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The ethical and legal concerns of the use of genetically modified (GM) foods in South Africa

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CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1 General Introduction

"In all of humanity's past experience, living things enjoyed a separate, unique and identifiable place in the order of nature. There were always rabbits and robins, oaks and ostriches, and while human beings could tinker with the surface of each, they couldn't penetrate to the interior of any….The redesign of existing organisms and the engineering of wholly new ones marks a qualitative break with humanity's entire past relationship to the living world…. Engineering new forms of life requires a wholesale transformation of our thought patterns" (Rifkin, 1983).

Worldwide genetically modified (GM) foods have created one of the main challenges in the 21st century in the food manufacturing industry. GM foods are questioned regarding their safety by consumers, scientists and medical professionals because of the perception that these foods may create a severe risk to the health of society and those most susceptible are the young, aged, pregnant and immuno-compromised (Azadi and Ho, 2010). Presently GM food safety remains uncertain largely because of deficient long term scientific data on the effects of exposure to GM products. Presently the world has over 800 million people who lack adequate food supplies. Malnutrition contributes to almost half the 12 million deaths occurring annually in 3rd world countries of children under the age of five (Asante, 2008).

Therefore, the call for escalating agricultural yields is a vital concern in the entire developing world. Numerous reasons are suggested to authenticate GM food production. Politicians and scientists' world over see GM crops as the only response to food shortage impediments and an answer to the anguish for the worlds famished masses (NCB, 2012).

Developments in cell biology and molecular biology have resulted in the genetic engineering or modification of organisms (Racovita, 2013). The use of GM microorganisms does not inevitably increase alarms but there are significant ethical apprehensions; concerns about muddling with nature; concerns about safety for human health, and concerns about the environmental impact (Racovita, 2013). However, the new knowledge of GM technology will provide openings to hasten the competence and add to agricultural improvements by the transferring of genes which display characteristics resistant to "pests, disease, herbicides and environmental stresses, as well as quality traits such as improved post-harvest storage, flavour improvements, enhanced nutritional content and colour" (Coles and Ladikas, 2013).

GM foods usually originate from animals, plants or microorganisms which have previously been genetically manoeuvred at the molecular level to give them the characteristics that farmers and society want (Racovita, 2013).

There are many who perceive GM organisms as equal to "playing God": an act which is considered to be unnatural and therefore should not be done. The commercialisation of nature may be considered to be unacceptable by some people. There is an entrenched conviction in a number of societies that interfering with nature is offensive (Cromstock, 2000). This view point is as true in African cultures as it is in European cultures. The notion that genetic modification cannot happen naturally is erroneous and is the view of many, although it is not frequently visibly articulated (Asante, 2008).

Cromstock (2000) stated "that many argue that this argument precludes any selective approach that results in improved crop plants, for by doing so, we are playing God. Others argue that it is only that which could not have happened without human intervention that is unacceptable." Even though the modification may be accepted, religious opposition may signify that the resultant organism is undesirable, for example "genes derived from the pig

inserted into foods could arguably be unacceptable to those whose religion precludes the use of products derived from the unclean animal" (Cromstock, 2000). This research project is aimed at raising the ethical, legal and social issues about the use of GM foods in South Africa and will also highlight the continuing deliberations on the aspects of health protection, societal perceptions and approval and ethical concerns. The relevant legislation and controls which are currently in place in South Africa governing GM usage will also be reviewed.

As in other types of technology, introducing novel technologies like GM may be dependent on the perceived balance between the advantages of the innovation and the possible hazard to the eco system and the wellbeing of society (Pattron, 2000). The necessity for precise legislation on the usage of GMOs was never assumed although it was acknowledged that policy was required. The UK regulated genetic manipulation in 1978 and by 1983 had regulations in place. A few years later, the US published policy aimed at ensuring the safety of biotechnology research and products (Kinderleren and Adcock, 2003). Up until 1997 when legislation was put in place, South Africa, regulated transgenic organisms through a voluntary system (Kinderleren and Adcock, 2003).

It is very important to acknowledge that numerous groups of people in the world have opposing human rights and fears and it is important to equilibrate their needs (Kirsten et al., 2002). The principle of distributive justice brings to light numerous questions which must be addressed in order to achieve equilibration. Nicolaides (2014) highlights a few, "Is this new technology likely to increase the gap between the rich and the poor, both across and within countries and particularly in developing countries? Are the products produced by the technology able to provide for those who really need it most viz. the poor? Will it generate wealth for the society as a whole which can assist those who need it?"

1.2 Aim and Research Questions

The aim of this research is: To normatively assess the ethical concerns of the use of Genetically Modified (GM) Foods used in South Africa by addressing the following research questions.

Is it ethically justifiable to produce genetically modified foods and does South African legislation provide adequate control over the use of GM foods in South Africa?

1.3 Study Objectives

a. To provide a historical account of the use of GM technology in the production of food for human consumption.

b. To examine the ethical and social concerns raised by the use of GM technology in food production.

c. To critically evaluate the South African Laws governing the use of GM foods

1.4 Methods

The study design is normative analysis. It is centred on a desktop and library based research project. No new data will be collected or analyzed. The research does not involve human study participants. The typical research methods and standards applicable to philosophical research is employed. The findings should be discussed from literature which is ethically analysed. This should primarily involve the interpretation and critical analysis of the most important texts, postings and relevant government legislation to answer the research questions. The analysis of the relevant texts should include the clarification of concepts, the identification and criticisms of assumptions, the analysis and evaluation of theoretical frameworks and the articulation of the most reasonable interpretation of significant concepts

found in the sources. Sources of literature are to include and not be limited to research articles, books, Google Scholar, Pubmed, Government legislation and other academic search engines using key words and phrases such as genetic modification/engineering, genetically modified foods and crops and biotechnology for gathering the research data.

1.5 The History and Background of GM Technologies

It is useful to provide a historical background to the development of GM technologies and its applications which form the corner stone of the development of Modern Biotechnology. Going back to pre-historic times the improvement of "plants and animals has been done by selective breeding" (GM Education, 2012).The concept originated at the start of farming when a selection of wild grasses was subsequently cross bred to form the forerunners of current day staple grains such as wheat, rice and maize (GM Education, 2012).

Many of the selections and applications of these procedures have achieved huge differences with special reference to "form and function from a single wild species, for example, the Great Dane and Chihuahua dog varieties which originate from the wolf" (GM Education, 2012). Further to this atypical hybrids i.e., developing breeds across genus obstacles were made in earliest times e.g. "a mule – which is a cross between a jackass or male donkey and a mare, has been used as a pack animal for at least 3000 years" (GM Education, 2012).

To better understand and visualise the evolution of genetic technologies is to look at the history of the discoveries and developments in genetic technologies which was drawn up by genetics expert G.L. Woolsey and was first published in July 2012.

"Biotechnology, genetic modification, transgenic crops, *Bacillus thurgiensis* is words and phrases used in debates on genetically manipulating food" (Woolsey, 2012). What is the meaning of all of this? The lingo of GM can be the biggest obstacle to society's perception of

the technology. For the purpose of this research work one needs to appreciate GM simply as, "The manipulation of an organism's genetic make-up to create or enhance desirable characteristics from the same or another species" (ADEH, 2001).

Gene manipulation of foods goes back in history, even though the current wonders of GMOs and transgenic crops have come to the forefront over the past few decades. "The 1980's marked the scientific discovery that specific pieces of DNA could be transferred from one organism to another" (Cramer et al., 2001). This became the foundation on which GM processes were built. In 1983, "the first transgenic plant, a tobacco plant resistant to anti-biotic was made known" (Cramer et al., 2001). Monsanto the leading biotechnology company followed five years later by introducing "herbicide-immune soybeans otherwise known as Round-Up-Ready" (Cramer et al., 2001). The guarantee that GM processes were manipulated to introduce essential micronutrients to enrich foods led to the development of Golden Rice which had an increased vitamin A and iron content and this progressed onto Bt Cotton (Cramer et al., 2001).

It is over 60 years since the identification of the deoxy-ribonucleic acid (DNA) was made known by Watson and Crick (1953). This discovery recognised the supportive association between Adenosine and Thymidine and between Guanosine and Cytidine" (Watson and Crick, 1953). This highlighted the possibility of a mechanism for the transfer of information between organisms in a specific and controlled way.

The potential applications of GM became clear when it became possible to transfer genes between two unrelated organisms (Kinderleren and Adcock, 2003). Following this, the government of the United Kingdom started a committee and in 1975 reported on the possible benefits of genetic manipulation technologies and stated, the technology could has the potential to offer considerable unpredictable benefits some of which may include compass the

climatic array of crops thus equipping plants to secure their nitrogen supply from the air (Kinderleren and Adcock, 2003).

This was followed by a set of guidelines drawn up on using the very latest recombinant DNA technology by a group of scientists in California in 1975 who called themselves the *Ashby Committee*. The guidelines for the use of this technology incorporated the necessity to recognise the likely dangers to the investigator and or others parties and the procedures that can be used to test for and reduce the biohazards so that there is continuation with the research (Kinderleren and Adcock, 2003). At this point the committee of scientists established that the advantages of the technology overshadowed the risks provided that appropriate safety measures were in place (Kinderleren and Adcock, 2003).

In current times biotechnology and the development of genetic modification is up-and-coming and progressing around the world and it extends beyond arable agriculture. It's now used extensively in the commercialisation of chemicals and pharmaceuticals which have a high value (Kinderleren and Adcock, 2003).

Introducing GMOs into food products has had various degrees of success across the globe. Even though, societies in numerous countries have feared introducing the products of this technology. Governments are not as unforthcoming, and acknowledged the advantages which may come from GM use and the hazards that it hypothetically presents (Kinderleren and Adcock, 2003).

The Cartagena Protocol was agreed on in 2000, after much negotiating and discussion, and was published in Article 19(3) of the Convention on Biological Diversity. Worldwide participation was taken into consideration for the possibility of a Protocol to be used for the use of living modified organisms that might have adverse effects on biological diversity (Kinderleren and Adcock, 2003). Developing countries wanted more out of the Protocol than

they could get; to include multiple safety measures. It must be remembered that while the potential of GM foods is good, the number of unknowns is of great concern, especially those who want the development set aside until the safety of GMOs can be confirmed by science and further research studies and thus modern Emerging Biotechnologies come to the forefront (Kinderleren and Adcock, 2003).

1.6 Modern Biotechnologies

The term Biotechnology was reportedly coined in 1919 by Karl Ereky, a Hungarian engineer, in "reference to the science and the methods that permits products to be produced from raw materials with the aid of living organisms" (OECD, 1999).

In its widest description, biotechnology is defined as any technique using~~w~~ living organisms to manufacture products, to improve plants or animals, or to develop microbes for particular uses (EUFIC, 2000). This extends to the age old technique of plant cultivation, animal husbandry and fermentation, which extends back to many years (EUFIC, 2000). The birth of Modern Biotechnology can be traced back to when Watson and Crick produced their double helix model of DNA (Kinderleren and Adcock, 2003).

Even though the start of modern biotechnology could be dated, it is doubtful that mankind's continuous hunt for a more profound understanding and more knowledgeable use of nature will ever be addressed. The coming out of biotechnology is categorized as a process of drawing together knowledge, practices, products and applications into a feasible and industrious relationship (OEDC, 1999).

In knowledge founded technology areas such as modern biotechnology, requires an exceptional technological and intellectual environment for scientific and economic success

(Rahman, 1998). Modern biotechnologies are unlike established biotechnologies in that they are particularly sensitive to contextual factors that can shape their evolution (NCB, 2012).

Modern or emerging biotechnologies are distinguished from other technologies by the fact that they utilize or affect living things, and therefore engage the public interest in distinctive ways (NCB, 2012).

A significant component of "modern biotechnology is the understanding, transferring and altering of genes, the components which allow all traits to be inherited" (NCB, 2012). It could result in the maximum yield of an ear of wheat, the colour of a tomato or the enzymes produced by a strain of yeast (NCB, 2012). The modified plants are known and referred to as transgenic. Transgenic plants encompasses a number of issues in "philosophy; the meaning of words; free will, the concepts of right and wrong and ultimately the meaning of life itself" (Robinson, 1999).

Transgenes involves the use of information about the "inheritance of traits (Robinson, 1999). Thus, plant propagation assumed scientific status and during the past 100-years has developed to allow very direct control over crop progression for man's benefit (Robinson, 1999). Until the beginning of Genetic Engineering plant breeding was confined to cross breeding within and between plant species which could occur naturally. The development of transgenic plants had become an everyday occurrence over the past few years (Robinson, 1999). In most living things their genes consist of DNA, whose function it is to produce proteins and store genetic material.

