramiller 1994). Tornatzky and Klein (1982) conducted research on innovation characteristics studies and reported that compatibility seems to represents two distinct concepts: consistency with the values and congruence with existing practices. However, Moore and Benbasat (1991:216) departed from Rogers' definition by explaining compatibility as follows:

1. Using (the innovation) is well-matched with all facets of my work.
2. Using (the innovation) is completely well-matched with my present situation.
3. I think using (the innovation) fits well with my work style.
4. Using (the innovation) suits my work style.

A better review of the potential adopter would be more precise about the 'aspects of work' and the elements of the 'situation' that matter (Ramiller 1994:3). Such opinion would underscore that a user who works and makes sense of things in an environment of complex demands and interdependencies, sees the innovation in a broad frame of reference and therefore identifies issues of compatibility across a broad sweep of concerns. For example, a farmer may identify drought in his or her environment as a current situation and may see new GM technology as being compatible to boost production yields since the old technology has lost value because of drought. Roger's definition of compatibility assumes that an innovation is perceived in a specific location and that the connection between the innovation and the other elements in the location influence the adoption and diffusion of the innovation (Ramiller 1994:3).

3.5.3.4 **Cost**

The aspect of cost can be explained as the perceived initial and the recurring expenses of a particular technology. According to Moore and Benbasat (1991), high costs were found to have a negative correlation with the adoption rate when considered with other attributes. In view of many demands on scarce economic resources, perceived expensive innovations would have a lower adoption rate than less expensive innovations (Fliegel & Kivlin 1962:203). Fliegel and Kivlin (1962) further explained that each of the following could delay support and acceptance of modern practices: high initial cost, high operating cost, maintenance cost and a slow rate of recovering of costs through increased earnings. Each of these could deter immediate support and acceptance of modern practices. According to Hall and Khan (2002:3), individuals weigh the benefits of adopting a new technology against the initial cost and ongoing fees, in an environment often characterised by uncertainty. When farmers or consumers are not certain about the future costs and benefits of new technology, it may slow the adoption process, even though they may have positive perception associated with the technology (Smith & Ulu 2012:263).An empirical study carried out in South Africa by Mushunje et al. (2011) suggested that the cost of GM technology may prevent small-scale farmers from adopting it; e.g. if the seeds become too expensive, they cannot afford to use GM technology.

3.5.3.5 **Perceived risk**

Perceived risk is a recognised concept in decision making. For instance, the perception of food security risk influences the behaviour of producers and consumers (Yeung & Morris 2005:172). The perception of risk has consequences for both consumers and producers and the general efficacy and effectiveness of, for example, food supply. Perceived risk associated with producing food needs to be assessed as it is assumed that GM technology has perceived risk attributes. Cellini et al. (2004:1091) point out that it is essential to define the instruments whereby unplanned effects may arise during GM crop cultivation. GM crops are made in a laboratory; hence the technology used may be associated with a risk. Technology hazard is based on two fundamentals: uncertainty and consequences. Perceptions of both uncertainty of an unknown future outcome and the possible loss related to failed technology leads to technology performance risk and slower diffusion (Keelan, Flanagan, Newman, & Mullins 2009). According to Hardaker et al. (1997) cited in Liu (2013:30), "risk is imperfect knowledge where the probabilities of the possible outcomes are known, and uncertainty exists when these probabilities are unknown." When farmers need to make an adoption decision, they do not have perfect information on the risk of GM technology, and therefore, uncertainty is a key factor in their technology adoption decision.

Modern Decision Risk theory has to do with the amount of uncertainty in a given circumstance. On the other hand, uncertainty is a state of mind in which the individual perceives alternative outcomes to a particular action. According to Roumasset (1979) there appears to be no agreement on how risk should be measured. The distinction between risk and uncertainty has focused primarily on the objective versus subjective probabilities. Subjective and objective probabilities are distinguished by assumptions about prior information. Anderson et al. (in Barry, 1984) argue that all likelihoods are personal because the decision-maker must personally evaluate whether any objective data are appropriate for their decision situation.

The outcomes of decisions are often not known with certainty until long after they have occurred. It is therefore difficult to predict outcomes with any measure of certainty. Risk is that uncertainty which affects the welfare of individuals, and is often associated with adversity and loss. Risky decisions happen when at least some of the consequences are not known (Barry, 1984). Typically, this uncertainty arises because of the interval between the decision point and the outcome. It can be reasoned that the perceptions of uncertainty of an unknown unintended future outcome associated with GM technology leads to perceived GM technology risk which slows its adoption. This situation has created a culture of fear- some farmers are afraid to accept GM technology because of the perceived risk.

Risk is not a phenomenon that is unique to the agricultural segment of the economy. Nevertheless, the agricultural zone is confronted with a mixture of risk variables that are very infrequently found in the same blend in any other sector. Barry et al. (2000) argued that business risk for farmers include: manufacture and crop risk; market and price risk; losses from severe casualties and disasters; and risk of technological change. It is correct that some of these risks are insurable, even though at a high price; nonetheless, there are other risk variables that are not insurable. The impacts of some of these risk variables are readily recognisable (e.g. flood and fire damage), although the impact of others is only noticeable over the short to medium term (e.g. drought). It is even true that the effect of some other risk variables will only be visible over the medium to long term (variations in buyer favourites and knowledge). Dealing with all these types of risks systematically, whether for farmers, researchers or policy makers, is difficult (Huirne & Hardaker 2000). There are two principal reasons why risk investigation matters in agriculture. First, most people are risk averse. An individual who is risk averse will be willing to sacrifice some predictable return for a reduction in risk. Risk in agriculture is of some importance to society as a whole. Risk aversion can be thought of as a sort of tension preventing the sufficient allocation of farm resources. For example risk averse farmers may be slow in adopting GM technology. Such risk-induced tension means that the aggregate farm output is less than it would be if there has been less risk. Attitudes towards risk vary, contingent on the individual's purposes and monetary resources (Boehlje & Eidman 1984).

Although perceived risk is not among Roger's innovative five features, risk has been shown in a number of studies to be strongly negatively related to the rate of adoption and diffusion (Winter 2011). The study of perceived risk related to food security can begin with documentation of food hazards. According to Ruth and Morris (2001) a hazard is an occurrence related to an action or procedure which can result in negative consequences and is therefore a sources of risk to the recipient population or environment. Hazards linked with the consumption of food can be categorised into sources of risk: microbiological, chemical and technological hazards. Technological hazards refer to the possible negative consequences of technological advancements in food products such as genetically modified (GM) food (Ruth & Morris 2001: 173).

Over-all, technology has contributed to food safety and greater food obtainability. Nevertheless genetically modified (GM) foods have become one of the major food safety concerns following the publication of a contentious study demonstrating the likely health problems in rats fed with gene-altered potatoes (Ross, Santos & Capon 2010). Some experts claim that there is inadequate indication to evaluate the risks to public health and the environment of GM foods (Jacob 1999). Concerns have been raised that the present method of using targeted analyses to compare the composition of GM crops to their old-style counterpart is biased and does not take into account the likelihood of unintentional and unanticipated effect that could result directly or indirectly from GM technology (Cellini et al. 2004:1090). The probable incidence of unplanned effects is one of the major worries being raised concerning the application of recombinant DNA techniques in the manufacturing of foods. Perceptions of unintended and unexpected risks and the potential loss associated with failed technology lead to innovation risk and slower diffusion. As noted in Chapters 1 and 2, perceived risk is assumed to be negatively related to the adoption of GM technology. Perceived risk has emerged as a major concern of GM technology acceptance. Hall (2007) observed that the fear of perceived risk has made some farmers rejected GM technology in Scotland. According to Negatu and Parikh (1999) risk-averse small-scale farmers' perceptions of risk constrains them from adopting new agricultural technologies.

3.5.3.6 **Saving of time**

Saving of time is an attribute of innovation. According to Ratz (1995), saving of time is non-economic attribute of agriculture technology. Farmers may adopt new technology that may help to grow crops at a faster rate. Due to population growth and higher demand of food farmers will adopt technology that has features of faster growth in order to save time. According to Fliegel and Kivlin (1966) farmers are more willing to adopt technology that may help to mature their crops at a faster rate. GM technology offers a time-saving method for producing larger, higher-quality crops with less effort as compare to conventional method of farming (www.learn.genetics.utah.edu)

3.6 Conclusion

An individual farmer's adoption behaviour involves a complex procedure. Farmers go through some stages before adopting or not adopting new agricultural practices. There are three models used to clarify the factors and behaviours of farmers when adopting a new agricultural technology. These are the Innovation-diffusion model, the Economic constraints model and the Adopter-perception model. The Innovation-diffusion model suggests that exposure to information associated with innovation is the main factor affecting adoption decisions. The Economic constraint model which offers an alternative explanation, asserts that distribution patterns of resources are the major predictor of adoption behaviour. The Adopter perception model, on which this study is based, assumes that while the potential adopter may have economic resources (capital and land) and have information about an innovation, yet these things are not enough to ensure adoption behaviour. Adopter perception suggests that a potential adopter may reject or accept new technology based on specific technological attributes or characteristics.

The research methodology used in the study is discussed in the next chapter.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

This chapter focuses on the research methodology, describes the case study area and discusses the research paradigm as well as the methodology used to analyse the perceptions among small-scale and large-scale farmers of the adoption of GM technology in Paarl, South Africa. It explains how the research methodology was followed and addresses issues such as the representativeness of the sample, the validity and the reliability of the method used in the study as well as the problems encountered and how they were solved. The chapter begins by giving a brief outline of the case study area followed by a discussion of the research paradigm and methodological perspectives that informed the choices of the research method. This is in turn followed by a discussion of the study population, sampling and data collection techniques. Attention is also paid to ethical considerations; and issues of validity, reliability, limitations and challenges.

4.2 Case study area

The overall research aim was to document perceptions among farmers as to the adoption of GM technology. The case study as a qualitative research design is a suitable instrument to conduct the study as it delivers an opportunity to the researcher of gaining a close understanding of a person's conditions, views and surroundings. A case study typically combines qualitative data collection means such as interviews, questionnaires, focus group discussion (FGDs) and observation (Eisenhardt 1989:534). In other words, a case study is qualitative in nature. According to Gerring (2004:341), a case study is a rigorous study of a particular element with the intention of generalizing across a larger set of components. Also Polite and Beck (2003:259) concur that case studies are detailed studies of a distinct object or small numbers of objects. The objects may be a person, family, groups, institutions or public. A study of this nature can be used to accomplish various aims: to deliver explanation, test model or create model (Gerring 2004).

Case study not only enriches philosophy but also the researcher. By piloting a study in the field and being wide-opened to actual glitches, the perceptions of the farmers that influence GM technology adoption at all levels in the community can be known. However, there are difficulties in piloting case study research: it takes a lot of time, it demands experienced interviewers, and care is required in drawing generalizable conclusion from limited data. In spite of this, the consequences of case study research could have high impact. Unimpeded by the inflexible limits of questionnaires and models, it may well lead to fresh and imaginative visions, as well as growth of fresh concept, and achieve high validity as far as practitioners are concerned (Gerring 2004). Furthermore, according to Yin (2003) a case study strategy should be well-thought-out when

a) the attention of the research is to reply" how" "what" and "why" interrogations

b) the researcher cannot influence the actions of those involved in the study

c) the researcher wants to cover contextual situations because he or she believes they are significant to the marvel under study, and

d) the borders between the marvel and the setting are not vivid.