Biotechnology in general and more specifically modern biotechnology, is considered one of the leading empowering technologies of the 21st century. Biotechnology applications extends to four major industrial areas including health care (medical), crop production and

agriculture, non-food (industrial) uses of crops and other products and environmental uses (NCB, 2012).

Modern or emerging biotechnologies could potentially provide a tool for increasing productivity in agriculture as well as deliver crops that have enhanced nutritional values and are resistant to different kinds of stresses. A number of expressions have been derived to classify the many avenues of Modern Biotechnology. Rahman (1998) for example categorised Biotechnology into four main areas namely:

1. **Blue Biotechnology** which is used to describe the application of biotechnology in marine and aquatic life systems

2. **Green Biotechnology** refers to the application of biotechnology to agricultural processes. A good example which can be used to demonstrate this area is the designing of transgenic plants suited for specific climatic conditions.

3. **Red Biotechnology** is the application of biotechnology to medical processes which include the design of organisms for the production of novel more effective antibiotics and other medicines and cures.

4. **White Biotechnology** is the industrial application of biotechnology which is used to improve productivity and reduce carbon emission by substituting chemical processes with transgenic organisms and their products i.e. enzymes.

To summarise this, modern biotechnology proposes prospects to advance the quality of products, improved nutritional value and financial advantages. The genetic character of plants and animals may be adapted by inserting new more useful genes or the exclusion of undesirable genes. Biotechnology is altering how plants and animals grow, which in turn increases their value to growers, processors and consumers (Rahman, 1998).

However, Modern Emerging Biotechnologies is faced with three major challenges for policy and governance, those being uncertainty, ambiguity and transformative potential (NCB, 2012).

- **Uncertainty**

A lack of knowledge about the array of likely consequences of a biotechnology, for example whether desired outcomes can be achieved or unintended harms can be avoided. Uncertainty is differentiated from measurable risks, where both the variety of consequences and the probability of their incidence are foreseeable with realistic levels of self-assurance (NCB, 2012).

- **Ambiguity**

The implications and products of biotechnologies mean different things to different people and in different ways. An appreciation of the different meanings of harm and benefit, for example, as well as whose harm and benefits are allowed to count and how these are distributed, may be an important condition of ethical decision making (NCB, 2012)-.

- **Transformative Potential**

Emerging biotechnologies have the potential to change common ways of life and open entirely new range of possibilities. Transformative effects may operate not only at the level of what can be made or done, but also affect the way in which the future may be thought about or imagined (NCB, 2012).

Even though modern biotechnology offers a variety of useful applications, some raise novel challenges and anxieties that require consideration. The rapid adaptation into new products and processes by research, observing of expansions in modern biotechnology appears

essential to develop policy which is specific to the evolving issues and to cautiously evaluate the dangers and benefits in the process (IPTS, 2007).

1.7 Food Safety and Food Security

World over the magnitude of food safety is not yet fully appreciated by the community health establishments. We are faced with a continuous rise in outbreaks of diseases such as Cholera, *E.coli* infections, and Foot and Mouth disease in both industrialized and developed countries (Käferstein and Abdussalam 1999; Juanillo 2001; WHO 1988). The continuing coverage of the risks and benefits of agricultural Biotechnology have repeatedly placed science and the scientist in the midst of this dilemma (Juanillo, 2001).

There is substantial public interest in the issue of food safety which will remain in the spotlight in the 21st century. This is especially true in light of global changes – (e.g. urbanisation and environmental changes) and new technologies – (e.g. genetic modification) which have become more prevalent (Käferstein and Abdussalam, 1999).

Although public opinion studies do not show the anti-biotechnology phenomenon which is often spoken about, the move against biotechnological developments does exist in some parts of the world. In Europe and in parts of Asia, it can be seen that the public opinion about biotechnology has been negative and more specifically the mistrust of the use of GMOs (Käferstein and Abdussalam, 1999).

Currently the global debate on GMOs is centred on the concern with food safety and the environment as much as it would address the questions facing agriculture, science, technology and society. There are all relevant issues with regard to ensuring food security and safety in the 21st century as the applications of this technology forges ahead (FAO, 2001). Food safety forms the basis of customers' anxieties about GMOs. This arises out of

problems associated with already existing non-GMO foods. The problems cause consumers to be weary of the safety of foods produced with the new technologies (FAO, 2001).

One can agree that anxieties on food security has grown over the past fifty years or more from both a physical point of view at an international level to providing food to persons. The position of poverty is the driving point to make sure there is access to food around the year for the global population (FAO, 2001).

Swaminathan (1998) concludes that one has to consider food security in terms of physical availability and socio-economic and environmental access (cited in Hall, 1998).

Hall (1998) cited that Maxwell (1998) concluded that there have been important modifications in the food security program since the mid-1970s. According to Maxwell, the discussion on food security is "concerned with the complexities of livelihood strategies in difficult and uncertain environments and with understanding how people themselves respond to perceived risks and uncertainties" (Hall, 1998).

As the process of the adoption of this new technology rapidly unfolds there is much to be done with addressing the challenges that are presented in addressing food safety and food security globally before there is societal acceptance. A number of the 3rd world countries do not have the ability essential to carry out the required evaluations and controls on whether they would profit from the GM technologies and whether they can comply with the safety regulations or not.

An outline of the following chapters in this research report include:-

1. Chapter Two – Existing and possible applications of GM technologies in food safety and security.

2. Chapter Three – Agriculture in 3rd world countries, societies' acceptance of GM technology and the advantages and disadvantages of GM products,

3. Chapter Four – The ethical concerns

4. Chapter Five – Overview and analysis of South African law

5. Chapter Six – Conclusion

CHAPTER TWO: TRADITIONAL AND GM TECHNOLOGY FOR PLANT PROPAGATION: ITS IMPACT ON AGRICULTURE AND INFLUENCE ON SOUTH AFRICAN FOOD PRODUCTION

2.1 Introduction

In this chapter the concepts of GM propagation versus traditional plant propagation will be discussed. The chapter will proceed with the effects of adopting GM technology on agriculture showing how the technology has contributed to advancing agriculture. In conclusion the chapter will provide an overview of the available products and plants in SA to demonstrate how GM technology has infiltrated the SA food and agricultural sectors.

The importance of investigating or evaluating agricultural applications in South Africa is to establish the bases of where South Africa is positioned within the GM technologies. This sets the platform on which the rest of the report is built.

The potential applications of modern biotechnology are vast and its application extends to many different sectors such as biopharmaceuticals, plant breeding and production of chemicals (IPTS, 2007). Modern biotechnology is seen as the main an enabling technology of the 21st century (IPTS, 2007).

Traditionally biotechnology has been applied for many years in the fermentation industry for the manufacture of breads, wines and beer. In the late 19th century, farmers became aware of the principles of heredity, which gave them new tools for breeding crops and animals. In the 19th century farmers selected individual organisms with beneficial characteristics and they cross bred them creating hybrid crops. Since the discovery of the DNA structure in 1954 new methods of breeding have been developed applying the new technology (FAO, 2004). DNA carries the genetic code which regulates all biological processes in living organisms and is

structured in a similar way in different species which aids in the identification of potentially useful genes. Fragments of DNA are used to identify the position of a particular gene which are used to the selection of organisms carry beneficial genes (FAO, 2004).

In conventional breeding half of the genetic makeup of the off-spring comes from each of the parents; unlike in GM one or many select genes are added to the genetic makeup of the organism. Unlike GM, conventional plant breeding can only combined with closely related plants, while GM allows the transfer of genes between organisms which are not normally able to cross breed (FAO, 2007).

Agricultural biotechnology is seen in two ways. The first being a scientific complement to conventional agriculture, aiding plant breeding programs (FAO, 2007) and the second being a departure from conventional agriculture, enabling GM technology (FAO, 2007).

2.2 The use of GM Technologies for Plant Propagation VS. Traditional Propagation Methods

The application of new biotechnologies together with novel agricultural processes, and the joint use of new knowledge have made a substantial contribution to the doubling of global food production in more than 60 years. Parallel to this cultivators have adopted an assortment of novel technologies which are being implemented in first and third world countries. A number of these advances have resulted from contributions made by biotechnology (NCB, 2003).

Some of the biotechnological contributions made towards agriculture include double haploids, (which enables the creation of pure breeding lines in a single step); mutation breeding (which allows for the generation of new variations through irradiation or chemical

treatments; tissue culture (Wambugu and Kiome, 2001) and the application of transgenic technologies to improve the desired characteristics of crops.

A basic understanding of the differences between the concepts of conventional plant breeding vs. GM plant breeding is needed so that a greater appreciation of the concepts will be achieved. GM plant breeding allows the selection of single genes from an organism to be incorporated as part of another species. The resultant organism is transgenic, so the application of GM technology allows for the creation of a GMO. This could occur between two unknown or known varieties of species. GM technologies are mainly used to promote desirable or specifically required crop characteristics or traits. Thus, the name transgenic originated from transferring the gene from one organism to another (NCB, 2003).

Traditional on the other hand is thought by many to be morally the right approach, because it is perceived that it is immoral to modify the core of naturally created things like plant life. This creates discussions which are complex and which may become contentious. Therefore, it makes sense that the initial starting point would be to address the connection between conventional cultivation which is otherwise referred to as the traditional approach and cultivation using genetic modification. It then would be necessary to understand the impact of transferring genes across species and the effects they may have on infringing on the natural borders of species.

Traditional plant breeding is seen as selecting specific entities from larger more varied natural plant types and is seen as being natural. Similarly the methodical inbreeding of plants in nature is viewed in the same way. Crop cultivators are also known to produce crops which may not otherwise be possible without well thought out inbreeding utilising methods such as wide-crossing which leads to a totally novel range of plants being created. Mutation breeding is another method which involves radiating exposure or chemical exposure of crops and seeds

for the purpose of stimulating mutations. This type of mutation is classed as a natural mutation even though it is forced by other agents, because the actual mutation that occurs is seen as natural and that the outcome of it is not predetermined by man. Both methods of deliberately altering of the crops as they occur naturally have been used for a long time in agriculture (NCB, 2003).

Therefore, in the same context GM is perceived as a novel way of achieving a similar result. GM technology allows genes to be inserted by researchers from unconnected species into crops. This may usually be the case when bacterial gene sequences are inserted into different plant species (NCB, 2003).

The difference of GM and conventional plant breeding is that using GM technologies is a faster more efficient method in acquiring the desired end result of improved crops because it is target specific. In 1999 the Nuffield Council of Bioethics decided "that it was not helpful to classify a crop that was achieved by conventional plant breeding as natural and to classify a crop with the same genetic complement as unnatural if it has been produced through GM" (NCB, 2003).

To further explain this one can use the propagation of roses as an example. If one has a white rose and a red rose and if one wishes to cultivate a pink rose, the farmer will simply cross breed the red and white rose and hope that the resulting rose would be pink. However, there is no guarantee that this will result in the desired outcome. The resulting rose could be a white rose with speckled red spots. This type of conventional cross breeding would be considered to be natural.

However, if one had applied GM technology, the relevant gene from the red rose would be transferred to the white rose or vice versa and it would guarantee that the resulting rose would be pink. This type of breeding will be considered unnatural.

One can argue then on how mutation breeding can be considered to be natural. Although the mutation is forced by outside sources like chemicals, the end result cannot be guaranteed or predicted and therefore, it is considered to be a natural manipulation.

Evidence which supports this theory is the transformation over time of a single stem rose to multiple roses on a single stem. This may result by allowing natural mutations to occur, however it could very well take a number of years to achieve the desired end result. While the application of GM technology could hasten the process and the benefit would be seen immediately.

However, what is of great concern is that the method of GM may have unknown risks which may be different from those which may occur from other crop cultivating methods i.e. conventional or traditional methods. What is of concern is based on the premise that the anticipated effect achieved by conferring a specific characteristic by inserting a particular gene in the modified plants may result in inadvertent traits (WHO, 1988). It can be argued that unintentional effects are not only explicit in the use of GM technologies and may also occur in conventional cultivation and more specifically in the case of mutation breeding (Royal Society, 2002).

Indirect environmental effects may be caused by transgenic crops as a consequence of altering agricultural or environmental methods related to the novel varieties of crops. These consequential outcomes may be of benefit or harm depending on the nature of the transformation involved (ICSU, 2003). It is agreed by scientists that the use of "conventional agricultural pesticides and herbicides" have been known to cause damage to the natural habitat of birds, insects and undomesticated plants (ICSU, 2003). Transgenic plants are known to change the chemical constituents of the soil and land-use formats and cultivation methods, however, this is not entirely agreed upon by scientists, because they cannot be sure

that these total changes will be positive or negative to the environment (ICSU, 2003). It is accepted by scientists that more research on the new technology and comparisons to the conventional farming methods is required.

2.3 The Effect of Genetic Modification on the Agricultural Environment

The main reason for using GM technologies is to improve the yield and/or quality of crops. Various factors influence the yield of crops for example pests, disease, soil conditions, or abiotic stresses stemming from unsuitable climate conditions (Witcombe and Sanchez, 2004; Conway, 2003). Agricultural crop yields can be improved by irrigation, the application of insecticides or pesticides and the addition of fertilisers (Witcombe and Sanchez, 2004; Conway, 2003). The down side of this is that these methods are costly especially for smaller farmers in developing countries (Witcombe and Sanchez, 2004; Conway, 2003). This raises the issue of justice and fair trade, because smaller farmers in developing countries do not have the financial backing to use the novel technologies and therefore are unable to compete with larger commercial farmers. This injustice forces the smaller farmer to continue to use conventional methods which limits their growth and economic stability.

Using GM technologies offers plant breeder's novel prospects to the production of plants that are sheltered from ecological stresses and the attack from disease causing organisms as well as insects. There are numerous plant characteristics which researchers work towards developing by using GM technologies. Some of these are still in the early developmental stages while others have been accomplished and implemented by cultivators. There are instances where these characteristics can be achieved by using traditional cultivation methods, while others may only be achieved by using GM technologies. The five most important and commonly desired traits are herbicide tolerance; insect and pest resistance;

bacterial; fungal and viral resistance; abiotic stress resistance and micronutrient enrichment, each of which will be discussed briefly (NCB, 2003).

2.3.1 Herbicide Tolerance - These plants' transgenic characteristics bestow tolerance of the plant to specific herbicides. This characteristic permits farmers to utilise herbicides which will be active against a wide selection of weeds while at the same time not having any adverse effect to the modified crop itself. Globally the tolerance to herbicide is the main trait in use, e.g., in soybean, maize, cotton and oil rape seed (NCB, 2003). These herbicide tolerant (NCB, 2003) plants are most commonly cultivated in first world countries with the sole purpose of reducing the use of herbicides in agriculture. This particular trait is also attained by using other methods and more specifically mutation breeding and genetic transfer from naturally occurring species (NCB, 2003).

2.3.2 Plant Resistance to Insect/Pests - This transgenic trait is known to produce a certain toxin which is active against specific insects that feed on the crops. These types of genes are now widely used and have led to the considerable reduction in using pesticides and insecticides (NCB, 2003). Insect resistant cotton, maize and potato cultivars are being grown in both developed and developing countries (NCB, 2003).

2.3.3 Bacterial, Fungal and Viral Resistance -This transgenic trait builds the resistance of the plants against biotic stress such as plant pathogens which has a substantial impact on lowering the yields of the crops. The application of these transgenes is far reaching and has been applied to the following crops, for example, coffee, bananas, cassava, potato, sweet potatoes beans, wheat, papaya, squash and melon (NCB, 2003). In some instances the transgenes which are used actually arise in nature within the same plant species (NCB, 2003).

2.3.4 Resistance to Abiotic Stress - Some plants have difficulty to thrive under harsh climatic and soil conditions and this is usually linked with specially chosen genes. These

specific genes are isolated and reintroduced into other plants so as to impart the same desired trait. This type of transgene application promises to be especially beneficial in developing countries, because abiotic stress is increased by conditions such as drought, frost, heat and acidic or salty soils are common (NCB, 2003). Development of these transgenes is currently in progress on staple cultivars such as cotton, coffee, rice, wheat, potato, Brassica, tomato and barely (NCB, 2003). The research is at various phases of development (NCB, 2003).

2.3.5 Micronutrient Enrichment - With the sole purpose of preventing malnutrition, transgenes could play an important role in providing vitamins and minerals or increasing their content. The use of GM technology could assist with providing society with vital micronutrients by consuming their main staple crops which have been genetically enhanced. The development within the area of transgenes is presently in progress and is undertaken on staple foods like rice, cassava, millet and potato (NCB, 2003).

2.3.6 Other Applications of GM Technology

The controversial Gene Use Restriction Technology (GURT) (AEBC, 2002), is another application of genetic modification; it may also be referred to as terminator technology (AEBC, 2002), because it leads to the sterilisation of seeds. The other applications where this technology is applied and is at an advanced research phase include using specific transgenes which improves the shelf-life of fruit and vegetables, and the use of plants for the production of biopharmaceuticals, such as vaccines (AEBC, 2002).

Most of the GM crops grown globally are cultivated in developed countries and this is usually done on large scale industrial farming. However, in 2002 China and SA, cultivated GM crops on a much smaller scale (James, 2002).

2.3.7 Environmental Benefits of GM Technology

The benefits to the environment are far reaching and extend to those applications previously discussed in this chapter as well as other applications which are sometimes not counted because it is not seen to have direct crop yield and quality improvement. These are equally important and examples of these are, the reduction of land needed for agriculture, conserving resources through reducing labour, fuel, fertilizer and water, and water quality protection (Uzogara, 2000).

2.4 Identification of GM Product and Crops Available in South Africa

The use of GM products in most food produced globally is almost unavoidable. A better understanding of this is shown in Table One which serves to demonstrate how vast the applications extend. The use of minor ingredients in a product could be the difference between GM and Non- GM Foods. Table One is a list of randomly selected foods available in South Africa, and demonstrates the varied applications of GM technologies in South African food products both, knowingly and unknowingly.

Table One: A list of household products which contain GM ingredients (Uzogara, 2000)

Common Household Commodities	GM Constituents
Pickles	Dextrose from corn, corn syrup
Milk	Recombinant bovine growth hormone
Soft Drinks	Corn syrup
Tomato Sauce	Tomato and corn syrup
Bread	Yeast, corn syrup, soybean oil, corn-starch, soy flour, dextrose from corn
Aspirin	Corn starch
Honey	GM enzymes (alpha amylase)
Beer	Corn, yeast, enzymes
Some antibiotics	Corn Starch
Breakfast Cereals	Corn, corn syrup, soybean oil
Peanuts Butter	Peanuts, cotton seed oil, soybean oil, dextrose from corn syrup
Food Tenderizers	Food Enzymes
Candy and Gum	Corn syrup, corn starch, dextrose from corn, soy flour
Biscuits	Corn starch, corn syrup, corn flour, canola oil, soybean oil, cotton seed oil
Chips	Potatoes, Corn, cotton seed oil.

Table adapted from: Uzogara SG. 2000. The impact of genetic modification of human foods in the 21st century A review. Biotechnology Advances. 18:179-206.

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In South Africa the GM crops as listed in Table Two are grown and are used for food processing as well as for export purposes. Table Two also identifies the companies and districts in and around SA which cultivates GM crops.

Table Two: List of GM crops grown in South Africa and the districts where grown (Nicolaides, 2014)

GM Crop Type	Company	Districts where grown in SA.
Maize	Agrevo, BASF, Carnia, Pannar and Monsanto	Delmas, Nelspruit, White River, Rustenberg, Swartberg, Hoopstad, Potchefstroom, Malelane etc. (12 districts)
Cotton	Monsanto	Welpe, Messina, Nelspruit, Brits and Rustenburg, Pongola etc. (22 districts)
Soya bean	Carnia, Pannar and Monsanto	Petit, Hendrina, Vrede, Vryheid etc. (10)
Potatoes	First Potato Dynamics	Koue Bokkeveld and Ceres
Tomato	Seminas ARC	Roodeplaat
Apple	ARC – Infuitec	Stellenbosch
Canola	AgroEvo	Krommeree and Elsenburg
Honey	May be contaminated by GM pollens	

Table adapted from: Nicolaides A. 2014. Integrating ethical discourse into GM production. Asian Journal of Business and Management Sciences. 3:04 (84-95).

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There have been concerns expressed about the haste in the introduction of GM plants or the intentions to introduce them into some third world countries. The reasoning behind this is simple. Although developing countries have a greater need for the new technologies, they do not have the necessary support structures in place which will ensure that the implementation will be successful. It has been claimed that despite the increasing populations around the global, the world food production has increased by 16% more than the population in 1st world countries (Five Year Freeze, 2002). Therefore, it is predicted that the current world food production is more than adequate to feed the humankind around the world, that is if the disparity in the right to food availability were eradicated (Five Year Freeze, 2002).

This is only true in developed 1st world countries and the same does not apply to developing 3rd world countries which lag far behind in relation to the population ratio and food security and is a direct result of the lack of adequate support for the implementation of GM technologies as well as available land to sufficiently expand agriculture. The other factor

which influences this is that the ratio of the population in developed countries is far lower in comparison to developing countries. GM plants are often seen as a technological fix (NCB, 2003), and are suggested by those who are unsuccessful in addressing the primary causes of hunger and poverty, which requires economic, political and social change (NCB, 2003).

In the agricultural food industry, biotechnology is applied mainly to advance production competence and improve the quality of food. Therefore, modern biotechnology contributes to reducing the use of resources and the release of unsafe substances. It is not possible to measure the overall contribution of modern biotechnology to the different environmental aims. The fact that the applications of modern biotechnology generally leads to enhancing the eco-efficiency of production processes and serve as new sources for financially viable activity, it also emphasizes its role in decoupling financial expansion due to ecological demands (IPTS, 2007).

This chapter has explained the differences between traditional methods of plant propagation and the application of GM technology for plant propagation. It also demonstrates how adopting GM technology in the agricultural sector has resulted in the evolution of agriculture. The chapter concludes by illustrating how far the application of GM technology has influenced agricultural and food manufacturing in SA.

CHAPTER THREE: AGRICULTURE IN 3RD WORLD COUNTRIES, SOCIETIES' ACCEPTANCE OF GM TECHNOLOGY AND THE ADVANTAGES AND DISADVANTAGES OF GM PRODUCTS

3.1 Introduction

In this chapter the role of agriculture in 3rd world countries, society's acceptance, attitudes and responsibility towards GM technology will be discussed. The chapter will conclude with the advantages and disadvantages of adopting GM technologies.

Biotechnology has been implemented and is often used as an economic, technological and political tool in the 21st Century (Azadi and Ho, 2010). More specifically agricultural biotechnology is an important instrument which offers a variety of possible "environmental, social and economic risks and benefits" (Blaine et al., 2002). In the past few years, modern biotechnology has been severely criticised by the public and has formed the centre of many political debates (Blaine et al., 2002). Research into the opinion of the public, shows that while there has been discussions about the influence of public approval of GM foods and its uses, there is evidence that the public does not outright reject GM foods but rather objects to some specific applications of the technology e.g. the use of animal and human genetic material (Fewer et al., 1997).

Consumers have a particularly contradictory approach to GM technologies compared to innovators, farmers or producers and distributors (GEST, 2013). This is because the latter have economic profits as their most important goal. On the other hand the most important concern of consumers is their personal health and well-being and whether the food meets the consumers' needs in relation to the quality of the food and how it appeals to their senses (GEST, 2013).

3.2 The Function of Agriculture in 3rd World Countries

A 1999 Nuffield Council on Bioethics report considers the potential benefits of GM crops for poor people in developing countries (NCB, 1999). The council argues that in developed countries (first world) the production of food was way ahead of the rate of population growth and this has been so for the past 60 or more years. In Asia and Latin America, a yield enhancing Green Revolution (NCB, 2003), offered a stimulus to increasing employment and as a consequence it improved the life of smaller-scale farmers and landless labourers (NCB, 2003). This also increased food supplies and made it less expensive and provided a more reliable staple food source for the poorer consumers (NCB, 2003).

The same could not be said about Africa and some parts of Asia, because they saw virtually no benefit from the Green Revolution and the population growth outgrew agricultural growth. The reason for the decline in yields was influenced by water shortages, soil erosion and new types of plant pests and plant diseases (NCB, 2003). It is believed that these tendencies will persist in 3rd world countries and so will the rise in the population and persons of workable age (NCB, 2003).

Von Braun and Brown, (2006), showed that economic equity plays a major role in the reduction or increase of poverty and this is greatly influenced by income-generating prospects (Von Braun and Brown, 2006). They said that a justifiable food production system is one that aids needy people and those that are underprivileged and discriminated against (Von Braun and Brown, 2006). Therefore, it is so important to find ways to facilitate reducing poverty and they propose that the way to achieve this is, by improving food security as well as by providing economic development prospects (Von Braun and Brown, 2006).