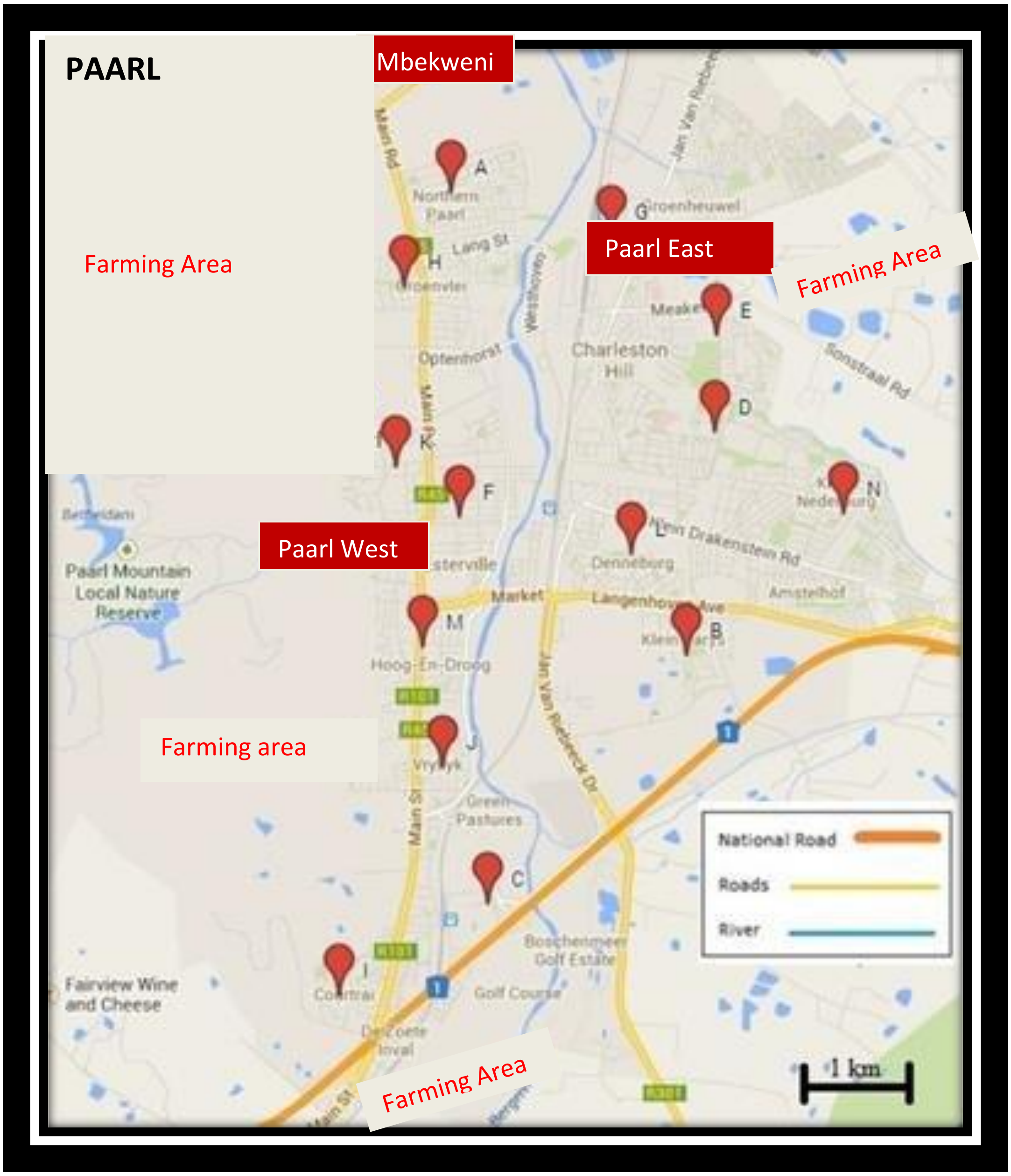
For instance, this study sought to analyse perceptions among farmers on the adoption of GM technology. A case study was selected because the case comprised the perceptions among farmers that impact their pronouncement to accept or discard GM technology. But the case could not be considered without its context. In this study the Paarl farming community is the context of the study. It is in this setting that perceptions are developed and accepted. Furthermore, the case study is defined by Perry (1998:786) as "a contemporary phenomenon within its real-life context". In this study the context of the bounded system is of a geographical nature. The farmers in the geographical area of Paarl constitute the bounded system and this study seeks to investigate their perceptions that influence their decisions. In this research the investigator attempted to understand the perceptions of farmers selected from within the said farming community on adoption of GM technology. The researcher established an intimate relationship with a selected group of farmers who narrated a unique story showing how their perceptions affected their adoption of GM technology negatively or positively.

Paarl is located 60 km North-west of Cape Town in the Berg River Valley alongside the N1 highway and main railway line, which leads through the town itself (see Map 4.1). The town was founded in 1687 just 35years after the arrival of the first Dutch settlers in South Africa. It is the third oldest town in the Republic of South Africa and the biggest town in the Cape Winelands. Paarl connects to the metropolitan area of Cape Town through railway and road connections and is positioned 25km from the nearest international airport and harbour. These features make the town a perfect place for the establishment of export and other industries. The farming, wine industry, cultural-historical museums, old buildings, natural environment resources and outdoor activities also make it a popular tourist attraction. The town covers an area of 67 000 ha (including the Parl mountain nature reserve of 2895 ha). Paarl is one of the five towns that fall under the Drakenstein municipality, the other four being Saron, Gouda, Hermon and Wellington.

The area is divided into four areas by natural boundaries (see Map 4.1); the industrial area is situated all along the Berg River which runs down the length and through the middle. To the North of the industrial region is an area called Mbekweni. To the west and east of the industrial area are the other two areas: Paarl-West and Paarl–East. Each of these areas accommodates a community with unique characteristics. In 1996 the Paarl district housed a total population of 153 321 inhabitants. Since then the population of Paarl district had grown to 197 735 in 2011(www.citypopulation.de). According to the Department of Social Development, the population of Paarl is about 273 066 in 2018 and is expected to increase to 286 563 in 2023 (Western Cape Government 2017).

The total population of Mbekweni was 27 214 in 2011 people of whom 48 percent are male and 52 percent female. The dominant population group in this area is black/African while the common language is Xhosa (96%). More than 50 percent of the households in Mbekweni are informal dwellings (shacks). In terms of population, Paarl-East is the most densely populated area (approximately 55 000); it is three times the size of Paarl–West and about twice that of Mbekweni. The population speaks mostly Afrikaans (92%) and belongs to the coloured population group. Coloured refers to people of mixed descent (Erasmus & Mans 2005)

Map 4.1: Geographical mapping of Paarl community and farming areas



Source: Google map of Paarl (2020)

4.3 Agriculture and farming community

Agriculture plays a most essential role in the Paarl community. The importance of agriculture depends on its ability to make substantial contributions to economic growth through earning foreign exchange, job creation and assisting with poverty alleviation. In addition, agriculture helps ensure food security. Paarl is a major area for the production of grapes; however, vegetables such as, onions, tomatoes and potatoes are also significant crops. Paarl agricultural produce is different from that of areas in other provinces due to its winter and summer rainfall.

According to Cape Winelands District (2010), the climatic circumstances, arrangement of agricultural output and the export orientation of the sector not only defined the agricultural sector in Paarl but also have important implications for the needs of small and emerging farmers as they attempt to develop a sustainable farming system. The main feature of Paarl's farming is production constancy, grounded on steady and comparatively satisfactory winter precipitation and reinforced by well-developed infrastructure for both input and out-supply. However, recently the Paarl district has been undergoing a life-threatening drought which is extremely impacting on farming activities. Little wintertime rain over the years together with high temperatures and evaporation have caused extremely low dam levels in the area. Additionally, quick urbanization, population growth and increasing numbers of economic activities are placing much gravity on the inadequate water resources.

The area has a Mediterranean climate. Temperatures on average range between 18^0 C and 34^0 C in February and 6^0 C and 20^0 C in July. In addition, Paarl receives about 657mm of rainfall per annum (Grobler, Belcher & Barrow 2016:8). These climate conditions play a determining role in the types of crops that are produced (Plessis 2003). Within the area, the climate and the soil fluctuate to a vast extent. Crops are therefore produced to suit these different conditions (Taylor 2009). Climate-related disasters pose substantial challenges to the agricultural sector. Summers are very dry and the rate of evaporation is high. The average summer temperatures are extremely high; heat waves occur regularly (Taylor 2009).

Cultivation of crops on dry land is excluded except for wine grapes and olives (Grobler, Belcher & Barrow 2016). The moderate wind temperature excludes the production of deciduous fruit with high cold resistance. In the summer the evaporation rate may reach extremely high values that will put crops under severe stress if the moisture status of the soil is low (Plessis 2003). In the winter the situation could occur where crops might be drenched because of the weak drainage of the soil (Taylor 2009). The reason for this is that most of the rainfall occurs between May and August. High summer temperatures above 34 degrees can be found for a couple of days in January and February. These high temperatures are unfavourable for the production of premium wine cultivars (Grobler, Belcher & Barrow 2016).

4.4 **Research paradigm**

There are many ways in which human beings approach problems and seek answers. Social scientists have come up with several research paradigms for understanding social behaviours. Lincoln and Denzin (2000: 157) defined a research paradigm as a basic set of believes that guide action or the researcher's worldview. However, our assumptions, interests and purpose shape which paradigm we select (Taylor & Bogdan 1984:1). Because there are diverse research models, the problem was to choose the most suitable one for this research. The pursuit for an impartial method led to the learning of numerous research paradigms which comprises of the positivist, the functionalist and phenomenological ones as the important models for observations and reasoning since research is about producing understanding of "why or how things work or should work" (Punch 2009: 2). The three paradigms have provided a helpful understanding into the numerous paradigms appropriate to this study and afforded an opportunity to equate and select the accurate model relevant to the particular topic.

4.4.1 **Positivist paradigm**

Positivism appeared as a logical model in the 19th century with Auguste Comte's dismissal of metaphysics and his declaration that only scientific knowledge can disclose the truth about reality. Comte was worried about the truth that explanations of human intellectual and social life were weakening in the pre-scientific era, when biology, chemistry and physics all, as he argued, had already arrived at the scientific stage (Hasan 2003). He was of the belief that the social sciences should also focus on scientific rules rather than observation, and for that he sought to build an approach grounded on truths rather than suppositions (Craig 1998 cited in Kim 2003).

This was later documented as the leading scientific process in the initial part of the 20th century by members of the Vienna Circle. The Circle pursued to build a 'unified scientific world-conception' that rejected the use of viewpoint as a ways of studying about the true nature of reality. However, it botched as a rational idea of science because of a serious discrepancy between its philosophy of 'reality' and its theory of 'knowledge' (Kaboub 2008). Positivism accepted David Hume's model of the nature of reality (i.e., philosophical ontology). Hume assumed that reality comprises of atomistic (micro-level) and independent events. He believed that metaphysical and rational thinking could lead us to 'see' non-existing relations between events happening concurrently.

The positivist paradigm states that actual actions can be witnessed empirically and described by means of rational analysis. Positivist study method emphasizes micro-level experimentation in a laboratory-like environment that removes the difficulty of the external world (e.g. societal, mental, and economic linkages). Policies are then recommended grounded on assumptions resulting from the "scientific method" (e.g. skill training for the jobless, antidepressants for the suicidal, and jail time for the criminal). Positivism exercised an imperative effect on scientific practice in the social sciences for decades in the early 20th century. This was particularly correct in the natural sciences where laboratory experiments are able to closely approximate the real world surroundings, therefore permitting for precise forecasts. In the social sciences, nevertheless, human wish and doubt make the laboratory experiment less reliable. Eventually, its interior discrepancy caused the rejection of positivism in favour of scientific approaches, which are grounded on the trust that no one method is ever adequate for emerging a valid understanding of a phenomenon. The application of critical judgment in investigating multiple research questions using multiple measures, samples, designs, and analyses is necessary to permit researchers to converge on a valid understanding of a phenomenon.

4.4.2 **Functionalist paradigm**

Functionalism, which can be called social systems philosophy, was presented by Comte (1798-1857) and Spencer (1820-1903). Functionalist theory is grounded on the concept that community is a steady, arranged scheme with interconnected portions that serves precise purposes. Community is observed by functionalists as a structure of interrelated parts in which the various parts perform a role for the general welfare of the whole community. According to functionalists, the household is a small community – every associate of the household plays a role to enable the household to function well (Turner & Maryanski 1979 cited in Sato 2011). Babbie (2010:38) explains the functionalists' concept by equating the operative of the community to the human body or automobile; asserting that in the human body for example "each component – the heart, lungs, kidneys, skin, and the brain has a specific work to do. The body as a whole cannot survive unless each of these parts does its work, and none of the parts can survive except as a part of the whole body." Employing the similarity of the automobile, Babbie (2010:38-39) again compares the functioning of the society to an automobile where the "tires, the steering wheel, the gas tank, the spark plugs... each of the parts serve a function for the whole; taken together, the system can get us across town."

Furthermore, the term 'functionalism is explained by Holmwood (2000) as follows: "A central methodological principle of the early twentieth-century was that social actions are not to be explained by the immediate meanings they have for individual actors. They are to be explained by the function they serve for wider social groups". For instance, anthropologists had long observed the annual rain dance of the Hopi tribe in North America. From the viewpoint of Western knowledge, the behaviour appeared irrational but look at in another way, it came to be known that, although the rain dances served no instrumental purpose, they were expressive activities helping to uphold unity among the group; the purpose of the rain dance was to produce unity in the tribe. Functionalism thus sought to understand human behaviours in terms of the universal functional requirements of societies.

It can be argued that the central notion of the positivist model is reductionism which is an effort to comprehend the working of the entire society through an analysis of its individual parts. By its feature this method offers a mechanistic clue to understanding human activities. Additionally, the positivist model structures the kinds of questions probed by the researcher; thereby not giving enough room for the participants to express their feelings. Positivism searches for the truths or sources of societal occurrences apart from the personal conditions of individuals. According to Durkheim (1938:14), cited in (Taylor & Bogdan 1984:1), social facts or social phenomena should be considered as a 'thing' that exercises an external influence on people. Positivism seeks answers from external factors but not the subjective thinking of an individual. Meanwhile, functionalism proposes that the overall system relies upon each function; it is the independency and interaction among structures that determine the extent to which a system meets its stated needs. This paradigm studies human behaviour from the perspectives of social solidarity or collective conscience.

In the light of the above assertions, this research study has subscribed to the phenomenological paradigm so as to analyse and bring about an understanding of farmers' perceptions that influence their decision to accept or reject GM technology. In the section that follows, the phenomenological research paradigm will be addressed.