Even though there have been some improvements in the past few years, it is hardly enough, because statistics show that "over half of all children under the age of five years of age have

stunted growth and the proportion of this is even higher in Africa" (ACC/SCN AND IFPRI, 2000). In developing countries (3rd world) this is as a result of the staple foods having a low nutritional value and lack sufficient essential nutrients like Vitamin A and iron. It must also be noted that the staple foods consist of grains and many growing children consume little or no protein rich foods. As a result they have depressed immune systems which make them susceptible to many diseases and illnesses which thrive in poorer populations.

The population growth which is expected in Asia and Africa by 2030 is 1.33 and 1.76 times its current level respectively (NCB, 2003), and therefore, people in these countries are even more susceptible to increased poverty and poorer nutrition because the food supply is not sustainable (NCB, 2003).

In the poverty stricken areas of the world, agricultural labour is the major resource of employment for the poor. The poor depend on farming as there is not much else where they can draw an income from (Lipton and Ravallion, 1993). Globally farm labourers are confronted with many ethical issues around living environments, the treatment of workers and discrimination based on gender ~~discrimination~~ (Von Braun and Brown, 2006).

In Africa, the farm workers are predominantly women, who are responsible for ploughing the soil and crop cultivation and who also continue to hold other responsibilities in the home, for example, raising children, running the home and preparing the food (Von Braun and Brown, 2006).

Other important components of an, impartial food production system includes the distribution of land, the size of farms, land access and natural resources (Von Braun and Brown, 2006). Access to these components are vital for food production and hence the reduction of poverty. From sustainability view point, the rights of humans to food and to a healthy natural environment (Von Braun and Brown, 2006), cannot be separated, because the ruin of the

environment puts a risk on the global ability to satisfy increasing food obligations. Added to this it is known that reduced food production is adversely related to the exhaustion of natural resources (Von Braun and Brown, 2006). Notwithstanding all of the above, what is equally important to equity in food production is the access to information, knowledge and research findings which plays an important role in contributing to poverty alleviation and to increase food outputs especially with small farmers in rural areas through the advancement of GM technologies.

3.3 Societal Responsibility, Consumer Attitudes and Acceptance of GM Technologies

The attitudes of consumers towards new and existing food products are known to play a big role in influencing and predicting behaviour in light of food safety. Consumer differences are based on many influential issues, including demographics and socio-economic status (Wilcock et al, 2004). The social, economic and cultural diversity of people in relation to using and releasing of GM products do not receive as much thought as does the normal scientific and technological side. Technology is inseparable from the social perspectives where it is first introduced (Daño, 2007). In accordance with this the diverse fields of humans whether it is economic, political, social, and cultural or ethical are all influenced when new technologies are introduced and adopted, although they differ in method and speed (Daño, 2007).

The one approach which will advance the welfare of society is to ensure that consumers are given choices, keeping in mind that it is human tendency to make choices which are good for them and they will avoid choices which may cause harm. This highlights the concerns about rights and the welfare of society (NCB, 2003). The concerns which consumers have about food are based not only on human welfare but also on agriculture, the environment and food

culture (Holm and Kildevang, 1996). Aspects which are also of concern to society are the technical and ecological transformation related to new food processing, technologies and the application of pesticides in agriculture (Holm and Kildevang, 1996). Studies comparing first world and third world consumers differ in attitudes and acceptance of new found technologies. It is suggested that this should not be perceived for the latter as having a lack of interest in food safety but should rather be seen as a result of a lack of consumer knowledge and awareness of such new technologies (Wilcock et al., 2004).

Kraus, (1995) stated that "attitudes, which are relatively permanent and stable evaluative summaries of an item, are an important psychological construct because they have been found to influence and predict such behaviour", as demonstrated by 1st and 3rd world consumers in their different attitudes to new technologies.

However, the attitude of consumers towards issues of food safety can be distinguished on the basis of the safety of food concerns. Brewer et al. (1994) projected six factors dominating the approach of consumers towards food safety. They included chemical issues, e.g., hormones in milk and food additives; health issues, e.g., cholesterol contents and nutritional imbalances; spoilage issues, e.g., microbial contamination; regulatory issues, e.g., food inspection and labelling; deceptive practices, e.g., weight-reduction diets; and ideal situations, e.g., length of time for pesticide safety assessment (Brewer et al., 1994).

After having considered the above it is important to evaluate the socio-economic impact of GM foods which has been outlined by Daño (2007)

3.3.1. Social Responsibility - Scientist who introduces technology into society need to bear the moral responsibility for the impacts that their innovation may have. This also involves the potential socio-economic impacts of technologies beyond the controlled confines of laboratories and greenhouse. The history of technology has repeatedly been shown to

introduce stresses that the role of scientists and technologists should not end once a technology leaves the laboratory, but more important as it is introduced into society" (Daño, 2007). The socio impacts include the perceived risks associated with GM technologies and the economic impact includes expected rise in food prices because of the adoption of the new technology.

3.3.2. Inter-Generational Responsibility – The aim of a technology's should be to contribute to sustainable development and is therefore, it should be hinged on the inter-generational responsibility of developers of the technology and government regulators. Assessing the socio-economic impacts of GMOs would not only ensure that adverse effects are avoided, or at least minimised, but may also protect the interests and needs of the present as well as those of future generations since socio-economic impacts of technologies are felt throughout generations (Daño, 2007).

3.3.3. Social Acceptance - Giving serious consideration to the potential socio-economic impacts of GMOs, developers and regulators would have a better sense of society's acceptance of the technology and/or its product. Effective assessment of the potential socio-economic consequences of GMOs would require the active and broad involvement of various social participants (Daño, 2007).

3.3.4. Reducing Long-Term Costs - A primary concern in the socio-economic assessment of GMOs is the costs related to the processes of broad participation of various stakeholders and actors and the period of time it takes to go through these processes. While this may be a valid concern in the short-term, it ignores the possible long-term costs of the technology on society arising from its potentially adverse impacts. Hence, by taking socio-economic considerations into account in decision making on GMOs, irreversible social, economic and cultural costs must be avoided or minimised (Daño, 2007).

Society's acceptance of commodities produced using biotechnology will always be a vital yet contentious issue for scientists and the others involved with such innovation. The most important concern at the consumer level about GM foods is their safety, although all novel foods will have to undergo rigid testing for the safety of use before it is released to the public (Robinson, 1997). Other concerns are concentrated on the future safety of the new technology, e.g., "creation of super-weeds and serious illnesses" (Moseley, 1999), which will only manifest and become known at a much later stage after prolonged usage (Moseley, 1999).

Innovators and regulatory authorities will not be able to avoid the moral aspect of the introduction of GMOs without cautiously evaluating their possible socio-economic impact. The release of GM commodities into society is not anything like research work carried out on GMOs in the confines of a laboratory or greenhouse which is considered to be a controlled environment. The difference being that social and economic forces are beyond the control of anyone. Therefore, the moral accountability cannot emphasize enough the need for proper evaluation of the socio-economic impact before the introduction of GMOs into society (Daño, 2007).

3.4 Advantages and Disadvantages of GM Technologies

The major advantage of GM food crops is the promise of food sustainability and security especially in developing countries. For those who support GM technologies the advantages are the safety of food security, improved quality, and extended shelf-life which is the most important reason why they believe that the application of GM technologies will benefit society as a whole (Wisniewski et al., 2002).

The world population has gone beyond six billion people and it is forecasted that it will increase twofold in the next fifty years (Whitman, 2000). The greatest challenge that the

world will face will be to ensure an adequate supply of food for this expanding population. GM technologies are our only hope and promise in many different ways as outlined by Whitman (2000) and summarised below.

3.4.1. Crop Resistance to Pests - Losses of crops from pest infestations could have dire consequences and could result in major financial and crop losses which could be a contributing factor to the starving masses in developing countries. Consumers are also hesitant to eat foods which have been treated with pesticides because of the health risks which it may present. The application of GM technologies promises to produce crops that are resistant to pests and therefore, eliminates the need for pesticide use (Whitman, 2000).

3.4.2. Crop Tolerance of Herbicides - Depending on the crop type it maybe more beneficial to physically remove weeds which grow among the crops. In most cases this method of weed removal is not cost-effective and therefore, the farmers have to resort to spraying the plantations with herbicides to kill the weeds. This method of weed control comes at great cost and is time consuming. Care also needs to be taken to ensure that the weed killer doesn't have any adverse effects on the crops or the environment. GM crops can be designed so that they are resistant to herbicides and therefore fewer herbicides need to be used. This will reduce cost; reduce adverse environmental effects and any other potential dangers associated with excessive use of herbicides (Whitman, 2000).

3.4.3. Crop Resistance to Disease - Numerous types of microorganism are known to cause diseases in crops and wipe out entire fields of crops in a very short space of time. The long term effects of this is that these organisms can lie dormant for extended periods of time and once again become active and have the same detrimental effect on consecutive cultivars. Again the application of GM technology can enable the development of plants which have a

built in resistance to certain organism and diseases therefore, minimising crop losses through diseases (Whitman, 2000).

3.4.4. Crop Tolerance of the Cold - Most crops thrive in warmer climates. However, unseasonal frost can be destructive to young and established plants. This could cause devastation to entire plantations and there is no recovery from frost damage to plants. GM technologies can be used to introduce an anti-freezing gene which will allow the crops to be more tolerant to frost and lower temperatures (Whitman, 2000).

3.4.5. Crop Tolerance to Drought and Salinity - The increasing world's population has resulted in more land being utilised to build homes rather than to be used for farming. The lack of farm land has resulted in farms being moved to locations which are not suitable for farming and plant cultivation. GM technologies can produce plants which will withstand the drought conditions as well as grow in soils that have a high salt content (Whitman, 2000).

3.4.6. Improved Nutrition - Human health is always a very important priority and it is well known that health is enhanced when starvation is eliminated and the quality of food is improved. A healthy nation means a more empowered nation because they are then able to participate in society and are therefore, able to live more meaningful lives. Theoretically growing transgenic crops could, intensify agriculture, contribute to increased agricultural production and could alleviate human hunger while promoting environmental conservation (Robinson, 1999).

Malnutrition is prevalent in third world countries. In these developing countries the populations are usually dependant on one type of crop for their nutrition and this forms their staple food. Most of these staple crops do not have adequate nutritional content to sustain the population. Therefore, there is a prevalence of immune deficient diseases and malnutrition is rife among these societies. The application of GM technologies is known to increase the

nutritional content of these staple foods, for example, Vitamin A content of rice and corn (Whitman, 2000).

GM crops such as "Golden Rice" can make a significant contribution on the nutritional status of the poorest of the poor. GM rice could offer increased amounts of vitamin A and iron, which is lacking in unmodified rice and therefore, will help address malnutrition. A relatively new application which could also have huge potential and benefits is the incorporation of vaccines into fruit.

Franck-Oberaspach and Keller (1997) reviewed the consequences of classical and biotechnological resistance breeding for food toxicology and allergenicity. They reported on many classes of actual and putative toxins and allergens, and came to the conclusion that numerous naturally occurring defence substances which are found in plants are highly toxic to mammals; they also indicated that the safety of food can be severely compromised by natural pathogens and their by-products (Robinson, 1999).

3.4.7. Pharmaceuticals - there is a growing demand for new and more efficient therapeutic drugs to treat many health conditions and there is an increasing resistance to current available drugs. The cost of developing new drugs and vaccines is also high and storage and shelf life is limited. GM technologies have also been seen as a way to produce new more efficient and cheaper drugs. Its applications have also been extended to incorporating the vaccines into crops which will facilitate the immunisation of large populations in developing countries (Whitman, 2000).

3.4.8. Bioremediation and Phytoremediation - The environment is increasingly inundated with many pollutants due to various factors, e.g., acid mine drainage, and heavy metal contamination of soil and water. It must be noted that not all genetically modified crops are

cultivated for food. Some are used specially to help remove these environmental pollutants from soil and water (Whitman, 2000).

As much as GM technologies have many advantages which will contribute to advancing society, there are also many disadvantages which may be known or unknown. There are many organisations which are anti-GM technology because of the many unanswered dilemmas, some are religious organisations, others are environmental activists all working against the introduction of GM technologies for one reason or another. Some have been outlined by Whitman, (2000) and are summarised below.

3.4.9. Unintentional Harm to Other Organisms - GM technologies developed a pesticide resistant corn called Bt corn. It has been found that the pollen from the Bt corn plants have contaminated the milkweed plants in the plantations, which is consumed by Monarch Caterpillars. This resulted in the Monarch Caterpillars perishing as a result of consuming milkweed which had Bt corn pollen on them and almost wiping out Monarch Butterflies (Whitman, 2000).

3.4.10. Reduction in Pesticide Effectiveness - There is growing concern that insects and pests will develop resistance to the GM Bt which renders the crops pest resistant. As is known from the past some species of mosquitos did develop resistance to DDT which is now a banned substance. And the concern then is what would happen should other pests develop resistance to Bt crops (Whitman, 2000).

3.4.11. Transfer of Genes to Non-Target Species - There is a concern that GM plants that have been modified for specific reasons and uses, when in the open, may cross breed with other plants which have been modified with different traits. The concern is then what would happen should there be unintentional cross breeding between the different GM plants. These are some of the unknowns of GM technologies (Whitman, 2000).

3.4.12. Risk to Human Health - This is of great concern especially because GM technologies have not been around long enough for us to know what long term effects it will have on human health and wellbeing. The main concern is that of allergens, and the possibility of new allergens being developed through the GM of food commodities and because unknown, it can cause unexpected allergic reactions which could be fatal. Therefore, labelling of foods that have been genetically modified could provide information to help inform customers of the potential risks. The second concern is that of the unknown effect on human health. What is known is that certain mutations can act as a precursor to the development of certain health conditions like cancer, to date GM technologies have not shown such effects, but again who knows what the future holds with regards to the technology (Whitman, 2000).

The possible motivating factors for the acceptance of GM technologies will occur as the development of the technologies proceeds and society becomes increasingly aware and will probable reflect on those concerns of the organic food industry. Approval will most likely be related to awareness of the advantages and hazards related to the health of humans and the environmental surroundings (Larue et al., 2004; Moon and Balasubramanian, 2001; Onyango and Nayga, 2004). At the same time while awareness about hazards normally has not been well thought-out regarding the organic production methods used or food consumption patterns, the current available writings propose that apparent hazards and moral thought is imperative for recognition of modern biotechnology.

It is not known whether or not conventional plant breeding raises risks and or if new plant varieties are safe for human consumption or the environment. Not much has been done in this area because it is believed that it is a natural progression then it must be good and therefore, safer. However, this kind of breeding has sometimes caused negative effects on health for

example; a cultivated plant which was created by cross breeding could have a high percentage of natural toxins.

Similarly in the case of GM crops there is insufficient information known to draw the conclusion that it is unsafe or may have adverse effects on humans or the environment. What is known is that GM crops can offer known benefits to the human race.

The chapter outlines the various important issues facing developing countries and the function of agriculture in developing these countries. The benefits of adopting GM technology in developing countries was also discussed and is deemed to be the answer to addressing the main issues which concern 3rd world countries like poverty, malnutrition and food security to mention but a few. The importance of consumer acceptance and attitudes towards adopting GM technologies was also highlighted as well as the influence that consumers will have on determining the success of the new technology in the food manufacturing and agricultural sectors.

Despite the significant benefits that the application of GM technology has on agriculture and in addressing the issues facing developing countries, the concerns about the future implications of GM technology will remain.

CHAPTER FOUR: THE ETHICAL CONCERNS REGARDING THE DEVELOPMENT OF GM FOODS

4.1 Introduction

In a world that shows off capacity to produce enough food for its populace, the uncertainty of available food and prevalent scarcity is an undesirable truth. The inability to supply essential wants and access to sufficient food for 800 million people is the main human crisis facing us today – even greater is the problem because the probable way out has numerous moral implications (FAO, 2001).

This chapter will begin with a discussion on the natural vs. the unnatural dilemma of GM foods. It will proceed to discuss the potential benefits of GM foods. Finally the chapter will use the ethical principles associated with the application of GM Foods as well as the ethical concerns, risks and benefits facing the various stakeholders within the food chain to evaluate the moral implications of GM foods. An ethical matrix will be used as a guide to evaluate the ethical constraints of GM agricultural practices and foods. A principled approach will be adopted and applied to the ethical matrix. The Beauchamp and Childress (2013) principles will be used to assess the ethical impact of GM Foods and thereby provide a means for ethical analysis.

As important as the issues of safety and food security in GM food discussions are, other debates have resulted with regard to the ethics of GM foods. Society has different views over the production and use of GMO foods and the moral acceptability. The leading dilemma is whether GM foods are morally or ethically acceptable (Burkhardt, 2006). If morally accepted there will be nothing wrong in producing, using or consuming GM foods (Burkhardt, 2006). If ethically unacceptable, people should stop producing GM foods, or if found unacceptable by some they have the option not to use them.

4.2 The Natural versus the Unnatural Ethical Dilemma

There are many who perceive GM foods to be equal to "Playing God" and consider it an unnatural act that should not be done. This may also be seen to many as the industrialisation of nature and therefore, unacceptable. These beliefs extend to many societies and are as strong in Africa as it is elsewhere. It is perceived that man has dominance over the natural world, which means that we have the liability to take care of and guard it without owning it (Genesis Chapter 1:26).

When considering this dilemma one must remember that GM has been taking place on its own or in nature without human intervention since time immemorial. The natural transfer of genetic material occurs in nature through cross pollination and through plants growing close enough to incorporate genes from neighbouring plants. However, the question that should be asked is what makes a plant that has undergone the so called natural gene transfer safer than a plant that has been subjected to deliberate gene transfer by human intervention and termed unnatural high risk?

Thus, one can argue that of the two types of gene transfers, i.e., Natural versus Unnatural that the so called unnatural gene transfers have a greater chance of being safer, because the actual gene which was transferred is known and the characteristics thereof also known. Unlike the natural transgenic plant, where the gene's transferred are not known. How then can the risk be less or the expected characteristics of the plant be known?

However, it may be interpreted that the reason natural gene transfers are more acceptable is the fact that it is more likely to only occur between like species, e.g., between plants and plants; animals and animals; and microorganisms and microorganisms. So from this point of view it is ethically more acceptable and therefore, considered to be natural. Simply put Natural makes reference to human assisting nature to mutate without actually physically

doing the gene transfer. In the case of unnatural gene transfers, which only happens through complete human intervention with no restriction to genes of unlike species being transferred between each other species. More often than not many unnatural gene transfers occur across species, e.g., plant and microorganisms; animals and microorganisms; and insects and plants. This depends on the specific genetic requirements and desired characteristics.

This raises the moral question of GM technologies being acceptable to mixing the genetic material of differing species. The fundamental view to this instinctive retort is the consequential order which exists in nature which must be respected (NCB, 2003).

There are different ways to look at this. Initially it can make known the prominence of the species and the function they play in the natural world. A variety of wild species of crops can be an indication of the course of natural selection and other developmental methods. GM therefore, may be viewed seriously since it is perceived to impede this progression. The chance that GM plants maybe cross-breed with other wild plant species may be seen as changing nature's natural choice (NCB, 2003).

Subsequently the second declaration is "that the natural world order should be upheld and should be understood" (Hume, 1903), as the reason for the unwillingness to cross boundaries between species. It can be argued that species were established by nature and that an intended balance between species was created and the risk of upsetting this balance is of great concern (Hume, 1903). More specifically is the genetic transfer which has taken place in the past through the process of evolution, which was known to have taken place between higher and lower order organisms including humans (Syvanen, 2002).

Therefore, it is not simple to maintain that nature should not be distorted. The third claim refers to the point that the command of nature must be upheld since natural and environmental systems are fairly vigorous and expected and poses fewer dangers to man.

Though, meddling may cause irreparable unfavourable consequences for biological systems, which could have dangerous effects on our natural world and how we relate to it. The argument could then be that nature knows best especially on the amalgamation of gene based modifications, and it is suggested that it is negligent to mess about with a very complex system which advances very gradually with time (Hume, 1903).

Therefore, there is no logical argument, and the argument is based on society's beliefs even though scientific evidence may be conflicting. The conflict here is that in the case of what is termed a Natural gene transfer is also aided my humans, by subjecting the organism to certain conditions which stimulates mutations. Because the actual gene which is transferred using this method is unknown and the form of mutation which the plant takes is allowed to take place in a so called natural way, infers that this is more natural than the application of GM gene transfers. Some may view both methods as being unnatural or that one method is more natural than the other. This is what makes it an illogical argument.

4.3 The Moral Imperative of GM Foods

The potential benefits of GM foods have been well documented and Weale (2010) outlined the most important ones as being:

1. Herbicide tolerance, enabling reduced applications of herbicides
2. Insect and pest resistance
3. Bacterial, fungal and viral resistance
4. Abiotic stress resistance
5. Micronutrient enrichment

Viewpoints on the ethical suitability are largely dependent on the response to numerous initial queries is required for e.g. the safety of consuming GM foods and the long term side effects of GM foods and its impact on the environment. At the same time there are those who reject GM foods based on philosophical or religious reasons no matter what the applications of the technology is. Nonetheless, it is significant to recognise the dissimilarities among the products of biotechnology and therefore, it must be noted that different GM foods will have different ethical dimensions (Burkhardt, 2006). A good example is the treatment of cows with bovine growth hormones to increase milk production without increasing feed intake. This as opposed to farmers using herbicides to kill weeds without affecting the crop, while others point out the possible human health risks associated with Bt corn (Burkhardt, 2006), which was designed to create substances in plants which are poisonous to pests (Burkhardt, 2006).

Within the scientific community, the focus of the position of New Biotechnology (Burkhardt, 2006) is to assist with improving "food quantity, quality and affordability, while others have focused on the context of human (animal) health, environmental safety, issues concerning social justice or fairness or different implications of GM foods for the developed versus the developing world" (Burkhardt, 2006). However, it must be noted that each of these concerns are vital in the ethical evaluation of GM foods (Burkhardt, 2006).

However, the argument must be based on how these benefits are relevant to developing countries. Central to the argument is related to the need to increase agricultural productivity to improve food supply and income (Weale, 2010). The argument also makes the assumption that GM food is beneficial and that there is a moral imperative which allows developing countries to exploit the new technologies (Weale, 2010).

The argument can be summarized by the following salient points:

1. To assist with the swift reduction of poverty and malnutrition;
2. Employment on farms and an increase in productivity in staple crops had to be improved in Africa, through expanding farmlands or increasing yields
3. Expanding farmland was not always feasible environmentally.
4. Conventional plant breeding is substantially used but confronted with many problems associated with new pest species, exhaustion of environmental micronutrients, water shortage, and unsuitable land forms for crop cultivation.
5. GM crops could be grown in areas untouched by the Green Revolution and crops better suited to environmental constraints could be developed, leading to increase in yields.
6. GM crops as a tool, added to conventional plant breeding could increase growth yields of staple foods and other crops grown by the poor.

4.4 GM Foods in Relation to Human Hunger and Health

Science is frequently undefined and exposed to understanding, while ethical and moral debates often separate sentiments both within countries and between countries (FANRPAN/IFPRI, 2003). However, "food security is one of the major challenges facing the world and perhaps the largest challenge facing Southern Africa and is exemplified by the current famine in the region" (FANRPAN/IFPRI, 2003). "Agricultural Biotechnology has the potential to help alleviate the current situation by providing crops that are targeted for a particular environment" (FANRPAN/IFPRI, 2003).

When any new technology is introduced such as agricultural biotechnology (FANRPAN/IFPRI, 2003) the success of such technologies often depends on the balance of perceptions between the advantages and the potential dangers to the eco-system and the health of humans (FANRPAN/IFPRI, 2003). It is known that the transformation of agriculture is an ethical necessity for the reduction of poverty and hunger as well as advancing fairness in many of the globally poorest nations (Serageldin, 1997; Ortiz, 1998). It is necessary that biotechnology has to be used for the profit of human beings' society and the environment (FANRPAN/IFPRI, 2003). There is an assumption that "acceptability of the risk must include an improved quality of life, perhaps as we develop better or more food, better health and an environment which is improved in a sustainable manner" (FANRPAN/IFPRI, 2003).

Nourishing a populace of 10 billion people in the predictable future, which represents the moral defence for using such biotechnology, has been the concern of many (Jaffe, 1994; Borlaug, 1997). This assumes that the principle cause of hunger is caused by food shortages, and disregards the fact that there are other mitigating factors which also impact on poverty, some of which may be the inequitable distribution of food, land tenure inequity, overpopulation, poor health, poor education, etc. Carr and Levidow (1997), placed emphasis on the multifaceted nature of hunger, and criticised the assumption that transgenic technologies have a moral head start on other technologies. Carr and Levidow (1997), argued on the premise that there are many factors contributing to poverty and addressing these factors would also contribute to reducing poverty.

Consider overpopulation, poor health and poor education as contributing factors to poverty. The following examples would offer some relief to poverty. In the case of overpopulation this could be controlled by restricting the number of offspring per family. However, would this be morally right? With regard to poor health, the provision of better health facilities, free

immunisation, and rapid disease diagnosis as well as vitamin supplementation to rural communities will drastically reduce poverty. Providing a sound education system with an emphasis on training entrepreneurs will allow people to become self-sufficient hence reducing poverty and dependence on the state for assistance. The introduction of other technologies like nanotechnology will assist in quick and precise disease screening and diagnosis, new drug development and delivery systems etc. All of these examples will positively contribute to poverty alleviation (Gardner, 2015) in support of Carr and Levidow's (1997) argument that GM technology is not the only available technology which can be used to reduce poverty.