4.4.3 **Phenomenological paradigm**

The phenomenological movement was introduced by Husserl (1859-1838), who overruled the notion that entities in the outside biosphere occur freely and that the evidence about such entities are dependable. He argued that individuals can be assured or convinced about how things appear in or present themselves in their consciousness. To attain conviction, everything outside instant understanding must be overlooked; in this technique the outside ecosphere is abridged to the matters of personal perception (Groenewald 2004). "At the core of phenomenology the intent is to understand phenomena in their own terms - to provide a description of human experience as it is experienced by the person herself" (Bentz & Shapiro 1998 cited in Groenewald 2004). In other words, phenomenologists argue that, in order for a researcher to understand the participant, he or she has to study the unique experiences of the people being studied. By doing so, this allows the perceptions of the people to emerge. As mentioned in section 3.2 perception can be thought of as consisting of variables that influence behaviour and decision making. It can be argued that perceptions direct intentions to accept or reject an object.

Moreover, Husserl came up with descriptive phenomenology whereby everyday experiences and perceptions of the researcher were set aside or bracketed to prevent preconceived opinions (Reiners 2012). We have to see outside the details of everyday life to the essence underlying them. To ensure this Husserl encouraged mankind to 'put the world in brackets' or free ourselves from our normal habits of observing the ecosphere. He believed that it is significant for investigators to deny their experiences associated with the phenomena under study; hence the researcher has to describe the phenomena from the contributor's perspective in order to avoid bias. Reiners (2012) indicated that descriptive phenomenology is applied once the investigator wants to describe the phenomena under study while putting his or her biases into brackets. The approach of bracketing is an attempt to bring impartiality to a phenomenological technique of research. Bracketing is the postponement of all biases and principles regarding the phenomenon being researched prior to collecting data about it (Dowling 2004). According to Dowling (2004) descriptive phenomenology, directed by the work of Husserl, aims to achieve ultimate knowledge of the phenomena under study.

However, Martin Heidegger (1889-1976), Husserl's student, disallowed the concept of knowledge known as epistemology, and embraced the concept of ontology. Heidegger deliberated that the first attention on the philosophy was the nature of presence (ontology), whereas Husserl's emphasis was on the nature of knowledge (epistemology) (Cohen & Omery 1994 cited in Dowling 2004). Heidegger established explanatory phenomenology by lengthening hermeneutics, the beliefs of interpretation: expanding hermeneutics by learning the theory of being in the world rather than knowing the world. Hermeneutics moves away from the explanation of the experience and pursues connotations that are surrounded by ordinary incidences. Heidegger, who was involved in interpreting and describing human experience, assumed that bracketing was not necessary because hermeneutics assumed previous understanding of the experience(s). He eventually placed emphases on the 'principle of awareness' as the distinct means to all forms of realism (Kafle 2011:185). As elucidated by Wilberg (2006) 'the awareness principle' is the only promising philosophy of all. Heidegger believed that it was impossible to refute our involvements connected to the marvel under study, for he understood personal awareness was intrinsic to phenomenological study. He declared that human presence is a more important notion than human cognizance and human understanding. His viewpoint makes it clear that the essence of human understanding is hermeneutic: that is, our understanding of the normal world is resulting from our explanation of it.

Husserl's philosophical phenomenology provided a point of exit for Alfred Schultz towards the customs in which normal members of community attend their daily lives (Gubrium & Holstein 2000: 488-489). The origin of meaning to Schultz emerges in the stream of the cognizance: fundamentally an unbroken stream of lived involvements which have no significance on their own. An individual can only assign connotation to them on second thoughts by the process of turning back on oneself and observing what has been going on. Linguistic is the dominant mediocre for communicating meaning and as such delivers a procedural orientation for a phenomenology of societal life that is anxious with the connections between language use and the objects of experience. The significance of a word is taken to be what it references, corresponds with, or stands for in the real world. This is grounded on the principle that the vital duty of language is to deliver information and describe 'reality'. It is also presumed that there is an amount of harmony in that others experience the world in fundamentally the same way, intersubjectively sharing the same meaning. The rudimentary supposition is that an individual's life is a socially constructed totality in which experiences interconnect logically and meaningfully (Babbie 2001). Phenomenological methods are grounded on a model of individual awareness and bias and underlined the prominence of personal perspectives and explanation (Lester 1999:1). Phenomenology has become a powerful tool for accepting personal experience, gaining understandings into people's perceptions, motives and movements and wounding through the clutter of assumptions that are taken for granted, as well as conventional wisdom. With regard to the process of enquiry, the phenomenologist has only one legitimate source of data: the views and experiences of the participants themselves. The investigation usually involves long in-depth interviews with subjects; sometimes researchers will interview the same subject several times to obtain a full picture of their experience with the phenomenon. This in itself assumes that the participant's view is taken as 'fact'. Furthermore, participants are selected only if they have lived the experience under study. Sampling is therefore purposive and prescribed from the start, while the main instrument of data collection is the interview.

According to phenomenologists, the fact that individuals are endlessly building, emerging and altering the daily understandings of their worlds, should be taken into account in any conceptions of social research. The phenomenologist observed human actions, whatever individuals say and do, as an outcome of how people define their world (Taylor & Bog 1984). The phenomenologist argues that people describe their life as it makes sense to them. According to Babbie (2001:282) phenomenologists perceive the necessity to "make sense" out of the informants' perceptions of the world. Phenomenologists place significance on the collective meanings people ascribe to the world around them. It can be argued that phenomenologists' concepts rest on some elementary ideologies. The first is that people act towards things, including adoption of GM technology, on the basis of the meanings attached to the adoption of GM technology and what it holds for them. Hence, individuals do not just reply to incentives or act out cultural scripts. It is the meaning that determines actions.

The second principle is that meanings are socially constructed through interactions. "The meaning of a thing for a person grows out of the ways in which other persons act toward the person with regard to the thing" (Blumer 1969 cited in Taylor & Bogdan 1984). People learn the world from other people. In this case, some farmers might well adopt or reject GM technology as a result of their interactions with other farmers who have used GM seeds previously.

The fundamental premise of the phenomenologist according to Schultz is that public actors assign meanings to conditions, things, others and themselves through a process of clarification (Gubrium & Holstein 2000). The said procedure acts as an arbitrator between meanings or tendencies to behave in some way and the action itself. Persons are continuously deducing and describing things as they move through diverse circumstances. This explains why individuals act and say different things. One reason is that individuals have had different experiences and have learned various social meanings. For example, some farmers may adopt GM technology while others may not. Another reason why people act differently is that they find themselves in different situations. If we want to understand why some farmers adopt GM technology and others do not, we have to look at the situations they confront.

From the phenomenologist's viewpoint, all groups, philosophies and organizations consist of performers who are involved in a continuous method of deducing the world around them. Even though individual may act within the structure of an organization, culture or group, it is their understandings and descriptions of the condition that determine actions; not their standards, morals, characters or objectives. An interpretive approach is part of phenomenological research where people are assumed to mold their own realism of the world in different settings through contacts with others; in this model the researcher has no direct contact with the real world (Khan 2014). People observe the world differently because of their own experiences and perceptions in varying contexts (Khan 2014:299). This explanation is also applicable to understanding perceptions among farmers as to the adoption of GM technology. Within the farming communities not all farmers may accept this technology even though it is associated with high productivity, as mentioned in chapter two. This may happen due to the fact that each individual farmer may have different perceptions and experiences of the said technology.

The researcher chose the phenomenological paradigm as it is predominantly active in conveying to the forefront the knowledge and insights of people from their own viewpoints and consequently stimulating structural or normative assumptions. The test for an investigator is to let the voices of participants emerge genuinely in coming to an understanding of what fundamentally the research respondents mean in their personal accounts expressed through the data collection devices. In this study the phenomenon that the researcher was interested in studying was 'perceptions among farmers that influence their decision to accept or reject GM technology'. Of course, the phenomenon could be something else like land reform policy or any other topic. In this case the researcher interviewed individual farmers to gather their perceptions on GM technology to determine how their perceptions influence their decisions to accept or reject the latter.

This positioned me as the researcher to detach myself from any previous information or understanding I might have had in the perceptions among farmers on adoption of GM technology but then to change that understanding by connecting it interpretatively to the meanings of the respondents. Such an association is only made possible by phenomenological paradigm. Adding an interpretive dimension to phenomenological research enables it to be used as the basis for practical theory and allows it to inform, support or challenge policy and action.

4.5 **Research Approach**

The objective of this section is to scrutinize the research approach and methodology used to analyze the perceptions investigated in this research. In an effort to guarantee that the research is based on the phenomenological model and the debates surrounding these farmers' perceptions, I have pledged to use a qualitative approach. Qualitative research as defined by Davads, Maphunge and Theron (2005:37) is the study of "people in their natural environment as they go about their daily lives. It tries to understand how people live, how they talk, behave and think and what makes them different from others." It understands the meanings people attach to their world and their behaviour. It is an umbrella term referring to several research strategies that share certain specific and common characteristics. According to Merriam (2009:5), qualitative researchers are concerned in understanding "how people interpret their experiences, how they construct their worlds and what meaning they attribute to their experiences.” Braun and Clark (2013) point out that qualitative research uses words (that is, written or spoken language) and images as data; it also generates thick descriptions and tends to take longer to complete because it is interpretive and has no ready-made formula. A qualitative research approach encompasses several types of research designs (Babbie & Mouton 2010). For the purpose of this research, as noted, a case study design was chosen.

A qualitative phenomenological approach, backed up by qualitative data collection tools, was followed. In this instance, the given approach indicates how perceptions among farmers (small-scale and large-scale) influence their decision to accept or reject GM technology in Paarl settlements based on the knowledge and information that was collected. The qualitative phenomenological approach also answered questions such as how, what and when? Davads, Maphunge and Theron (2005:37) believe that people have their own understanding and interpretation of their social reality and that this is often removed from outsiders' perspectives, while the jargon sometimes used by policy makers and academics does not depict or reflect the knowledge of the marginalized people. It is also significant to know that qualitative research is usually used when the research objective does not simply give itself to statistics and numbers. In other words, while quantitative research is grounded on the logical-positive paradigm which uses experimental research methodologies, qualitative research is reinforced by phenomenological paradigm which makes use of a variety of interpretive research methodologies (Best & Khan 2006). In this regard qualitative method was chosen for the study.

4.6 **Population**

The word population denotes the whole group of objects in which all the measurements of concern to the researcher are characterized, to which they can apply their inferences (De Vos 2002:198). In the setting of this research study, the accessible population consists of the small- and large-scale farmers in Paarl, approximately a total of 7 776, of which about 150 are small-scale farmers (Tregurtha & Vink 2001). A study population (population frame) on the other hand, is referred to as the group of elements from which a sample is selected (Babbie 2010:199). In this case study the population frame consisted of 300 farmers of which 30 were selected.

4.7 **Sample techniques**

Sampling, as it associate with research, denotes to the selection of entities, units, and settings to be studied (Seaburg in De Vos 2002:199). Sampling must be done in such a way that the collection of entities from the study population precisely depicts the total population from which the entities are selected. The two types of sampling are: probability sampling and non-probability sampling. Probability sampling is a technique whereby all elements in the population have equal chances of being selected. The probability sampling comprises of random, stratified, systematic and cluster sampling techniques.

Non-probability sampling on the other hand is a process whereby population elements are designated because of the researcher's personal understanding that they are illustrative of the population and obtainable. Purposive sampling is a nonprobability method in which the elements to be watched are nominated on the basis of the researcher's own decision about which ones will be the most valuable or representative of the population (Babbie 2005: 189). In other words, purposive sampling is applied when the investigator has information on the features to be studied, its rudiments and the drive of the study.

This study applied non-probability sampling method in the selection of the participants because the respondents were purposefully selected. Hence, non-probable purposive sampling became the sampling techniques for this study.

4.8 **Respondents**

Both large- and small-scale farmers in Paarl were interviewed. As noted, a total of 30 farmers from the farming community were chosen. Fifteen of them were large-scale and the other 15 small-scale. The choice of 30 respondents was made taking into consideration that the respondents might know and understand GM technology. It is imperative to note that all the respondents had obtained a college or university education in agriculture. In this regard, the researcher had confidence that the information or data collected were of high accuracy and reliable for making inferences and generalizations since the respondents were educated and had solid insight into and understanding of the topic of study. This assumes that the conclusion of the study will reflect the perception of educated and experienced Paarl farmers about GM technology and its adoption.

4.9 **Data Collection Methods**

4.9.1 **Primary data collection method**

Primary data were collected through two participatory qualitative methods: interviews and focus group discussions (FGDs).

4.9.1.2 **Interview**

An interview is a story collectively accumulated. According to Holstein and Gubrium (1995) it is a discussion with a conclusion in which the interviewer and the interviewee 'construct' the story (Holstein & Gubrium 1995). Qualitative interviews could be structured, semi-structured and unstructured (Layla 2017; Halloway 1997). However, in this study, semi-structured interviews consisting of open-and closed-ended questions were chosen as the means of data collection for two reasons. First, they are well suited for the exploration of the perceptions and opinions of respondents regarding the issues of adoption of GM technology. They also offer a suitable method to explore these perceptions, attitudes, values and beliefs. In employing semi-structured interviews, the researcher has a core list of questions that each interviewee is asked, so that there is standardization. However, the researcher also has the flexibility to follow up questions with additional questions or discussion, depending on the interviewee's responses. This allows the former to probe and establish more information that may not have been covered in the core list of questions.