Those living in Southern Africa are exposed to severe drought which is causing havoc and the people are suffering from severe malnutrition. One must consider that the application of modern biological techniques has the potential to result in developing agricultural products which can better survive drought and heat, and also be able to provide more food in the right place (FAO, 2001). This then clearly demonstrates the benefits that will result from using this technology and the ethical consequences will depend on the specific application of GM technology. It is obvious that food is vital for our existence "both formal ethical systems and ethical practices in every society presume the need to providing the able-bodied with the means to obtain food and enable those unable to feed them to receive food directly" (FAO, 2001).

4.5 The Ethical Matrix and the Principles Approach

An ethical matrix will be used as a guide to evaluate the ethical constraints of GM agricultural practices and GM foods. The matrix as devised by Mepham (2000), which is used to resolve ethical dilemmas and is based on the principles as prescribed by Beauchamp and Childress (2013), will be adapted to this research report. This may sometimes be referred

to as the "the four principles approach" (Beauchamp and Childress, 2013). The purpose of using this approach would be to discover reasonable and justifiable principles that are embodied in "common sense morality" which is fundamental to Beauchamp and Childress (2013). The approach involves prima facie acts and obligations which must be fulfilled unless it is in conflict with an equal or greater obligation (Beauchamp and Childress, 2013).

The construction of the Matrix is in principle ethically neutral, i.e., it is an analytical tool. According to Beauchamp and Childress (2013), the principles "are general guides that leave considerable room for judgement in specific cases and that provide substantive guidance for the development of more detailed rules and policies" (Beauchamp and Childress, 2013). The Matrix records the ethical impacts in one set of circumstances (e.g., the prospective introduction of a technology) with another set of circumstances (usually the status quo). Hence, the impacts recorded are relative to a pre-existing condition, which in itself may be far from ethically acceptable by reference to some other actual or possible condition. While the ethical Matrix might guide individual ethical judgements, the principle aim of the Matrix is to facilitate rational decision-making by articulating the ethical dimensions of any issue in a manner that is transparent and broadly comprehensible (Mepham, 2000).

The matrix in this report will mirror the ethical matrix designed by Mepham (2000). Mepham (2000) suggests that the ethical principles i.e. autonomy, beneficence, non-maleficence and justice are the principles which should be used in the matrix. According to Beauchamp and Childress (2013), the principle of autonomy is related to individuals and their right to self-rule and is free from both any interference which prevents meaningful choice. In relation to GM foods it would mean that the person has the freedom to choose whether or not they want to use GM foods or not. The principle of non-maleficence deals with the obligation not to cause harm to anyone (Beauchamp and Childress, 2013). In light of GM foods this principle is used to evaluate if GM foods has the potential to cause harm, what would that harm be and

the severity of the harm is questionable. When reviewing morality it is not only concerned with treating people autonomously and preventing them from harm, it also deals with how does it contribute to their wellbeing and what is the benefit to them (Beauchamp and Childress, 2013). When applying the principle of beneficence in relation to GM foods one has to evaluate the benefit of GM foods to the consumer and how would it contribute to a better life. The principle of justice when applied to GM foods one has to look at how the means justifies the end for e.g., are the laws fair to promote fair trade and do the benefits of improved quality of foods justifies the use of GM foods.

Taking the background of the principles into consideration and then applying them to the different interest groups concerned with GM foods will determine the ultimate benefit of GM foods against an ethical backdrop. The interest groups which will be covered in this report will focus on innovators, farmers and producers, consumers and the environment. These are the main interest groups which are directly related to the production of GM foods. Table Three represents the Matrix used and provides a more in depth analysis of the application of the ethical principles against the interest groups detailing how each principle impacts on the chosen interest groups.

Table Three: Ethical Matrix Adapted from Mepham (2000) for GM Food using the Principles Approach

Respect for:	Autonomy	Beneficence	Non-Maleficence	Justice
Innovators	Behavioural freedom and the ability to decide where they would like to expand their research	Responsibility to stakeholders and financial viability. And secondary it social responsibility	Does not damage company profitability or reputation. Products derived from it would have no adverse effects.	Regulations should not prevent the exploitation of innovation. Patents and trade marks
Farmers and Producers	Freedom to adopt or not to adopt the GM technologies. In choosing their suppliers, production methods and marketing strategies. Choosing which crops they wish to farm.	Increased productivity, reducing cost, maximizing profits and expanding their business, effective marketing and maintaining their reputation.	Adequate income and working conditions. Products contain no contaminants harmful or otherwise, allergenic products to be clearly labelled. Marketing and advertising is not misleading	Trade freely; be able to establish equitable deals between them. No burdensome regulations in relation to production and marketing.
Consumers	Right to choice and the right to know what they purchase and eat. Free and informed choices	Benefit to society, affordability, flavour, convenience, health benefits, availability of supply and assurance that food is safe.	Not cause harm through their food choices, not promoting unfair competition or providing support for local, national or fair trade producers.	Improved nutrition, affordability. Provided with accurate information about products. Advertising must be fair. Labelling must provide correct information especially about hazards. No unjustified and unrealistic health claims.
Environment	All four of the principles and closely intertwined in considering GM technologies and are likely to have some impact on the environment resources, unintended contamination by-products of production, contamination by waste and none-recyclable materials. Balance of nature vs. environmental impacts should be considered. Heavy metal contamination.			

Mepham B. 2000. A framework for the ethical analysis of novel foods: the ethical matrix. Journal of Agricultural and Environmental Ethics. 12:165-176.

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Usually when a new technology or a novel activity such as the production of GM foods appears to pose a health threat or create a hazard this will be of public concern. There may be insufficient evidence to prove that GM foods could have a negative outcome or the magnitude of the hazard unknown. Therefore the risk cannot be quantified and the weighting

of the risk and benefit analysis may not work. In this scenario beneficence can only be applied by using precautionary measures (Beauchamp and Childress, 2013). The precautionary principle can be described as a normative principle used for making practical decisions under conditions of scientific uncertainty. Its use entails the identification of risk, scientific uncertainty and ignorance, and it involves transparent and inclusive decision making processes (Raffensperger and Tickner, 1999).

No matter which ethical approach is used in evaluating the ethical concerns of GM foods it should be based on the proposition that the presentation of harm is sometimes extended to promote the adoption of the so-called precautionary principle (Maastricht Treaty, 1992). The precautionary principles described by Gardner and Dhai (2013) states that it is "a philosophical approach allowing for decision-making by policy makers when uncertainties and risks result in potential for harm to humans and the environment." The Wingspread Statement on the precautionary principle, adopted in 2011, states "that when activities threaten harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are fully established scientifically" (Rachel's Environment and Health Weekly, 1998).

Morally one would view the positive contributions that GM foods will have on human livelihood. The moral philosophy will also take into consideration that the application of GM foods results in products or processes that do not infringe on ethical boundaries. This could be viewed as the GM foods not having a negative effect on human health and wellbeing. In a similar light one can look at “ethical rightness in terms of whether or not an action, practice or policy promotes or is consistent with a set of virtues set by moral tradition” and differences among society (Crisp and Slote, 1997).

The point here is to recognise in advance with regard to any discussion on GMO foods, that these are established ethical perceptions which have informed moral debates. The application to controversial issues of GM foods will remain an attractive and significant feature of these differences (Blackburn, 2001).

It is also true that in certain circumstances the "greatest good for the greatest number" (FAO, 2000), of people emerges to violate traditions on limitations on the exercising of specific rights. There may also be instances where preserving a community's way of life (FAO, 2000), appears to be an infringement of a person's independence. No matter which ethical construct is chosen, the bottom line is that everyone has the right to freely shape their lives by responsible actions in accordance with moral laws (FAO, 2000).

4.6 GM Innovators and Ethics

A good example to demonstrate the ethical issues which concern innovators is a company involved with GM research and development for the agricultural industry called "Monsanto" (GEST, 2013). They have contributed to developing a range of GM products such as "Roundup Ready" (GEST, 2013) – which is a herbicide resistant plant which allows close cultivation, which will result in increased yields without excessive use of herbicides and weed infestations. The company also produced a synthetic hormone called rGBH which is used to increase milk yields in cows; and another GM product which they introduced are plants that produce Bt insecticide toxins and most recently they are researching the development of plants which are drought resistant. The primary perception of non-maleficence will be that the invention doesn't damage the company's profits or its reputation, and that the resulting products will have no negative effects on the consumer (GEST, 2013).

Taking all these developments into consideration it is understood that the company competes in an open market economy and at the same time has responsibilities to the proprietors of the

company. Therefore, ethically the primary aim will be seen as that of beneficence from a financial profitability point of view. The secondary aim would be one of social responsibility to the other stakeholders which would be to make a positive impact on world food security (GEST, 2013).

However, the innovators' view on justice would be that the innovations would not be restricted by regulation from exploiting the market. They would also want their inventions to be protected from competitors and trade restriction. Therefore, the innovators' perception on autonomy would be that it has the right to decide on how they develop the market and exploit their innovations (GEST, 2013).

4.7 Ethical Views of Farmers and Producers

The main objective of farmers and producers with regard to beneficence would be their concern with increasing crop yields so that their businesses are profitable and they can make a good living. The farmers are also looking for cultivars which will make their jobs easier, as well as minimise time, effort and crop losses. However, it must be noted that this applies to the larger commercial farmers and not the small farmer. In applying the principle of non-maleficence the farmers should stay away from crops which will pose health or any other risks to their business, the public or the environment (GEST, 2013). This in no way suggests that the farmers should not use GM technologies, it emphasises that the farmers should not use the technology at the expense of risking their profits. Loss in profits could result from the unwarranted introduction of new unknown risks from self-mutating plants which will contaminate their farms with undesirables e.g. weeds, new plant diseases or dwarf crops.

However, producers view non-maleficence as in the case of making sure that the products are free from contaminants whether harmful of not; that all allergenic substances are made

known by labelling and that they do not engage in false and misleading marketing and advertising (GEST, 2013).

Farmers will also seek justice by establishing good deals between themselves, suppliers and consumers while being governed by regulations which will permit free trade for all to benefit. Added to this producers would view justice as not being subjected to difficult to deal with or over arduous regulations (GEST, 2013). Autonomy for farmers would mean that they are allowed to choose the crops which they want to cultivate and they will also be free to change cultivars and suppliers at any given time as they so wish and producers will want autonomy in the selection of suppliers and processing methods (GEST, 2013). However, this would be dependent on the availability of GM and non-GM seeds to the farmers, especially the smaller farmers.

4.8 Ethical Concerns of Consumers

Unlike the other stakeholders discussed previously, the main interests of consumers rest with their needs, personal health and wellbeing. Therefore, the end user relates differently to beneficence which they view as the benefit that they would gain from a particular food type. The choices they make may vary between their ability to afford the product, convenience, health benefits, availability, social appeal and safety of food (GEST, 2013).

There is an overlap of the principles of justice and autonomy with regards to the consumer, because it is their right to make free and informed choices. But to do this they must be provided with all the vital information about the product. This type of information will be provided perhaps by labelling and government regulatory authorities and bodies. The bottom line here is that the consumer's choices are based simply on whether or not the product will cause harm or will it benefit them. These are general rules which a consumer will apply whether the product is GM or not (GEST, 2013).

The application of the principles of non-maleficence on the part of the consumers usually incorporates the concerns of “inflicting harm to those close to them as well as themselves” (GEST, 2013). This is assumed to occur through “the food choices made, not promoting unfair competition or providing support for local, national or fair trade producers” (GEST, 2013); however, there may appear to be some conflicting opinions among these objectives.

4.9 Summary

The debate around food production must be handled with caution because there is limited information known about GM foods and what they might contribute to sustainable farming practices (Pretty, 1999). It is abundantly clear that access to these genetic resources must be promoted and made available to all agricultural communities as well as the consumer.

As in all new technologies, GM foods pose known and unknown risks. A number of questions have been generated around the negative consequences of GM crops and GM foods which have been introduced into the existing food production line. Some of these questions focuses on "the health effects; environmental safety and conservation; intellectual property rights; labelling, consumer choices and ethical issues" (Asante, 2008). However, notwithstanding the ethical issues which are connected with the creation of GM foods which are focused on interfering with nature of different species, this would not occur naturally.