Making contact and the interview procedure

As soon as the sample participants were identified, the researcher visited each of them on their respective farms. The researcher introduced himself and informed the farmer about the purpose of the study and that the farmer has been selected as part of a sample group to conduct the study. Also see Appendix C. It was made clear that the farmer has no obligation to participate and has to give his/her consent before the interview can take place. Also see section 4.10 for ethical considerations. Permission was also asked from the participant to record the interview. The researcher then responded to any queries the participant might have had. Once the participant gave his/her consent, the researcher started the interview. While directing the interviews, the researcher used the following interviewing methods, as labeled by De Vos (2002:293 - 294), which assisted to conduct the interviews with confidence and ease:

- The researcher must allow the participant to talk in about 90% of the interview time.
- The researcher must ask supplement questions if he does not comprehend the participant's response plainly.
- The researcher must not be afraid of soundless breaks during the discussion because it gives respondent time to contemplate on the question being asked.
- Be conscious of how the respondent contributes in the interview. The participant's body language and tone of voice may also reveal some respected information.

De Vos (2002:295 – 296) likewise recognizes some problems a researcher may face when conducting individual interviews. Aware of these problems assisted the researcher to make changes in case these problems appear in the course of the interviews. Some of the problems are:

- Several types of disturbance may happen in the course of the interview.
- An interview normally has the risk of being insincere if the researcher does not devote adequate time to get to know the participants before beginning with the interview. In order to escape this, the researcher initially should involve in discussion with the participants concerning his/her participation in farm operations.

After all the themes on the interview schedule had been discovered and deliberated, the researcher permitted the participants some time to ask questions or to add any additional information that they felt were essential. The researcher also undertook to send the participants a record of the audio taped interview and notes, with the aim of the participants making sure that everything they said was properly recorded and noted. This process elevated the reliability of the research (De Vos, 2002:305). The data collection procedure commenced in March 2018 and lasted for four months to the end of June 2018. Each interview took about 20-30 minutes and the researcher interviewed a maximum of 3 participants per week, depending on their availability.

4.9.1.3 **Focus group discussion (FGD)**

Focus group interview is a qualitative method for data gathering. A focus group is "a group comprised of individuals with certain characteristics who focus discussions on a given issue or topic" (Dilshad & Latif 2013). According to Madziakapita (2008:96-97), a focus group discussion is a gathering of a group of individuals, between 8 and 12 members, to deliberate their indulgent and knowledge on a certain topic to enable a researcher to gain greater understanding and information about such a topic. Babbie (2001:294) also stated that, it is a group of people between 12 and 15 brought together in a room to engage in a guided discussion of some topic. Focus group interview gave the researcher a chance of retrieving rich information in a participatory and effective way.

A typical FDG is a semi-structured data collection technique which is qualitative in nature and comprising of open-ended questions. The merit of a focus group interview is that information from one person can be double-checked with others and more than one view collected. Within this framework, a semi-structured interview schedule was used comprising of prudently nominated open-ended and close-ended questions to deliver better scope for discussion, giving respondents chances to disclose their own views, moods, and principles, and to describe whatever events seem important to them (Babbie 2001:240).

The researcher conducted focus group discussions in Mbekweni. Both small- scale and large-scale farmers agreed to meet. The first FGD involved a group of 15 farmers in Mbekweni. Seven (7) farmers were small-scale farmers and eight (8) were large-scale farmers, while the second FGD involved nine (9) large- scale farmers and six (6) small-scale farmers. Each discussion took 40-minutes and was conducted on one of the participant farms. The farmers were able to provide relevant information on the perceptions among farmers and how it affects adoption of GM technology.

However, focus group discussions have their own limits: there is a propensity by some participants to feel frightened and to avoid taking part in the deliberations; some members may control the interviews; there are periods when the discussions are inappropriate to the theme being deliberated; and the discussions may be tough to handle and to achieve. The researcher was conscious of all these undesirable effects of FGD and efforts were made to decrease dominant speeches and to include all the members in the deliberations. In the two FGDs, the researcher guided the discussions, cross-checked the comments, and encourage all participants to express their opinions.

4.9.2 **Secondary data collection**

The research also depended on secondary sources or content analysis as courtesy to primary data sources. Content analysis includes the use of current resources by researchers and the analyses of data formerly collected by other people. Moreover, according to Babbie (2010:394), content analysis is "the study of recorded human communication such as books, websites, paintings and laws". It is an unobtrusive technique of data gathering because it includes different nonreactive research methods (methods that have no influence on the people being studied). Content analysis is also observed by Rubin and Babbie (1997: 421) as a "way of transforming qualitative material into quantitative data", suggesting that every form of message, whether noted or not, can be converted into quantitative data by coding and tabulating the message. The study of secondary sources was essential to present the theory on farmer's perception and adoption of GM technology in Paarl, South Africa. Web documents connecting to the study theme serve as an essential element of data for this study. The following libraries were also visited for the study of secondary sources: University of South Africa library, and Community library in Lithar park-Khayelitsha.

The use of content analysis in this research was inexpensive in relations to time and money which were invested. Additionally, the unremarkable nature of content analysis made it possible to examine the problem under discussion without affecting the people concerned because the data has already been established.

4.10 **Ethical considerations**

Collecting data usually raises concern from many respondents. In social research it is important to have high regard for the privacy and anonymity of the respondents as well as to respect them as persons by not endangering them to unnecessary research (Goddard & Mellville 2001:49). Social researchers have an obligation to ensure that health and wellbeing of the respondents is always safe-guarded. Respondents have a right to informed consent. Babbie (2011:480) pointed out that respondents need to base their voluntary contribution in research projects on a full understanding of the likely risks involved. Kvale (2007:27) concurs by stating "informed consent entails informing the participants about the overall purpose of the investigations and the main features of the design as well as possible risks and benefits from participant in the research project". Consent was sought (see Appendix A) from all selected participants of the interviews and focus group discussions.

All the respondents voluntarily took part in the research. They were also told that they had a right to pull out at any time. In addition, they were free to state it they were not comfortable responding to certain questions. Care was also taken not to harm them and the researcher made sure that they were respected as individuals. The respondents' identities were protected and their responses kept anonymous and confidential.

4.11 **Data capturing and analysis**

The data gathered from the sample interviews was taken by ways of recording and notes taken. The recording was made with the written consent of the contributors. One benefit of recording is that it delivers more comprehensive information than merely notes taken by the investigator during an interview. According to De Vos (2002:304), it offers the opportunity to pay attention to the discussion with the participants, and not on taking notes in order to capture all the essential information required. Recording does, though, have a disadvantage. When recording the interviews, the investigator cannot recollect the facial terms and body language of the participant. It is therefore imperative for the researcher to take notes of any strange or unusual body language expressed by the respondent during the interview.

De Vos (2002:340) points out that, during the data-capturing stage, the researcher should follow some strategies to guarantee that this stage contributes to an effective and trouble-free analysis stage. These strategies contain that the researcher took great care in cataloging each recording properly and visibly to pledge stress-free recovery. The investigator also saved record of every respondent's contact details as well as the date, time and place where every interview took place. This record can be valuable if a respondent needs to be contacted again.

After an interview had been accomplished, the investigator tanscribed the interview word for word. This arrangement permits sufficient room for the investigator to write on and 're-work the data'. The transcript was then corrected to eliminate any insignificant data, and sent to the participants for their approval. As soon as the participants had given their support, the interviews were analyzed.

The information collected were analysed in relation to the set objectives, and thematic categories of the study. Thematic coding methods were used to summarize and analyse themes in relation to the research. Data were processed using 'coding' for discovering patterns' (Babbie 2010) before analysed software package for social science research (SPSS version 16.0). The contents of the themes were determined by the topics and objectives, which guided the interviews. However, since the interviews were semi-structured, some important yet unexpected themes emerged from the interviews. All these themes, expected and unexpected, are vital in an attempt to achieve the objectives.

The data was analysed by means of basic content analysis procedures (Henning et al., 2002:104-108). The initial phase of the analysis is known as open coding, where the data is intensively inspected and taken apart into different units of meaning. The investigator read through the interview transcriptions, and delineated every sentence or phrase that forms a unit of meaning. Following this process, the researcher conceptualized the different units of meaning by assigning a code to each unit. As the researcher read through the data, he kept the different codes already assigned, in mind, and assigned the same label to reoccurring or similar units of meaning. This was done to avoid confusion as well as too many labels (Henning et al., 2002:105).

After the labels had been assigned, the researcher examined the codes in search of correlations. Correlating codes were then grouped into categories (Henning et al., 2002:106). The researcher then titled the different categories according to the contents of the labels it hold.

According to Henning et al. (2004:106), “Once all the sets of data have been coded and categorized the researcher is left with all important task of seeing the whole.” In an attempt to ‘see the whole’, the researcher examined the different categories for possible correlations and differences. The result of this examination was the identification of different themes that all related to the research question. These identified themes are discussed accordingly in chapter 5.

4.12 **Validity**

Validity is very significant in any study and basically shows that a specific instrument measures what it is supposed to measure (Walizer and Wiener 2002). Walizer and Wiener (2002 added that in qualitative data validity might be addressed through the uprightness, depth, richness and scope of the data to mention a few while in quantitative data validity may be improved through careful sampling, appropriate instruments and appropriate treatment of the data. The research applied suitable sampling in order to collect high quality data, as well as an instrument to ensure that collected data was appropriately treated, so that errors were significantly reduced. The instruments were pre-tested on ten farms in order to ensure that an accurate and appropriate instrument was used when collecting data in the field.

4.13 **Reliability**

Walizer and Wiener (2002) enlightened that reliability is a replacement for steadiness over time; they argued that for the study to be dependable, it must be established that if it were to be conducted on a comparable group of respondents in a similar context, similar results would be yielded. In order to ensure that the instruments used in this study were reliable, the researcher himself conducted pretesting of the instruments in order to identify errors to be corrected so as to achieve similar results in any similar context should the same instruments be used.

4.14. **Limitations and challenges**

A researcher has to be careful not to let personal values and perceptions influence interpretation and analysis of data. To prevent my personal values from interfering with the interpretation of results, frequent feedback of findings to respondents for validation was undertaken. Furthermore, another person was consulted to provide an alternative source of interpreting the data collected, thereby minimizing any possible bias or misinterpretation by me. Another methodological challenge with regard to data collection was lack of knowledge amongst some respondents. In this case, the researcher explained GM technology to the participants in order to obtain their views. Furthermore, some participants were afraid to express their opinions; however, assurance of confidentiality made them open up. The study also encountered the challenge of persuading some people to participate in the interview at the agreed time. The researcher was obliged to visit some farms a few times in order to reach the owners of the farms for the interview. This is due to the fact that some of them were busy with other work activities which prevented them from participating in the interview at the scheduled time. There was also the challenge of limited funds being available to the researcher, but a bursary was granted that covered most of the costs. Lastly, the study was limited in scope as it is a case study of Paarl farming communities; thus making it not representative of all small- and large-scale farmers in South Africa or elsewhere.

4.15 **Conclusion**

This chapter provided the context of the case study area and the research methodology to analyse the perceptions among farmers on the adoption of GM technology in Paarl, South Africa. Based on an examination of the numerous research paradigms, the study opted for qualitative research as the overall methodological approach to guide the study. Within this framework of a qualitative method, the study adopted content analysis and field research in its data gathering and analysis. The chapter also elaborated on the methods of data collection and analysis. The next chapter looks at the findings and analysis.

CHAPTER FIVE: RESEARCH FINDINGS AND ANALYSIS

5.1 Introduction

This chapter discusses the research findings according to the themes that emerged from the analysis of the data. The themes were determined by the topics and objectives, emanating from the interviews and FGDs conducted with the participants. Since the interviews were semi-structured, some important but unexpected themes emerged from the interviews and focus group discussions. During the discussions and interviews, farmers commented about issues which were not anticipated by the researcher but had an unavoidable impact on the study. These issues relate to the farmers' awareness of GM technology, their perception of GM technology and the effect of their perception on GM adoption. It was important to identify these themes and present them as findings because they form the basis or rationale for farmers to either adopt or reject GM technology. In the following section, the various themes are presented.

5.2 Themes

The following themes were identified and explored during the interviews and focus group discussions.

5.2.1 Farming is business

The study presents a case study of small-scale and large-scale farmers in Paarl. Small-scale farming is normally considered as a farming system whereby the farmer produces food to feed the family, while large-scale is considered to be a process whereby the farmer produces and sells it for profit. Makanya (2004) noted that small-scale farmers tend to save seeds in order to sustain their families. Mannes (2010) (see Chapter 2, section 2.6.2) likewise observed that small-scale farmers produce mainly for household consumption. He further explained that in terms of GM technology adoption, large-scale farmers can more easily afford to buy seeds whilst as mentioned earlier, their counterparts rely on saving their seeds or borrowing them from friends or relatives.

With regard to this case study however, the researcher found that both types of farmers, regardless of their status, produced and sold their products for commercial purposes.