Disturbance of the natural genetic makeup of the host is also of ethical concern; subsequently the newly presented gene may display different characteristics within the host. By this the natural intrinsic values of the host are violated. The transfer of "animal genes into plants introduce important ethical concerns for vegetarians and religious groups." The technology may include the use of genes of animal origin in foods which may be unacceptable to many (Asante, 2008). Plants form the basis for any human diet and therefore the main concern of

GM crops also includes the presence of "antibiotic marker genes and promoter sequences derived from viruses" (Asante, 2008).

The careless publicity of GM developments by journalists and scientists has also contributed to the heightened concerns associated with human health by the consumption GM foods and products (Coghlan et al., 1999). In African countries as is in the developed world many people are distrustful of GM crops and antagonistic to their use, particularly in foods. On the other hand, looking at the status of hunger, starvation and malnutrition this could alter how one perceives GM technologies (Asante, 2008). "There are over 800 million people who do not have enough food to eat everyday" (FAO and SFIW, 2003). "Hunger and poverty claim 25 000 lives every day and the percentage is highest in the East, Central and Southern Africa (FAO quoted in www.wfp.org) of which rural populations, women and children are most affected" (FAO, 2003).

The promise of GM technology is to provide huge benefits for the population. Genetic modification has facilitated the scientific development of quality crops that traditional breeding couldn't achieve on its own (Asante, 2008). Increased yields, income, improved nutrition to prevent starvation, use of fewer pesticides are only some of the potentials which GM technologies offer Africa. This is the reason why it is believed by some that GM foods are the future to addressing food security issues in Africa (Asante, 2008).

From an ethical position the physical purpose of GM foods when viewing all the benefits and enhanced properties of foods it has to offer is good because it will serve as the answer to providing food and nutrients (Gichuru, 2012), to mankind. This will help the "common good" in the alleviation of poverty. Although the research on the possible hazards of GM foods has only been conducted on animals and has not been established in humans, patrons will "have the right to know what they are consuming so that they can make informed choices"

(Gichuru, 2012).These choices improve the "nature of the human person bestowed with the freedom and the capacity to choose because of their rational nature" (Gichuru, 2012).

As an extension of what has been discussed one of the most important principles of ethics which impacts on all stakeholders is the principle of justice. In whatever context this is viewed and whenever there is a potential for risk, there must be fairness in the way in which these risks are borne. Therefore, those exposed to any form of risk must be aware of them, and likewise the same must be said about benefits (GEST, 2013).

The point about each of these instances is in part, the moral suitability or deficiency and will depend on the type of GM foods which we are speaking about. The chapter shows that the range of GM technology applications which will improve human welfare is far reaching. However, what cannot be ascertained is whether that which is technically possible is also morally appropriate or not and this remains open to debate. The numerous issues were raised about GM technology applications, some of which include the potential for toxic effects on humans and the environment and potential economic effects, are real threats to hampering the successful application of GM technology was discussed. Therefore the possibility of unknown harm and benefits it represents to society warrants careful ethical consideration.

It has not been the intention to argue for or against any of the ethical principles in evaluating the ethical acceptability of GM foods. It was to ascertain the extent of the importance of each of these principles with regard to the acceptability, risks, benefits and potential harm of GM foods and in ethics it is permissible sometimes to limit or infringe individuals' rights for the sake of a greater good.

In conclusion, the fundamental requirement of ethics is for people to go further than self-centredness and to be concerned about the wellbeing of others. It also necessitates people to care for the environment and to be ready to share universal resources. However, it must be

remembered that, in practice, they are varied. The reverence for any form of life is essential to ethics. Hence, the guarantee of an adequate supply of food and its access to everyone is placed at the pinnacle of the hierarchy of human values (FAO, 2000).

CHAPTER FIVE: AN OVERVIEW AND ANALYSIS OF SOUTH AFRICAN GM LAWS AND THE LABELLING OF GM FOODS

5.1 Introduction

So far this report has discussed the existing and possible applications of GM technologies with regard to food safety and security; Agriculture in 3rd world countries, societies' acceptance of GM technology and the advantages and disadvantages of GM products; and the ethical concerns of the development and use of GM foods. The rationale behind this chapter is to give an overview of the South African stance regarding regulating and labelling of genetically modified organisms (GMOs) and genetically modified foods to ascertain the adequacy of the primary legislation concerning GMOs and GM foods.

Globally discussions on the regulating of biotechnology are preceded by much tension (Stirling, 2012). The most basic purpose of any governmental policy is to promote and offer protection to the welfare of its citizenship. This may be seen as a form of offering basic securities to include "safe and nutritious food stuff, protection from environmental harms and the enhancement of research and development" (NCB, 1999). The health and safety of citizens are always central to any government's regulations. Thus it is important to ensure that any form of harm is so small that it is acceptable and this applies to GMOs and GM Foods in particular.

South Africa first regulated transgenic organisms through a voluntary system and since 1997 has had legislation in place to ensure that the use of GMOs in South Africa (S.A.) would be done safely. Even though the South African government is in favour of GM Technology they do realise the need for regulation of all GMO associated usage.

5.2 International Influences on Governance and Regulation Design

The South African laws governing all aspects of GMOs and GM foods have been influenced by five major constituents of international regulations, collectively referred to as the Bioethics Protocol in relation to the research, sale and uses of GM crops. The Nuffield Council of Bioethics (2003) outlines the five major constituents which form part of the Bioethics Protocol to include:

1. The Agreements by the World Trade Organisation (WTO) which aim to control barriers to international trade (NBC, 2003). All countries who manufacture food for human and animal consumption conform to the international codes of practice, guidelines and recommendations pertaining to food safety as set out by this organisation (NBC, 2003).

2. The Codex Alimentarius which is a set of international codes of practice, guidelines and recommendations pertaining to food safety, upon which the WTO currently relies on when making its adjudications (NCB, 2003).

3. The Convention on Biological Diversity (CBD) Cartagena Protocol which is a global obligation to safeguard "biological diversity," for "biological resources sustainability" (IUCN, 1994; Nang'ayo, 2006) and to distribute equally the profits from using genetic information and material (IUCN, 1994).

4. The International Treaty on Plant Genetic Resources for Food and Agriculture was adopted in 2001 and is a global response to promote the conservation of plant genetic resources and to protect farmer's rights to access and have fair and equitable sharing of benefits arising out of their use (NCB, 2003)

5. The European (EU) Directives and Regulations Treaties the aims set out in the EU treaties are achieved by several types of legal acts. Some are binding while others are not (NCB, 2003).

5.3 South Africa's Biotechnology and GMO Position

South Africa's first step towards regulating Biotechnology was to develop a National Biotechnology Strategy (NBS). The strategy serves as a framework for policy development, with the main objective to incentivise the Biotechnology sector (NBS, 2001). Additionally, the country has, in place, a system of governance for GMOs which include a specific Genetically Modified Organisms (GMO) Act that controls all aspects which relate to research and commercialisation of GMOs. S.A. is the only African country which is approved for the commercialisation of GMOs.

Other laws that impact on the regulation of GMOs in S.A. are the Environmental Conservation Act (73 of 1989), the National Environmental Management Act (107 of 1998, the National Environment Management Biodiversity Act (10 of 2004), the Food Stuffs, Cosmetics and Disinfectants Act (54 of 1972), and the Consumer Protection Act (68 of 2008). The latter two Acts govern and regulate the labelling of GM foods in S.A. and aim to protect the consumer from unreliable or misleading marketing practices.

5.3.1 South African Genetically Modified Organisms Act

The Genetically Modified Organisms (GMO) Act (15 of 1997 as amended in 2006) was developed from the NBS which formed the framework for the Act. The Acts main objective is to provide ways of promoting the "responsible development, production, use and applications of GMOs" (NBS, 2001). It was also developed to make sure that activities

involving the use and applications of GMOs are carried out in ways that limits harm to the ecosystem, human and animal wellbeing.

Provision has been made within the GMO Act, which allows permits to be granted for different categories of activities which is inclusive of the "general release, where GMOs are released into the environment without any restrictions," "commodity clearance where GMOs are actually incorporated into foods and feed and are not actually cultivated," "trial release where GMOs are released into the environment for field testing" and "the contained use of GMOs which are used within a laboratory environment or green house" (DAFF, 2010b).

In 2004 a set of guidelines to the Act was published in the Government Gazette. There were guideline documents for working with GMOs; for use by the Advisory Committee when considering proposal or applications for activities involving GMOs and terms of reference for subcommittees to assist the Advisory Committee in terms of Section 11 (2) of the Genetically Modified Organisms Act, 1997 (Act No.15 of 1997).

The purpose of the guidelines is to offer additional support to the operational, management and monitoring of all activities covered within the GMO Act. The guidelines also outline the responsibilities, objectives, powers and duties council and the sub-committees of the council to ensure that the Act operates optimally in governing the development, production, use and application of GMOs.

At present no provision has been made in the law for regulating GMOs used in the processing of food. Thus the Act is limited in that it applies only to viable living GMOs and not products of GMOs. The Act has been condemned for not constituting "an adequate biosafety regime that ensures GMOs are appropriate and do not cause harm to the environment, or to human health" (Mayet, 2000). Additionally, Section 1 of the Act appears to absolve

developers of GMOs from liability and shift liability to users of GMOs (Andanda, 2006). This could be seen as an attempt to offer protection to the biotechnology industry.

5.3.2 Environmental Conservation Act (No 73 of 1989) – to provide for effective protection of the environment utilisation of the environment and for matters incidental there to.

5.3.3 National Environmental Management Act (No 107 of 1998) - to provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of site; and to provide for matters connected therewith.

5.3.4 National Environmental Management Biodiversity Act (No. 10 of 2004) - to provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998; the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith.

5.3.5 Foodstuffs, Cosmetics and Disinfectants Act (No. 54 of 1972) - outlines the minimum requirements to guarantee sufficient public safety and offers a structure by which other laws cover public safety. Under the Act, "Regulation 293" provides for any product which may have a GM ingredients phrase, which allows manufacturers not to label products if it is not realistic to analyse products for the presence of GMOs or GM components (Viljoen and Marx, 2013). This refers to not necessarily quantifying GM components but merely stating that the product is GM.

5.3.6 Consumer Protection Act (No 68 of 2008) – to promote a fair, accessible and sustainable marketplace for consumer products and services and for that purpose to establish national norms and standards relating to consumer protection, to provide for improved standards of consumer information and to prohibit certain unfair marketing and business practices.

The Consumer Protection Act (68 of 2008), plays a significant role in offering added protection to the consumer with regards to GM Foods. The aims to improve access to information for the public (Section 22) and it also requires special labelling for biotechnology (Lim Tung, 2013). In 2012, the Department of Trade and Industry published draft amendments to the Consumer Protection Act (68 of 2008) specifying "that all imported or locally produced food containing 5% or more GM components or ingredients must now be labelled as contains genetically modified ingredients or components" (Government Gazette 568 No. 35776, 2012).

Act is written in favour of the consumer and covers all pertinent sections which may concern the consumer directly or in directly and can be applied in conjunction to any other Act e.g. Act (Jacobs et al, 2010).There is no doubt that supplier's face a major task to comply with the Act, however from a consumers view point, the Act is most welcomed, as it contributes to the abolition of many abusive practices in the marketplace (Jacobs et al, 2010). An important aspect of the Act is that it offers the consumer protection against any misleading trade descriptions or trade depiction that has been interfered with (Section 24). Consequently, it is unlawful to use a trade depiction in any way which may be misleading to the consumer (Jacobs et al, 2010).

5.4 South African Regulation on GM Food Labelling

The second important part of a regulatory system deals with the labelling of GM foods. There are concerns about labelling which range from environmental issues, allergies and ethics (Jacobson, 2001). The rights of consumers to be informed about what they buy or consume should not be violated at any cost. It is not clearly understood why GM foods are not labelled even though it is the most suitable method to inform and to help the public to make knowledgeable decisions on whether or not they should purchase a GM product. It is perceived that manufacturers rather not label GM foods because they are fearful of the negative responses it may have on their products and this may result in huge economic losses for the manufacturer. This is an ongoing dilemma globally. Different legislative authorities have established varying policies and systems for labelling GM foods (Jacobson, 2001).

The labelling of GM foods in S.A. is an issue requiring some attention, owing to the speedy development of public – private partnerships which functions within the agricultural domains. It is imperative that any such partnerships comply with a given country's laws on biosafety and labelling. However, in the private sector in South Africa there is concern that labelling GM products may increase panic and doubt among the consumers which in all likelihood would impede the approval of GM technologies in agricultural biotechnology in South Africa.