None of the thirty (30) respondents stated they have to store seeds or borrow from friends. They all buy the seeds from seed companies, thus suggesting that the seeds were affordable. This contradicts what Mannes (2010) observed. In other words, none of the small-scale farmers produced crops just for feeding the family. As one small-scale farmer asserted, *"farming is [a] business and [it] is all about producing and making sure that there is enough fruits or vegetables in order to generate income."* Another participant mentioned that agriculture serves as employment for farm owners and workers, which in turn reduces poverty among the majority of people living in Paarl. A study done by Murray (2010) established that Paarl farmers employ 9 231 permanent workers and 15 122 seasonal workers. An FAO report (2004), (see Chapter 1 section 1.3) also confirmed that farming is important to food security in South Africa, it contributes to poverty mitigation by lowering food prices, generating employment as well as improving farm income and increasing wages.

5.2.2 **Agricultural techniques**

The thirty (30) respondents all indicated that they use different types of agriculture methods to enhance food production to feed the growing population. The participants stated food security is a major concern for South Africa and the government supports small-scale and large-scale farmers. A study done by Du Toit et al. (2011:1) (see chapter 1 section 1.3) confirmed that, food security policy document for South Africa (July 2002) embedded in Section 26 and 27 of the South African Constitutional law of 1996, serves to guide the Department of Agriculture, emphasizing that the constitution indicates that every South African citizen has a right to sufficient food and water. A similar study done by Mushunje et al (2011, see chapter 1, section 1.3) asserted that, due to drought and crop losses, the South African government has introduced a policy framework in the form of the National Biotechnology Strategy that supports plant biotechnology. The Genetically Modified Organism Act (No 15 of 1997) seeks to improve agricultural efficiency so as to improve food security particularly in the light of international environmental changes. Contrary to the South African Government's support of GM technology, the farmers who were consulted mentioned that there are farming methods that present alternatives to GM technology, which can improve agricultural productivity without causing controversy or resistance from the consumers. The respondents further mentioned that other innovative farming methods that have been used to maintain the standard of food security, have a positive impact on the environment as well as enhancing the wellbeing of labourers and farm owners. As one small-scale farmer stated, *"farming methods have changed over the years from traditional methods of growing fruits and vegetables to more innovative sustainable methods.*" The message was loud and clear from most farmers that they consider GM technology as just one of the many technologies on offer and that it does not deserve any place in agriculture for now. Plessis (2003) supported this view when he emphasised that the most important [thing] is to protect the land in order to produce more food for upcoming generations. In conclusion, the farmers held the firm belief that there are numerous agricultural technologies that can be used to increase food production in the face of climate change.

5.2.3 **Climate change**

The thirty (30) respondents all indicated that due to population growth and climate change, there has been a shift towards developing innovative solutions to various problems such as ensuring that fresh fruits and vegetables make their way to communities. This is in line with Wambugu's statement (2001:2) (see Chapter 1, section 1.2) that in order to make food available and achieve security, Africa needs to use science and technology to reduce production losses and increase production. Participants explained that given the extreme challenges that traditional approaches to agriculture face, including the effects of climate change, water shortages, population growth and changing political environments, there is a need for new agricultural technologies. These responses give rise to the question of whether it would be possible to increase production without the application of new technologies and new methods, other than GM technology. However, participants were of the opinion that there are numerous agricultural technologies that can be used to increase food production in the face of the climatic changes as mentioned above.

5.2.4 **Sustainability of GM technology**

A theme identified during the interviews and group discussions concerned the perceived sustainability of GM technology in the foreseeable future, which relates to the topic in Chapter 2, section 2.4. Farmers expressed their anxiety and doubts based on the affordability of GM technology if all farmers were to adopt it. They also felt it would have a detrimental effect on the environment, the economy and their livelihoods. Some of the comments, such as the two below, were admittedly vague and needed further probing for specific logical reasons. Words like 'any', 'risk' 'negative' were used, which is evident that there was to some level of doubt in their minds. All these factors contributed to their misgivings about this technology.

> *"The negative side effects of GM technology on the sustainable development will outweigh the positive side, any agricultural technology has risk including GM technology*".

> *"The long-term negative effects may have a detrimental impact on the wellbeing of future farmers, agricultural sustainability and the environment"*.

Not all farmers were vague in their comments. One farmer provided clear motivation for his skepticism. He said that:

> *"GM seeds is free in many African countries for the moment and is cheaper but it can be very expensive if all farmers depend on GM seeds. Not all future farmers would be able to afford to buy"*.

The above statement speaks to the shortcomings of GM in relation to its cost-effectiveness and sustainability. The farmers' doubts had some support from the literatures. According to Levidow (1998:214, see chapter 1, section 1.2) GM technology has been notable in its ability to increase crop production but as the ultimate human control over nature, it poses social, economic and environmental risks… The unintended and unexpected effects that could emerge directly or indirectly from GM technology may have adverse effects on the economic wellbeing of poor farmers and the environment. The bottom line is that technological choices are not neutral – they have an impact on economic and environmental aspects as well as livelihoods of people (Fig 2007:108)

5.2.4.1 GM technology's impact on the environment

This theme is directly related to the topic in Chapter 2, section 2.5 and it focused on the unintended consequences of GM technology on the environment. All the farmers, from both sides of the spectrum, spoke with one voice in their responses about the negative effects of GM. At the centre of their concerns was that GM technology may cause some variations in the environment and that these variations could harm the ecosystem and also non-GM crops. Their continued argument was that:

> *"GM crops can create pests or herbicides which may be resistant to pesticides and herbicides and GM plants may kill important insects like butterflies and bees".*
>
> *"It is likely [that] the gene of GM plants may have bad effects on non-GM plants".*

The above statements may sound like speculation to some, but there is some evidence in literature to support this. A range of studies by Adams (2000); Jan-Peter, Metz, Escaler and Conner (2002); Kruft (2001) and Wolfenbarger and Phifer (2002) (see Chapter 2 section 2.5.3) support the notion that GM crop may engender invasive plants, encourage gene flow through pollination, create cross-pollinating transgenic crops and produce the so-called "super-weed". All this would spell disaster for the ecosystem and serves to dampen the enthusiasm for GM technology in the minds of the farmers.

5.2.4.2 GM technology's impact on the economy

This theme is related to the topic in Chapter 2, section 2.6, and concerns the impact of GM technology on the economy and how farmers view this impact. A total number of 9 or 30% of the participants (5 large-scale and 4 small-scale farmers) felt that GM technology does have economic benefits. They listed GM technology's advantages as follows:

- It has the ability to increase the yields or production.
- It can be grown on a salty soil.
- It uses less pesticides and herbicides.
- It increases the profits margins.

According to the literature, the adoption of GM crops in developing countries has helped farmers to save from 33% to 77% on pesticide purchases (Qaim 2005) (see Chapter 2, section 2.6.1). Sanchez (2015) (see chapter 2 section 2.6.1) adds that genetically modified technology improves yields and does provide economic benefits to seed companies and farmers alike.

On the other hand, 21 (70%) farmers (10 large-scale and 11 small-scale farmers) held a different position. They reported that GM technology suffer from the following disadvantages:

- The seeds are expensive due to investment on research and development (R&D) by seed companies.
- The farmers are not allowed to reuse the seeds.
- The quality of its produce (wine from grapes) is relatively of a lower quality and more watery.
- Private companies dominate or monopolize the GM seed industry.
- There is still a strong anti-GM sentiment amongst the consumers.
- Profits can still be made without using GM technology.

The following are some of the farmers' views in this regard;

> *"Since farmers are not allow to reuse seeds, this will be worse nightmare now and in future"*.

> *"I prefer less fruits on a grapes tree, for example, if a tree of a grape has a lot of grapes (fruits) since there are so many grapes on one tree, the grapes share the nutrients hence [those] grapes become watery and it does not taste nice".*

A work done by Kropiwnicka (2005:45) (see Chapter 2, section 2.6.2) confirmed that within the present structure where technology is pushed by profit rather than by need-oriented R&D, the GM technology revolution can have adverse effects on farmers. GM technology, he explains, is owned by private companies or individuals, whose aim is to make a profit at the expense of the farmers.

A similar work by Kruft (2001:45) (see Chapter 2, section 2.6.2) observed that these seed companies protect their investment through setting up contracts with farmers. The contract between a farmer and a biotech company contains a "no seed saving" clause. As previously explained, this prohibits farmers from saving seed or reusing GM seeds and farmers are required to buy seeds every planting season. Under these conditions GM technology may not benefit farmers.

5.2.4.3 GM technology's impact on sustainable livelihood

This recurring theme of GM technology's impact on the livelihood of farmers is directly related to the topic as discussed in Chapter 2, section 2.7. All the respondents indicated that GM technology is perceived as having a negative impact on livelihood. Dependence on seed companies and the seasonal purchase of seeds are cited as reasons for not adopting GM technology. A complaint from one farmer reads as follows:

> *"Livelihood is to have the ability and means for living, the fact that farmers cannot reuse GM seeds but have to depend on GM Seeds Company every planting season may not help…"*

Studies by Altieri and Rosse (1999); Swaminathan (2001:39, see chapter 2, section 2.7.2); and most recently Walker (2014) found that GM technology

- provides employment for scientists at the expense of farmers through R&D;

- allows companies to incorporate genetic use restriction mechanisms like the "terminator";
- permits corporates to generate excessive profits in the developing countries; and
- creates an environment where seed companies control seeds and, by default, the entire food chain.

The picture thus far shows that the Paarl farmers are not in favour of GM seeds and reasons were accordingly provided.

5.2.5 **Perceptions and adoption of GM technology**

This theme is directly related to the topic in Chapter 2, section 2.8. This study concludes that perception has an influence on GM technology adoption. This view was confirmed by Kikulwe et al. (2011) who also contend that perception influences the adoption of GM technology and due to perceptions, not all farmers have adopted GM technology. A similar work done by Yang et al. 2005:230) confirmed that in order to sustain new technology, farmers' perceptions regarding the new technology needs to be measured and evaluated. A study undertaken by Cochran (2003) established that new agricultural innovations introduced by governments or other agencies are often abandoned for traditional practices after the development intervention project has been completed. This is due to the promoters of such innovation failing to consider the user's perception of the innovation in question.

In light of the above, a considerable amount of time was devoted to exploring the perceptions of participants on GM technology adoption. It was important to know whether the majority of the participants had specific perceptions concerning GM technology and whether these perceptions influenced their decisions in accepting or rejecting it. All thirty (30) respondents mentioned that their perceptions on GM technology influenced their adoption decisions. However, respondents further indicated that public or consumer perceptions also have a major influence on farmers' decisions to accept or reject GM technology since the public is the target market.

5.2.5.1 **Participants awareness on GM technology**

The majority of participants, 28 (93%), made up of 13 (43%) small-scale farmers and 15 (50%) large-scale farmers, acknowledged that they were aware of the existence of GM technology and understood what GM technology is all about. Only 2 (7%) of small-scale farmers conceded that they are not aware of GM technology. Table 5.1 below, records the number of participants who are aware and not aware of GM technology at the time of conducting the study.

Table 5. 1: Farmers awareness on GM technology

Farmer type	Aware	Not Aware	Total and percentage	
Large-scale	15	0	15	50%
Small-scale	13	2	15	50%
Total	28	2	30	100%

The study's finding in this regard demonstrates widespread awareness of GM technology amongst the Paarl farming communities and this enhances the adoption decision process. In order for GM technology to be adopted, farmers need some level of awareness so that they may determine whether it is appropriate for their circumstances. Awareness is key to adoption.

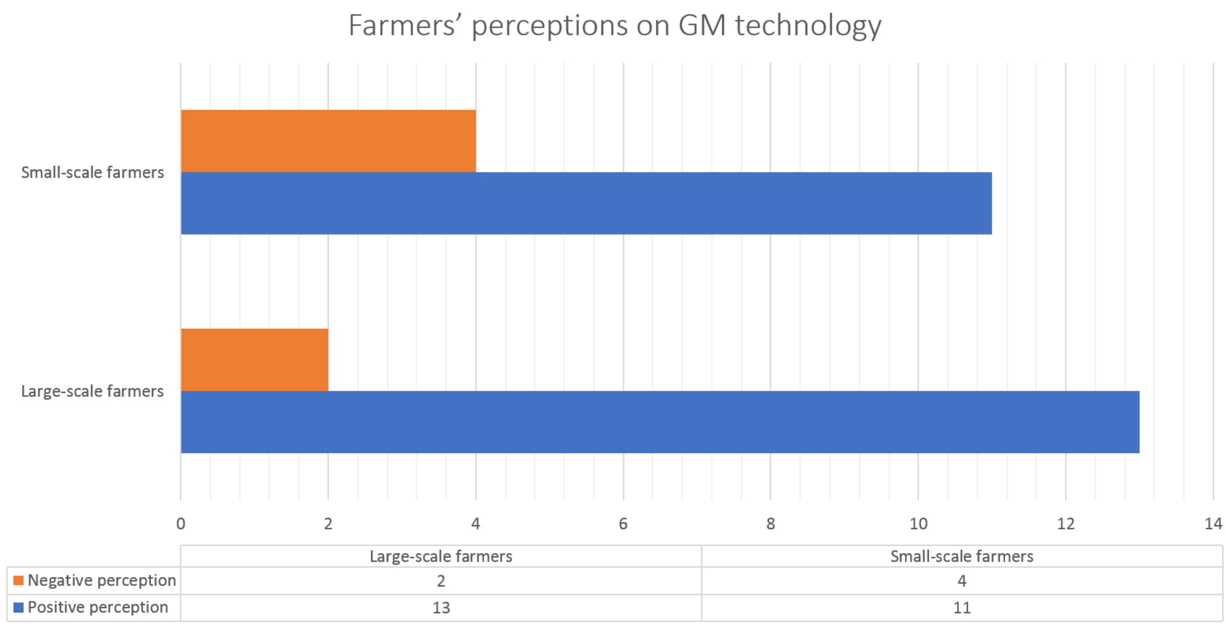
The works of Ismail (2006:16) (see Chapter 2, section 2.9); Rogers and Beal (1957) and Roger and Shoemaker (1991) confirmed that the first stage in adoption is either the awareness or knowledge stage. It is noted that these researchers used the latter two words interchangeably. In theory, one may assume that knowledge may lead to use, but in reality, the opposite may also happen.

In terms of the outcome of this awareness, an understanding of the use of the technology follows. In addition, farmers are then able to compare it with other agricultural technologies during the adoption decision process. To this end, the work done by Adenle (2013:242) (see Chapter 2, section 2.9); Hall (2008) (see chapter 2, section 2.9) and Neels and Kris (2005:2) placed strong emphasis on understanding perceptions regarding GM crops as being central to understanding the adoption or rejection of GM technology among farmers. The adoption decision is a process of decision-making by individuals that requires cognisance, meaning that it requires the use of an individual's abilities to understand something (Neels & Kris 2005:2).

5.2.5.2 **Participants perception of GM technology**

This topic is directly related to Chapter 2, section 2.6. Six participants (4 small-scale farmers and 2 large–scale farmers) held a positive perception of GM technology. Twenty-four (24) (80%) participants comprising 13 (43%) large-scale farmers and 11 (37%) small-scale farmers had negative perceptions of GM technology. The figure 5.2 illustrates the number of participants who have positive and negative perceptions of GM technology. Participants indicated that they formed their perceptions based on the information received and subjective analysis.

Figure 5.2 Farmers' perceptions of GM technology



The study proposes that information on GM technology stimulates farmers to develop positive and /or negative perceptions which influence their adoption decisions. Roger and Shoemaker (1971) and Rogers and Beal (1957) (see Chapter 3, section 3.3) confirmed that the awareness stage is followed by the interest stage where the individual starts gathering information about the GM technology; this aids them in reaching an informed positive or negative perception, leading to an adoption decision. A related work undertaken by Fazio (1990, cited in Parminter & Wilson 2003) (see Chapter 3 section 3.2) added that individual farmers form their perceptions "by systematically reflecting on any information that they have about the behaviour or innovation being considered." In addition, perceptions result from an individual's philosophy regarding the consequences of a particular innovation or behaviour and their assessment of those innovations based on their beliefs. The more an individual expects that a particular innovation will have positive consequences for him/ herself, the more that individual will have a positive perception towards that innovation. Likewise, the more that an individual expects that an innovation will have undesirable consequences, the more he/she, will have a negative perception about it.

Sanchez (2015) and Kershen (1999) (see Chapter 2 section 2.8) also established that personal viewpoints on GM technology shape perceptions and heavily influence adoption decisions. Acceptance (positive perceptions) or rejection (negative perceptions) of GM technology is based upon information about or understanding of the science and technology. Costa-Font and Mossialos (2005) (see Chapter 2, section 2.8) supported the notion that individual perceptions of GM technology differ because of the way an individual forms his/her perceptions. A work done by Moore and Benbasat (1991) established that farmers may perceive GM technology attributes in different ways, which will aid in forming different perceptions and therefore lead to varied adoption behaviours.

Much time was spent to find out the effects of perception on GM technology adoption. This topic relates to Chapter 2, section 2.8. Participants commented on this topic as follows. Twenty percent (20%) (6) of participants, consisting of 7% (2) large-scale farmers and thirteen percent 13% (4) small-scale farmers clearly stated that they would adopt GM technology because of the positive perception they have about it. However, they expressed concerns about whether the consumers would buy the resulting GM food or not. Twenty-four 24 (80%) of participants consisting of 13 (43%) large-scale farmers and 11 (37%) small-scale farmers mentioned that they would not adopt GM technology due to their negative perceptions of it. As one farmer said, "There is no scientific proof that GM crops has risk but I am sure it will have some risk which we don't know yet". Table 5.2 below show that positive perception leads to adoption and negative perception leads to non-adoption.

Table 5.2: **Perception leading to adoption and non- adoption**

Farmer type	Positive perception leads to adoption	Negative perception leads to non-adoption	Total and Perception	
Large-scale	2	13	15	50%

Small-scale	4	11	15 50%
Total	6	24	30 100

With regard to the above, the study suggests that perceptions associated with GM technology influence farmers' decisions to accept or reject GM technology. This is confirmed by Rogers (2003) (see Chapter 2, section 2.2.2) who said, perception is viewed as "an antecedent to the decision to adopt new technology". A study done by Costa-Font, Gil and Traill (2008:99) (see Chapter 2, section 2.8) also established that the demand side effect of GM technology is influenced by positive and negative perceptions, leading to acceptance and rejection. A study conducted in the USA in the State of Illinois, by Chimmiri et al. (2006) observed that farmers' perceptions of GM crops were positive as productivity increases were reported as one of the perceived benefits of BT maize which thus had a positive impact on adoption.

Furthermore, this study recommends that perception is used to differentiate between adopters and non-adopters of GM technology in Paarl. This is confirmed by Mushunje (2011:5919) (see chapter 2, section 2.8), who proposed that perception could be used to distinguish between adopters and non-adopters of GM crops.

5.2.6 **Adopter-perception model**

In preparation for this research an extensive literature study of agricultural technology adoption was undertaken, as reflected by the discussion in Chapter 3. Consequently, the different adoption models were analysed and the study highlighted the Adopter-perception model as a theoretical framework for the analysis of perceptions of small-scale and large-scale farmers on the adoption of GM technology. In order to apply the said model as a theoretical framework, participants commented on the Adopter-perception model, Innovation-diffusion model and Economic-constraints model (see Chapter 3, section 3.5). An additional theme, i.e. Public perception, identified by the respondents was developed during the interviews and FGDs, which was important for the establishment of the theoretical framework. The different sub-themes are presented in the discussion that follows.

5.2.6.1 **Adopter perception**

This sub-theme is related to the Adopter-perception model as discussed in Chapter 3, section 3.5.3. All the respondents were aware of GM technology attributes and commented that they would voluntarily adopt or reject GM technology based on its perceived attributes. Participants indicated that they use their own subjective thinking to assess the attributes of GM technology in order to accept or reject it. Subjective thinking is the farmers' views or perceptions and GM technology attributes are the features or the characteristics of GM technology perceived as by the adopters. The participants suggested that by seeking information on GM technology, it enhances their ability to think about the attributes of GM technology and decide whether to accept or reject it. As one of the participants mentioned:

"*The features of GM technology is very critical when it comes to adoption decision, I have to compare with other agricultural methods*".

All the farmers indicated that the perceived attributes of GM technology influence their decision to adopt or not to adopt GM technology. For example, one participant mentioned that;

> *"The features of any technology are very essential when it comes to adoption decision; one cannot accept any new agriculture technology without considering its features"*.

Participants commented on the following GM technology attributes: perceived relative advantage, perceived compatibility, perceived cost of GM seeds, perceived risks, and perceived complexity. Farmers believe that all these attributes influence adoption decision.

The study suggests that on the basis of voluntary adoption decision, adopters' (small-scale and large-scale farmers) perception is a factor that influences farmers to adopt or reject GM technology in Paarl. This is in line with Ashby and Sperling (1992) who stated that farmers might have subjective thinking regarding GM technology and this could play a crucial role in its adoption decision. Subjective thinking stimulates all kinds of behaviours, including adoption decisions (Shari & Dorit, 2018). Agarwal and Prasad (1997: 1) (see chapter 2, section 2.8) confirmed this by saying that a common theme underlying the various models that explained technology adoption includes perceptions (of an innovation) known as "Adopter perception". Adopter perception is the degree to which farmers are assumed to hold specific perceptions regarding the effects of GM technology and these subjective evaluations can be significant factors in adoption decision.

That the attributes of GM Technology influences adoption decisions is confirmed by Ram (1987) (see chapter 3, section 3.5.3), namely that the characteristics of GM technology perceived by farmers determine whether the farmer may accept or reject it as mentioned earlier. Fliegel and Kivlin (1966) furthermore established that decisions to reject or adopt technology are not based on single technology attributes. There are many attributes associated with technologies that need to be considered during the adoption process. A study done by Rogers (1995) (see chapter 3, section 3.5.3) developed a theoretical framework that reveals the relationship between perceived innovation characteristics and the adoption of innovation. The relationship of GM characteristics and adoption of GM technology highlights the importance of perception and its influence on an adoption decision. A similar study carried out by Adesina and Zinnah (1993:298) (see chapter 3, section 3.5.3) confirmed that adoption or rejection of technology by farmers may depend on the rational decision making based upon farmers' perceptions of the appropriateness of the characteristics of the technologies in question. Figure 3.4 illustrates this. GM technology attributes are explained as follows:

Perceived Relative advantage

Six (20%) of the participants mentioned that GM technology may have a perceived relative advantage. They further indicated that GM technology can give higher yields compare to other agricultural methods. One farmer believed that "*GM technology has potential to give higher yields with less use of chemicals*". Meanwhile, the majority of the participants, twenty-four (24) (80%)

said that GM technology does not have perceived relative advantage over various other farm methods. They stated that precision farming, hydroponics farming and mix methods farming give higher yields. The farmers clearly mentioned that when growing vegetables or fruits, for example; strawberries, they can control the temperature for this crop and to accomplish this, they employed greenhouse technology as a means to control the temperature. This technology gives higher yields. They argued [that]

> *"When talking about perceived relative advantage, it should not be looked from the perspective of how GM technology give higher in production but rather how GM technology produce healthy food for human consumption without any effects I know from the fact that the agricultural methods we are using give high production due to fertilizers, spraying, analysis the soil for specific type of crop, control climate changes and irrigation. These methods produce healthy fruits and vegetables, public does not complain but with GM crops the public are complaining. With organic food does not produce a lot but it is healthier. You have to consider this*".

> "*I have heard people saying GM technology can increase crops yields but the question is consumers don't want to buy GM food so is not profitable for us"*.

The study proposes that GM technology does not have perceived relative advantage over the agricultural methods used by the farmers, since the majority of them are of the opinion that their current methods of farming fulfil all their needs and requirements and that other non-GM technologies and innovations are available to them. The concept of 'relative advantage' captures the extent to which a potential adopter will gain or benefit from the adoption of a new innovation more than the previous one (Homans 1961) (see Chapter 3, section 3.5.3.1). Participants indicated that GM technology does not have superior performance over other agricultural methods. As one farmer said: "*I sell fresh vegetables every day with use of hydroponic and other agricultural methods without GM technology*." Holak and Lehman (1990) confirmed this by saying that relative advantages exist if an innovation offers superior performance relative to the old one. They further argue that GM technology does not provide utility maximisation simply because consumers are opposed to and do not want to buy GM foods. Consequently, farmers see GM technology as unprofitable. The findings of this study are contrary to those of a study conducted in Brazil by Almeida et al. (20015), which proposed that farmers adopted GM technology because of profit maximisation.

Compatibility

All the respondents stated that GM seeds are compatible with agriculture practices but may be incompatible with the environment and non-GM crops. One of the famers indicated that there is no difference between GM seeds and the normal seeds; the only difference is in colour or size. Although participants mentioned that GM technology is compatible with their style and agricultural practices, they distinctly stated that it may be incompatible with the environment and non-GM crops. As one participant mentioned, *"GM plants can cause some variation on the environment as well as non-GM plants".*

The study proposed that GM seed is compatible with farmers' life styles, values and agricultural practices, but it may be incompatible with the environment. Participants stated that past and current agricultural methods have no negative effects on the environment, but farmers fear that GM technology can change this experience. Negatu and Parikh (1999) (see Chapter 3, section 3.5.3.3) confirmed that the problem of non-compatibility of new technology with the ecological and other resources of famers constraints the acceptance of technology.

Cost

The majority (83%) of participants consisting of thirteen (43%) large-scale and twelve (40%) small-scale farmers stated that GM seeds are expensive and chances are that prices will increase in future. One of the participants said *"GM seeds cannot be cheap simply because GM Seeds Company spend huge sums of money to manufacture GM seeds and again we have to buy GM seeds every planting season, this will make it more expensive since all farmers will depend on it."* Five (17%) participants did not comment on this aspect.

The study proposes that GM technology may be expensive, therefore it may slow adoption or be rejected by the farmers. This concurs with the findings by Fliegel and Kivlin (1962)(see section 3.5.3.4) who said that perceived expensive innovations would be adopted at a lower rate than less expensive innovations, in view of many demands made on scarce economic resources. Hall and Khan (2002:3) also made the point that individuals weigh the benefits of adopting a new technology against the initial cost and ongoing fees, often in an environment characterised by uncertainty.