South Africa is the leading exporter of GMOs. The GMO statistics for South Africa shows local production of GM maize 80%, GM soya-bean 90% and GM cotton seed 100% (Jacobson, 2001). It must not be misunderstood that the approval of government for GMOs doesn't mean that safety is guaranteed. Much to the contrary it can be assumed and that rigorous labelling could be a way to increase trust in the process of GMO food production. In the international arena, there are many discussions on GM food labelling (Jacobson, 2001).

The "South African Bureau of Standards (SABS)" as well as the government and other stakeholders are developing an Identity Preservation (IPS) for non-GM foodstuff which will offer the public an opportunity to choose either a GM or a non-GM Food. This will make labelling compulsory and any claim made by a manufacturer will have to be validated (Jacobson, 2001).

In South African terms labelling can be categorised into two main areas, i.e., mandatory and voluntary labelling.

5.4.1 Mandatory Labelling of GMO Products

If a manufactured commodity has a "GM content of at least 5%," it then must be indicated on the package as "Contains GMOs." If the foodstuff is being manufactured "directly from GM sources" and no testing is required, then this product ought to be labelled indicating "produced using genetic modification." There may be situations which could be argued that it's scientifically impossible or not practical to analyse the "GM content," then it is necessary to label the foodstuff as "May contain GMOs, as outlined in Regulation 7(6) of 2011." And lastly if any GM product or part thereof may not be "produced, supplied, imported or packaged" without a visible label showing that the products contain GMOs and this is outlined in Regulation 7(4) of 2011 (Lim Tung, 2013).

5.4.2 Voluntary Labelling of GMO Products

Voluntary labelling may be applied in other instances not covered by the above points in mandatory labelling. Some cases may be included when "the GM content of a product has less than 5% of GM content but more than 1% of GM content", it is said that it is not necessary to state this information on the label. In the case when the GM content is less than 1% the South Africa regulations does not permit that the product be labelled that it is

"without GM or GM-free, or no GMO, or GMO free or biotech-free, or non GM". The rule of law is only applied if the GM content is less than 1%. In some countries, a product is not permitted to be labelled "GM-free" because it is not easy to certify that the food commodity is 100% GMO free. This is so because it is not easy to prove and give the assurance that a food commodity is 100% free of GMOs. Only total isolation can guarantee the reliability for "GM-free labelling" (Lim Tung, 2013).

Although the labelling of GM foods is important and necessary it could have many negative effects on the consumer and the manufacturer. The labelling of GM foods could increase food prices by as much as 10% according to the CEO of AfricaBio Dr. Obokoh which is a leading biotechnology company in South Africa; AfricaBio also indicated that the cost of GM products increased considerably in other countries. Mandatory labelling is also an expensive exercise for farmers, industry and government and GM food labelling does not advance the health of consumers, but will further extend the affordability of the foodstuff.

Dr. Obokoh also highlighted the concerns about the practical aspect of the implementation and feasibility of labelling regulations (Obokoh, 2013). GM labelling could result in expensive lawsuits against farmers, food manufacturers and retailers who may find it impractical, complicated and confusing to implement. AfriBio proposed that in order to cut costs it will be simpler to declare GM foods to be that, irrespective of the % GM present and foods with no GM be labelled as GM free.

It was also stated by Mr. Luterek an attorney that there were problems with the wording used in the latest draft amendments and that the new regulations were ambiguous (Obokoh, 2013). According to Lutrek the wording was not clear and would defeat the purpose of the regulation which will lead to an increased administration burden on the food manufacturers and retailers (Obokoh, 2013). The other negative side was the testing of ingredients because it

is expensive to detect GM content and the GM content was not always detectable (Obokoh, 2013).

It is therefore suggested that the latest amendments must be revised to provide consumers with essential information to help them make a choice of wanting to consume or not consume GM foods. This should also not put undue financial constraints on the producers. It must also be noted that declaration on any labelling requires testing of all the ingredients at high cost and is not infallible (Obokoh, 2013).

Labelling places the manufacturer at a quandary. Provided that we have GM Foods which are not labelled as such, individuals will challenge that the community's right to be informed has been over-looked, and this will open up governments and manufacturers to criticism for not making known to the public domain the real content of the foodstuff. On the other hand if GM Foods were labelled this may result in many people not buying them, and as a result manufacturers in the quest not to lose business may choose not to label GM foods. Taking into consideration the negative view which the public holds against GM food, labelling should be approached with a degree of caution. One way around this would be manufacturers being candid with the public about the advantages and potential risks of the technology (Jacobson, 2001).

5.5 Discussion

The development of useful policies and legislative frameworks for biotechnology focussing on genetically modified organisms and genetically modified foods is undoubtedly challenging. The South African experiences with the policy development would be beneficial to other developing countries. The positives that have been shown in the South African scenario were that having a clear strategy which provided the framework for the GM policy development facilitated the process and regulation development immensely. It helped by

giving the South African GM policy are more structured format covering all the pertinent points as outline in the guidelines. A good practice with regards to policy and regulation development in S.A. was the development of National Biotechnology Strategy which other developing countries can learn from. This formed the bases on which the GM policy was developed. The second example is that the South African Constitution which is the highest law in the country providing for a way in which the public can engage to develop policy. This also allows for the public to challenge the laws should they deem that their Constitutional rights have been infringed upon.

However, the one failure in the implementation of the South African GMO Act was the problem with the access to information and public consultation which needs to be better developed in South Africa. Many have criticised "that the South African GMO Act was enacted hastily without adequate public consultation since several multinational companies were already allowed to grow and import GMOs" (Biowatch, 2004).

Some of the gaps in the South African GM Act include the problems associated with the labelling of GM foods and this is left open to the interpretation of the GM Food manufacturers. The GM Act should clearly define the boundaries of when GM foods should be labelled GM or not. It is my feeling that 0% GM would mean that the food does not contain any genetically modified food, and anything above 0% should mean that the food should be classified as being a GM Food. The other limitation in the Act is that it only applies to viable living GMOs and does not cover the products of GMOs.

Although there are shortfalls in the South African Act, it is still considered to be satisfactorily adequate for the continued use and development of GMOs when compared to other developing countries.

CHAPTER SIX: DISCUSSION AND CONCLUSION

A mere 10 000 years ago the deliberate cultivation of plants began. At the time little was required beyond the seeds and a few basic farming equipment. Back then the world's population was around five million and today it has continued to increase exponentially over 1000 fold to almost 10 billion. During this time there was a steady improvement in agricultural development, some of which included terraced cultivation, crop protection, and the use of organic fertilizers to mention but a few. This later moved to high-yielding hybrid crops of the Green Revolution and much later the GM crops of the 21st century.

Throughout the growth process, the different innovations have often resulted in synergistic clusters, which are in sync with changes in wider society, i.e., industrialisation, population growth and rising food demands.

Not disregarding the importance of innovation, up until the 20th century the most important way of increasing world food production was achieved by increasing agricultural land. In the 21st century the available agricultural land was limited as it competed with the growing population and other important demands. Together with this there was an increase in food demands, quality of products and a sustainable food security system.

It led to the Green Revolution and started with its three central elements commencing with new seed types, improved fertilization and innovative irrigation systems. This later progressed to using mechanical agriculture rather than human and animal labour. It was done in an attempt to increase production yields. As time moved on the food demands grew and the technologies of the Green Revolution were no more adequate. Thus new innovative technologies came to the front and this saw the introduction and rise of GM technologies which was seen as the answer to address food insecurities of a growing population.

However, new technologies don't come without its' own challenges. The first challenge as shown in chapter two is the dilemma between adopting a traditional approach which is thought to be the morally correct approach because using a modified approach is seen as being unnatural. This made it necessary to start by drawing a distinction between the traditional and the genetically modified approach. Adopting new innovative technologies such as GM raised many concerns about the risks both known and unknown. An added challenge was to balance the risks with the benefits and hope that society would accept the new technology.

Setting all these challenges aside one must not detract from the ethical challenges that adopting a technology of this nature will present. A number of ethical principles were used to evaluate the different ethical implications of such a technology. During the course of this work it was not intended to argue for or against any particular ethical construct in the evaluation of the moral acceptance of GM foods and products. But rather it was more important to demonstrate how important it is to consider each of the ethical constructs used to address the ethical dilemmas of GM technology adoption. Each principle used had their own merits in helping to understand the ethical paradigms which may inhibit the progress of adopting GM technologies.

With many of the principles used there were some differences as well as overlaps. However, marginal the differences may be, none should be disregarded when considering the ethical impact the technology may have economically, on societies and the environment. One should not get consumed by the negative ethical issues in isolation but rather look at the ethical concerns in totality together with the benefits that GM technologies promise for human wellbeing of the majority of the world's population.

The application of GM technology in agriculture has shown great promise and potential to addressing the scourge of poverty especially in developing countries. GM technologies are known not only to improve the quality and quantity of the crops but also addresses other issues affecting crop yields, for example, crop resistance to disease, insects, weeds and drought. It can therefore be concluded from chapter two that the adoption of GM technology in the agricultural sector has revolutionised agriculture and its influence has been far reaching in the South African agricultural and food manufacturing sectors.

In a South African context it is known that the consumers are not knowledgeable about GM foods. The lack of knowledge is found at various levels of society and not only at the consumer level. Therefore, there is a need for GM knowledge sharing through all sections of stakeholders. It is apparent that there are many fears and perceptions of GM foods in South Africa as there are throughout the world and this is not limited to developing countries but rather the natural complacence of human nature.

Broadly speaking GM technologies have the potential to address global food insecurities as well as other related problems, for example, hunger and malnutrition and the protection and preservation of the eco system. Nevertheless, there are numerous challenges facing governments with regard to GM legislation and labelling. There are many who feel that adopting GM technology is an inevitable necessity and is filled with hope, potential and benefits. Therefore, it is a technology which cannot be ignored or disregarded. It was further concluded in chapter three that the importance of consumer acceptance and attributes towards adopting GM technologies is crucial to the success of the new technology.

However, adopting such technologies will require us to proceed cautiously to prevent unintended harm to human wellbeing and the environment. The ethical matrix and a principled approach were used in chapter four to analyse the benefits of adopting the GM

technologies against four ethical principles (autonomy, beneficence, non-maleficence and justice). This showed that there are ethical concerns for each group whom will encounter the application of GM technology in some way. It was also recognised that GM Foods does have the potential to pose unknown harms the extent of which is yet unknown and therefore the precautionary principle must also be considered.

From a moral point of view the analysis in chapter four showed that there are many positive contributions from adopting GM technologies in improving human livelihood which out ways the negative ethical concerns. In ethics it is permissible sometimes to limit or infringe individuals' rights for the sake of a greater good to mankind.

South Africa as the pioneer in GM technology on the African continent is in a position to translate the lessons learnt from the adoption of GM technologies to help other African countries in transforming their agricultural industry to address food insecurities and the many challenges which may be presented. Developing workable policies and legislation for GM technologies is challenging. The South African experience with policy and legislation development would benefit other African countries that are embarking on legalising the use of GM technologies in their countries.

South Africa is in a position to advise on issues of:-

- Environmental threats;
- Challenges which government faced with regard to policy and legislation development on the use of and labelling of GM products;
- The need for funding requirements for developing and adopting GM technologies;
- The setting up of bilateral collaboration models for research, development and knowledge sharing; and
- Finally the need for transparency and open participation of all stakeholders.

The positives that came out of the South African legislation experience were that a clear strategy provided a good framework around which the laws were established. There were also many good practices which emanated out of this and are shown in chapter five in more detail. However, one of the major gaps in the South African GM Act are the issues around labelling of GM foods, because much is left open to the interpretation of the GM manufacturers and the legislation seems only to cover viable GMOs and not products of GMOs. With this having been said, one must not detract from the fact that it is the consumer's right to insist on mandatory labelling of GM products, to have GM foods tested for safety and environmental impacts and the liability for any damages must be clearly articulated to all stakeholders.

These are lessons which South Africa can share with other countries in Africa to make their transition from conventional agricultural methods to GM technology easier, manageable and sustainable. The most important point to remember when adopting a developmental strategy of this nature in the quest to addressing food security is that it must be sustainable. To achieve this it would require that economic, social and environmental priorities must be comprehensibly addressed and that African leaders must identify the key problems which they want to resolve. African governments should have a strong political determination to make the best decisions in the interest of their people.

It can be clearly seen that the value of this technology for the foreseeable future will motivate upcoming generations. I am confident that the continued existence of humans in the future rests on the speedy growth and progress of biotechnology without ethically marginalising the human population. Therefore, I see GM foods as a way of the future which is here to stay for a long time or least until there is another safer alternative. The benefits of the applications of GM technologies as well as the production of GM foods far out ways the ethical concerns and offers the only solution to addressing the scourge of food shortages.

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8. APPENDICES