Perceived risks

The majority of the participants, twenty-seven (27) (90%) made up of thirteen (43%) large-scale and fourteen (47%) small-scale farmers) mentioned that GM technology may have perceived risks. They suggested that the perceived risks associated with GM technology make it difficult for farmers to adopt it. One participant mentioned this issue, saying "*GM seeds may have perceive risk, this unforeseen risk is our worry*." Three (10%) participants did not comment.

The study suggests that perceived risks associated with GM technology is a factor influencing farmers to reject GM technology. This view is supported by the study findings of Yeung and Morris (2005:172) i.e. that perceived risk is a critical factor in decision making. Perception of food risk is one such psychological interpretation which influences the behaviour of producers and consumers. A study carried out by Cellini et al (2004:1091) pointed out that it is essential to describe the mechanisms whereby unintended effects may arise during GM crop farming. GM crops are modified in laboratory; hence the technology may be associated with risk. A similar study done by Hall (2007) (see chapter 3; section 3.5.3.5) also endorsed this view when observing that fear of perceived risk has made some farmers in Scotland reject GM technology. A similar study carried out by Negatu and Parikh (1999) established that farmers' risk-averse perceptions hinder them from adopting new agricultural technologies.

Perceived complexity

In regard to perceived complexity, all of the respondents indicated that GM technology is easy to understand and use. Respondents argue that there is no difference between the GM seed and non-GM seed, the techniques use in planting non-GM seed is the same as used for GM seed. Ease of use relates to the notion of complexity and encapsulates that degree to which a potential adopter views usage of the innovation to be relatively free of effort. An innovation which is perceived as being easier to use and less complex has a higher likelihood of being accepted and used by potential users. However, respondents stated that even though GM technology is easy to use, this attribute is not a strong reason to consider when it comes to adoption of GM technology. This does not align with the discussion in section 3.5.3.2 where it is reflected that farmers will adopt more readily GM technology if it is easier to use.

Although this study found that GM technology would be easy to use in Paarl farming communities, its attribute of simplicity is not a strong factor in determining adoption decisions. It contradicts the statement that innovations that are easy to understand or use are more likely to be adopted at a faster rate than the difficult ones.

Saving of time

In regard to perceived saving of time, all the participants indicated that, they don't perceived GM technology to save time in terms of crops production. They further stated that the agricultural methods such as precision and hydroponics help crops to mature at a faster rate. This is not in line with www.Learn.genetics.utah.edub who argued that GM technology offers a time-saving method for producing larger, higher-quality crops with less effort.

5.2.7 **Innovation-diffusion model**

Some farmers did indicate that access to proper information on GM technology would enable them to be aware of the potential benefits associated with GM technology which will influence them to adopt or reject it. This is in line with Hooks, Napier and Carter (1983:309) (see chapter 3 section 3.5.1) who expressed the view that access to information sources speeds up the adoption process because people are made aware of the potential benefits associated with the new technology.

Five (17%) participants (10% small-scale and 7% large-scale farmers) mentioned that they will adopt GM technology through innovation diffusion process. They suggested that information regarding GM technology will help them to accept GM technology. One of the participants stated that, "*Most farmers do not know the full abilities, benefits and risk of GM technology*". Therefore, there is the need to have good information on GM technology in order to avoid farmers' misinterpretation. Twenty-five (83%) participants consisting of twelve (12) (40%) small-scale and thirteen (13) (43%) large-scale farmers specified that information on GM technology cannot influence them to accept it. They argued that most of the information on GM technology comes from the marketers or the crusaders of GM technology to promote GM seeds. This view is supported by Uaiene et al. (2009, cited in Mudzonga, 2010) (see Chapter 3, section 3.5.1) who contends that access to information about technology does not necessarily mean it will be adopted by all farmers. This implies that farmers may consider other factors after receiving information about innovation before accepting or rejecting it.

In light of the above, this study recommends that an Innovation-diffusion model be applied to spread information on GM technology to Paarl farming communities, as this model focuses on an understanding of how, why and at what rate innovative ideas and technologies are spread in a social system. Rogers's viewpoint is relevant in this regard (in Chapter 3 section 3.5.1).

5.2.8 **Economic- constraints model**

Nine (30%) participants: (4large-scale and 5 small-scale farmers), commented that economic constraints would be a factor to consider when adopting GM technology. They mentioned that land and capital are prerequisites for farming and GM technology adoption. Furthermore, 21 (70%) participants (11 large-scale and 10 small-scale farmers) were of the opinion that land and capital are fundamental for farming, but not for adopting GM technology, since there are other agricultural methods that can be applied. One of the participants stated "I *cannot adopt GM technology because I have land and capital. I have to assess that technology from my own perspective as well as from the public since there are other alternative agricultural technologies".*

The study suggests that Economic-constraints model is a factor that may be considered by some farmers. As one participant mentioned: "*Without land and enough money, it will be impossible to use agricultural technology"*. This is confirmed by Aikens et al. (1975) who stated that the Economic-constraints model maintains that distribution patterns of capital and land are the major predictor of adoption behaviour. Lack of capital and land will exclude some farmers from adopting technologies due to their inability to access input prerequisites.

As already mentioned, the majority of the participants held the view that land and capital are prerequisites for farming but not for adopting GM technology. Respondents are of the view that adoption of GM technology should not be based on having access to land and capital alone but rather, it should also include the target market's preferences. They argue that; "*since farming is business, having access to land and capital do not give one full power to adopt GM technology but is necessary to know what agricultural technology consumers prefer*". Furthermore, the participants indicated that there are other agricultural technologies that can be considered, therefore there is the need to assess GM technology from both the adopter and the public point of view before accepting it. The model ignores the societal influences on a farmer's decision making process and it is assumed that farmers are isolated, independent and make decisions based on their own assessment of the return on the innovation. In reality, however, farmers are influenced by relations, perceptions, social, economic and environmental conditions in society and as well as the attributes of technology. These findings confirm the conclusion in Chapter 3.

The following are the unexpected themes that emerged during the interviews and FGDs.

5.2.9 **Public perception**

The study used Adopter-perception theoretical framework to analyse the farmers' perception on the adoption of GM technology. In addition, the Innovation-diffusion and Economic-constraints models were also discussed in Chapter 3, section 3.5 as the main factors affecting adoption of new agricultural practices. The Adopter-perception model explains how farmers' perceptions of GM technology attributes determine adoption decisions. Small-holder and large-scale farmers in this study had the same objectives (see section 5.2.1) and this may reflect their perceptions on the use of GM technology. Although GM technology can be measured objectively, the meaning of the GM technology attributes is subjective and in the mind of the perceiver. On the other hand, the Economic-constraints model depends upon the assertion that the distribution pattern of the economic resources (land and capital) are the major factors determining adoption behaviour. Lack of these resources may deter a farmer from adopting an innovation, irrespective of his or her perceptions on GM technology. As stated in section 3.5.2, the economic potential in terms of yields, costs of the technology and profits are very important factors in adoption decisions. A person may have a strong desire to adopt something once he or she is made aware of the advantages of adoption but economic constraints frequently prevent individuals from acting. However, a farmer's decision to adopt new technology is based on various technical, economic and social factors that are associated with the technology in terms of costs and benefits (Mudzonga 2010).

The Innovation-diffusion model on the other hand holds that access to information about GM technology is the key factor that determines adoption decision. As a wise saying goes "information is powerful" because it creates an awareness which tends to influence behaviour. As discussed in section 3.5.1 access to information may create awareness that GM technology exists and this information may influence adoption decisions. It is critical that farmers need to be aware of the existence of technology: its' beneficial attributes and its' usage, for them to adopt it. The innovation-diffusion process helps farmers to form positive or negative perceptions towards the innovation in question. However, it ignores individual perceptions of the characteristics of an innovation as well as economic resources available to the individual. In other words, the model fails to (1) take into consideration the adopter's subjective assessment of the characteristics of the new technology; and (2) to consider economic resources (capital and land).

Adesina and Baidu (1995:2) (see Chapter 3, section 3.2) proposed that the 3 models discussed are used to explain the decisions taken by farmers to adopt or reject new technology. On the contrary, public perception or resistance is the main factor influencing farmers' decision to accept or reject GM technology in Paarl farming communities. As one farmer said: *"I think GM technology is good and I am willing to adopt it in my farm but public perception and their resistance do not allow me to adopt"*. All the respondents were aware of GM technology and stated clearly that GM produce is not accepted by the public. The participants mentioned that farmers are not using GM technology due to public resistance. As one of the respondents mentioned: "*GM wheat was on field test but due to public resistance we could not carry on the field assessment*". Participants specified that crops such as grapes, apples and strawberries are not only produced for the South African market but also for international markets. They have trade relationships with other countries like London, Germany, Holland and others. These trade partners do not want GM foods. One of the farmers explained it as follows: "*We cannot use GM technology and it is our tradition not to use it because consumers will not buy it. We cannot use GM Grapes to produce wine, we don't want to spoil our wine with GM technology".*

A study carried out by Hallman and Aquino (2005: 2) suggested that, while farmers are more willing to adopt genetically modified (GM) crops on a broad scale, it is also clear that the ultimate success or failure of agricultural biotechnology will necessarily be influenced by public opinion. As discussed in Chapter 2, section 2.4, the debate on GM technology has emerged with different views within the intellectual landscape and even farming communities. The debate may be seen as a solid indicator of movement towards farmers', public and consumers' engagement in deciding which agriculture technologies to be used in a democratic country. The role of farmers', public and consumers' voices in agricultural decision making has become a critical element in adoption decisions and, in practical terms, seems to be the best way to solve a number of perceived potential problems and difficulties associated with new agricultural practices. Farmers therefore do not alone have the power alone to decide which technology to use in agriculture; the public or consumers have the power to influence farmers' decisions to reject or accept agricultural technology. Kagai (2011:166) (see Chapter 1, section 1.4) supported this: however, he argued that although consumers play a major role in the success or failure of GM crops, the perceptions of producers (who are themselves consumers) play the most essential role in accepting or rejecting GM technology. It was against this background that this study investigated how the perceptions of large-scale and small-scale farmers impact on their decisions and willingness to adopt and experiment with GM technology and crops in Paarl in the Western Cape Province, South Africa. Against this background it is argued that the adopter- perception model needs an update to include public or consumer perception. Since farming, in this case small-scale and large-scale farming in Paarl, is a business revolving around the production of crops to generate income and profits, thus any agricultural technology needs to be assessed from the perspectives of both the farmers and the public, since the public is the target market.

5.2.10 **Alternative methods of farming**

Each of the thirty (30) participants responded that new agricultural methods are constantly emerging to shorten crop development and help guarantee higher yields. Participants alluded that GM technology is not the only vital technology that can help increase crop production in environmentally stressed conditions. Tester and Langridge (2010:818) (see Chapter 1, section 1.2) confirmed this by saying that there are various opportunities to boost yields and increase agricultural production through the adaptation of improved crop varieties and new agricultural technologies. One respondent was of the view that: "*Farmers always find solutions to new problems or challenges, we have ways and means to face drought and at same time feed the growing population. It is not only GM technology that can solve the problems of drought and at same time produce enough crops*". This is in line with Zechendorf (1999) who confirmed that to avoid environmental degradation and climate challenges like drought, humankind requires a range of options and tools that will help to increase food production. In line with this, participants mentioned a range of tools that can help improve agriculture as well improving the economic, social and environmental well-being for small-scale and large-scale farmers. The tools mentioned by the farmers were:

- Precision farming
- Hydroponics farming

- Aquaponics farming
- Organic farming

Moreover, the dominant methods used are

- Precision farming
- Hydroponic farming
- Organic farming.

These were confirmed by all 30 participants during the interviews. Respondents explained these farming methods which could be summarized as follows;

Precision farming: occasionally referred to as satellite farming, it is an agriculture management technique based on detecting, gauging and answering to inter and intra-field inconsistencies in crops through the use of technology (see Figure 5.2 below).

Figure 5.2 Precision farming

Source: www.afgric.co.za. Accessed on 12/05/2017

This technology allows farmers to examine and manage the soil before planting crops which decreases risks of lost yields. With the introduction of this technology, farmers can now manage and sense difficulties in minutes, which is much more suitable and cost effective as compared to the traditional method of routine patrols which could take hours on large scale farms. Participants explained precision farming as a process whereby the land and the soil is analysed to find out which type of crops is good for the land and the soil. By doing this, farmers mentioned that they don't grow crops on any kind of soil, but rather this method allows them to cultivate in soil that is suitable for the crops. Moreover, all the participants indicated chemicals are used when the need arises. As one of the respondents mentioned… "With this method I spray my crops when the need arises".

Hydroponics farming: this technology makes use of growing plants without soil by using mineral nutrient solutions in water (see figures 5.3a and 5.3b below). Hydroponics save on land use. This method also uses a smaller amount of water than traditional farming techniques. Participants further explained hydroponics farming as a process whereby the plants are grown above the ground. In essence the root of the crops do not touch the ground. They explained that hydroponic farming can be open (unprotected) or enclosed (protected). According to all the participants unprotected hydroponic farming is a process whereby the crops are grown in an open environment without controlling the temperature or environmental variations. On the other hand, protected hydroponic farming is a process whereby the crops are grown in an enclosed environment in order to control the temperature or the environmental variations. The participants mentioned that hydroponic systems can vary in size, can be arranged vertically, and use much less water than traditional methods of farming. Crops are grown in a nutrient solution, with or without the use of artificial growing media, to provide mechanical support to the plants. In recent years vertical hydroponic systems, where the plants are grown in vertical layers, are getting more attention. A likely benefit is that much higher yields per unit area of growing space are possible. The likelihood of gaining extraordinary harvests and superiority from various high value crops in a relatively small area suggests opportunities for small-scale farmers.

Figure 5.3a. Hydroponic farming

Source: www.haydrove.ac.za. Accessed on 12/06/2017

5.3b. Hydroponic farming

Source: www.smarthfarm.ac.za. Accessed on 12/06/2017

Organic farming: this method entails the use of cover crops, green manures, animal manures and crop rotations to fertilise the soil, maximise biological activity and maintain long-term soil health. In addition, it includes the application of biological control, crop rotations and other techniques to manage weeds, insects and diseases (see Figure 5.4 below).

Figure 5.4. Organic farming

Source: www.Paarl-infor.co.za. Accessed on 12/06/2017

Organic farming emphasises the biodiversity of the agricultural system and the neighbouring environment; uses rotational grazing and mixed forage pastures for livestock operations and alternative health care for animal wellbeing; reducing external and off-farm inputs; and eliminates the application of synthetic pesticides, fertilisers and other materials, such as hormones and antibiotics. It also focuses on renewable resources, soil and water conservation and management practices that restore, maintain and enhance the ecological balance. Respondents explained organic farming by saying that organic farming is a technique whereby crops are grown without the use of chemicals, but with the use of animal manures. As one of the farmers clarified: “I use animal manure as fertiliser and I use ducks to eat the insects or pests on the crops.”

Moreover, all participants asserted that fruits and vegetables that are grown in the Paarl geographical area are not genetically modified. They further explained that the crops that are genetically modified are cotton, maize and soybeans which are grown elsewhere. This is confirmed by the National Academy of Science (2010; see Chapter 1, section 1.2). None of the respondents grow maize, cotton or soybeans which are grown elsewhere. The main crops that are grown in Paarl are grapes, apples, strawberries and tomatoes; of these, grapes and strawberries are the most popular. None of these are genetically modified.

5.3 Conclusion

This chapter discussed the research findings classified according to themes. The latter were determined by the study objectives and topics emanating from the interviews and FGDs conducted with the participants. In order to paint a comprehensive picture, both the expected and unexpected themes were discussed based on the results of the interviews and FGDs.

The interviews and the discussions revealed that despite awareness about GM technology, none of the farmers who participated adopted GM technology and the majority of the farmers use alternative farming methods such as precision, organic and hydroponic farming. It was noted that farmers' perceptions do influence GM technology adoption. However, public perception also played a significant role in preventing these farmers from using GM technology. It was found that although the Adopter-perception model is the best existing model to assess farmers' perceptions on GM technology adoption, it should be expanded to include public perception and alternative methods of farming. These two aspects have a decisive influence on farmers' perceptions of genetically modified technology and how it affects their decision to adopt or reject GM technology.

The following chapter, Chapter 6, provides a summary of and conclusion to the study. Some policy guidelines are also recommended.

CHAPTER 6: SUMMARY, POLICY RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This chapter has a three-fold focus, it:

- summarises the study to refresh the mind of the reader;
- arrives at conclusions based on the research findings; and
- makes recommendations.

6.2 **Summary and conclusion**

This study focused on an analysis of perceptions held by a sample of large-scale farmers and small-scale farmers on the adoption of genetically modified (GM) technology and how it influences their decision to adopt or reject GM technology. The study was conducted in Paarl in the Western Cape Province, South Africa. Chapter 1 dealt mainly with the background of the research study, the research problem and objectives of the study. The debate on GM technology determined the framework for this study.

The following study objectives were set against the background of the South Africa government's promotion and legalisation of the use of GM technology in agricultural operations through a specific policy framework and an act of parliament:

1. to present and discuss the Adopter-perception model as a theoretical framework to study perceptions of farmers on adoption of GM technology;
2. to present the case study of large-scale and small-scale farmers in Paarl, Western Cape Province of South Africa in geographical, agricultural, economic, social and environmental terms;
3. to investigate the perceptions of large-scale and small-scale farmers regarding the adoption of GM technology and the effects thereof;
4. to identify and analyse factors as well as a conceptual model in terms of environmental, economic and social aspects that impact the farmers' decisions to adopt GM technology; and
5. to propose guidelines addressing the perception of farmers and to enhance an increase in the adoption of GM technology.

Chapter 2 dealt with the explanation of concepts, the origin of GM technology and the debate on GM technology. It further explored the impact of GM technology on the economy, livelihood and environment. The introduction of GM technology has elicited different views within the intellectual and the farming communities and; the intellectual debates on GM technology centered on Western knowledge and Indigenous knowledge. Furthermore, it emphasised that farmers form their own perceptions towards adoption and use of GM technology. Since perception is a contextual variable, small-scale and large-scale farmers may not have the same perceptions on the adoption of GM technology.

The Adopter-perception model as theoretical framework was presented in Chapter 3 provide a framework to explore the various perceptions held by Paarl farmers concerning GM technology and the relationships between these perceptions were analysed with regard to decision making pertaining to GM technology adoption. The ultimate aim was to confirm whether the Adopter-perception model could be used to determine the extent of adoption of GM technology amongst small-scale and large-scale farmers in Paarl. A detailed explanation of the adoption model was provided with detailed discussions on the Innovation-diffusion, Economic-constraints and Adopter-perception models. It was found that potential adopters perceive innovation characteristics differently to which may lead to varied adoption behaviours. Even if a given innovation's attributes appear attractive and acceptable to others, individuals may not adopt the innovation due to his or her perception of it. The behaviour of individuals is predicated on how they perceive GM technology attributes. Because different adopters might perceive these characteristics in different ways, their eventual behaviours might differ (Moore & Benbasat 1991:194). It can therefore be argued that smallholder and large-scale famers may perceive the attributes of agricultural technology differently, which may results in varied behaviours concerning GM technology adoption. For the purpose of this study, the researcher focused on the following innovation characteristics: perceived relative advantage, perceived complexity, perceived compatibility, perceived risk and perceived cost (as shown in Figure 3.4) to determine adoption behaviour among small-scale and large-scale farmers.

The chapter determined that a farmer's adoption behaviour involves complex procedures and farmers go through certain stages before adopting or rejecting new agricultural practice. The Adopter-perception model, on which this study is based, assumes that a potential adopter may have economic resources (capital and land) and have obtained information about the innovation in which he / she is interested. Nonetheless, these are not enough in themselves to determine adoption behaviour. Adopter perception suggests that a potential adopter may reject or accept a new technology based on its attributes or characteristics.

To investigate the perception of farmers on the adoption of GM technology, the study opted for a qualitative research paradigm as the overall methodological approach to guide the study (see Chapter 4). Using this approach, the study adopted content analysis and field research for its data gathering and analysis to examine the perceptions among the said sample of farmers regarding the adoption of GM technology. Through the case study design, primary data were collected from 15 small-scale and 15 large-scale farmers by means of semi-structured interviews and focus group discussions. Chapter 4 also provided contextual appreciation of the farmers. It furthermore dealt with the aspects of validity, reliability, ethics, limitations and challenges. Chapter 5 presented the research findings according to the themes that emerged from the empirical results, identifying and analysing the factors that impact on farmers' decisions to adopt GM technology.

The study demonstrated that perception has an effect on GM technology adoption and the findings can be used to distinguish users and non-users of GM technology. Both the small-scale and large-scale farmers who participated indicated that they are driven by commerce and profit-making and, they regarded farming as a business. All of the respondent farmers indicated that they use diverse types of agriculture methods; most of them were of the opinion that GM technology is just one of many technologies. They further stressed that given the drastic challenges that traditional farming methods face, including the effects of climate change, water scarcity, growth of population and changing political environments, there is a need for new agriculture technologies. However, they expressed their misgivings about GM technology because of doubts based on its affordability, its detrimental effect on the environment as well as on the economy and their livelihoods. According to their perspectives, GM technology may cause some variations in the environment and these variations could harm the ecosystem and non-GM crops too.

All 30 respondents mentioned that their perceptions on GM technology influences their adoption decision. However, respondents further indicated that consumer perception also has a major influence in their decision to accept or reject GM technology since the public is the target market. The majority of farmers acknowledged that they were aware of the existence of GM technology and understand what GM technology is all about. In this regard, the study's findings demonstrate widespread awareness of GM technology as the first stage in adoption. Participants mentioned that they form their perceptions based on the information received and their subjective analysis of it.

Results indicated that 20% of the farmers would be willing to adopt GM technology because of the positive perception they have of GM technology. However, they expressed concern about the consumers and whether they would buy the GM crops or not. It is clear that impact of public perception and sentiment outweighs farmers' perceptions with regard to adoption of GM technology. Farming in Paarl is considered business (not just subsistence) and all the farmers want to generate income, therefore they cannot depend solely upon their own perceptions in regard to their adoption decision.

Based on the analysis of data, this study suggests that the Adopter-perception model needs to include consumer and/or public opinion. In the next section recommendations for policy guidelines are made based on the findings of the research study.

6.3 Policy Guidelines

Farmers' perceptions as well as those of the public are key in adopting GM technology. What people think about a particular innovation influences their decision to accept or reject it. In light of the findings of the study, the following recommendations are made:

- The South African government should investigate public perceptions with regard to the adoption of GM technology or any new agricultural innovation prior to making policy decisions.

- The government and other relevant stakeholders need to educate farmers and the public about the full potential and risks associated with GM technology.

- Appropriate institutions should be developed to provide training programmes, outreach, research and demonstrations in order for all stakeholders (such as agriculturalists, farmers and the public) to make objective decisions regarding the adoption of GM technology, crops and food products.

- A management strategy of public perception needs to be implemented to ensure extensive and appropriate outreach about the technology for a wide range of audiences. Perception has strongly emerged as one of the factors that may constrain and/or promote the adoption of GM technology or any new agricultural innovation.

  In this regard use of both electronic and print media should be expanded to increase awareness and knowledge of GM technology.

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APPENDIX A

Title:

An analysis of perceptions amongst farmers on the adoption of GM technology in Paarl, Western Cape- South Africa.

Researcher name: Mr. FESTUS OWUSU

Please tick the box

1. I authorize that I have read and comprehend the information sheet dated 20/08/2018 for the above study. I have had the chance to reflect on the information, ask questions and have answered the questions reasonably ☐
2. I recognize that my involvement is optional and that I am allow to pull out any moment without giving reasons. ☐
3. I approve to participate in the above ☐ study.

Name of the participant …………………………………………………………………

Date ---

Signature ………………………………………………………………………………

APPENDIX B

INTERVIEW GUIDE

To present adopter perception model as theoretical framework.

Q1 Did you adopter GM technology base on your own perception or thinking? …………………………………………………………………………………………………… ……………………………………………………………………………………………………

1B. Give reasons why you adopted GM technology?...

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

To present the case study of large-scale and small-scale farmers.

Q2. State why GM technology is good or bad for you as a farmer in terms of:

Geographical --

Agriculture …………………………………………………………………….

Economic …………………………………………………………………….

Social ……………………………………………………………………….

And environmental …………………………………………………………..

To investigate the perceptions of large-scale and small-scale farmers

Q3. What do you think about GM seeds? ……………………………………………………………

3B. What factors influence you to adopt or not to adopt GM technology in your farm operations?

……
…………………………………………………………………………

APPENDIX C

UNISA university of south africa

Department of Development Studies
University of South Africa
P.O Box 392
UNISA
0003
Pretoria, South Africa

Date: 20 August 2018

To whom it may concern,

REQUEST FOR PERMISSION TO UNDERTAKE MASTERS (MA) RESEARCH BY MR FESTUS OWUSU (UNISA STUDENT NUMBER: 56754728)

I wish to introduce Mr. Festus Owusu as our Masters student in the Department of Development Studies, School of Human Sciences at the University of South Africa (UNISA). Mr. Owusu is currently pursuing his Masters studies in the field of Development Studies under the supervision of Prof DA Kotze. His approved research topic is: ***Analysis of perceptions among farmers on the adoption of GM technology in Paarl, Western Cape.*** Mr. Owusu is currently undertaking his field research, which is a fundamental requirement for the completion of his degree programme. In addition, it is important for you to know that the research proposal for Mr. Owusu has already been approved and given ethical clearance by the UNISA Policy on Research Ethics through the Ethics Review Committee. To that extent, high research ethical and confidential standards shall be adhered to at all cost.

Given the above background, it is my sincere hope that you will accord him the needed support to accomplish his research tasks and participate in the research study.

You are welcome to contact me, should you need any clarification or confirmation.

Yours sincerely,

Prof DA Kotzé

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