THE ECONOMIC IMPACT OF MAIZE-BASED ETHANOL PRODUCTION ON THE SOUTH AFRICAN ANIMAL FEED INDUSTRY

By

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Verklaring:

Ek verklaar hiermee dat die verhandeling wat hierby vir die graad M.Com aan die Universiteit van die Vrystaat deur my ingedien word, my selfstandige werk is en nie voorheen deur my vir ‘n graad aan ‘n ander universiteit/fakulteit ingedien is nie. Ek doen voorts afstand van outeursreg in die verhandeling ten gunste van die Universiteit van die Vrystaat”.

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Dirk B. Strydom

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Study leader: Dr PR Taljaard
Co-study leaders: Prof. BJ Willemse & Dr F Meyer

Abstract

This study focuses mainly on the economic impact of maize-based ethanol production on the South African animal feed industry. Over the past few years the world has witnessed substantial developments in the global production and the production capacity of ethanol. Bio-fuels are becoming an increasingly important source of energy globally. This tremendous industry growth is mainly driven by: increased energy and more specifically petroleum prices, the reliability of traditional crude oil exporters along with political motives, adverse pollution effects (methyl tertiary butyl ether – MTBE) and more specifically emission gases from fossil fuels leading to environmental pressure for the use of cleaner burning fuels.

Together with this growth, various researchers locally and globally have focused on ethanol production, but little work has been done on the economic impact that ethanol production will have on the animal feed industry. These impacts include substitution of the raw materials of animal feed, the price sensitivity of raw material prices (equilibrium prices), changes in feed costs and the consumption of distiller's dried grains with solubles (DDGS) by different animal species.

In order to simulate the results, the two main scenarios were analysed using three different models, namely the BFAP model, the APR model and the Nieuwoudt/McGuigan model. By applying the BFAP model to these scenarios, the equilibrium prices of animal-feed raw materials were simulated for the year 2015. The other two models were then applied to these prices in order to evaluate the impact of ethanol production on the animal feed industry.

Two main scenarios is constructed with 8 combinations, the main variables in the scenarios is the oil price and the blending ratios.

The results revealed that there is no significant effect on the animal feed industry. Various raw materials are affected, but only by small percentages. The only raw material that shows any significant change is lucerne with a 20% decrease in consumption. A few species were dominant consumers of DDGS, namely broilers, pigs and dairy cattle. In terms of the animal feed costs, there was only a 2% decrease with the introduction of ethanol production. The introduction of ethanol production resulted in various price reactions, including an increase in the price of yellow maize and a decrease in the prices of various oilcake raw materials. Under a scenario of high blending ratios and oil prices the yellow maize price increases with R169/ton and the soya oilcake price decreases with R347/ton.

Die Ekonomiese impak van mielie-gebaseerde etanol produksie op die Suid-Afrikaanse veevoer industrie.

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Samevatting

Hierdie studie se hooffokus is op die ekonomiese impak van mielie-gebaseerde etanol- produksie op die Suid-Afrikaanse voerindustrie. In die afgelope paar jaar was daar substansiële ontwikkelings in die globale produksie en produksiekapasiteit van etanol. Bio-brandstof is tans besig om een van die belangrikste bronne van globale energie te word. Die internasionale bio-brandstof industriegroei word hoofsaaklik gedryf deur: verhoogde energie en meer spesifiek in petroleum pryse, betroubaarheid van die tradisionele ru-olie uitvoerders saam met politieke motiewe, ongunstige besoedelingseffekte (Methyl tertiary butyl- MTBE) en meer spesifiek, uitlaatgasse van fossielbrandstowwe, wat dan om die beurt lei tot omgewings- druk om skoner brandstof te gebruik.

Saam met hierdie groei is daar navorsing gedoen op etanolproduksie, maar min inligting is ingewin oor die ekonomiese impak wat etanolproduksie op die voerindustrie gaan hê. Hierdie impakte, soos die vervanging van dierevoer rou materiaal en die pryssensitiwiteit van rou materiaale lei tot veranderinge in voerkoste verskillende dierspesie verbruik van DDGS word ook in ag geneem.

Om hierdie resultate te verkry, word drie verskillende modelle saam met twee scenario's gebruik.
Die scenario's bestaan uit twee hoof scenario's en agt byvoegende kombinasies waarvan die variasie groot en deels uit olie pryse en inmengings vlakke bestaan. Hierdie modelle is die BFAP-model, APR-model en die Niewoudt/McGuigan-model. Met hierdie scenario's, saam met die BFAP-model, is ekwilibriumpryse van dierevoer rou materiaal, vir die jaar 2015 gesimuleer.

Hierdie pryse saam met die twee ander modelle, word gebruik om die impak van etanolproduksie op die dierevoerindustrie te bepaal.

In die resultate is daar gevind dat daar geen merkwaardige effek op die dierevoerindustrie is nie. Verskeie rou materiale is geaffekteer, alhoewel slegs in klein persentasies. Die enigste rou materiaal wat beduidende verandering toon, is lusern met ’n 20% afname in verbruik. ’n Klein hoeveelheid spesies is dominante verbruikers van DDGS. Die spesies is soos volg: hoenders, varke en melkbeeste. In terme van die voerindustrie is daar net 2% afname in die voerkoste met die bekendstelling van etanolproduksie. Met die bekendstelling van etanolproduksie, is daar verskeie prysreaksies, soos die geelmielieprys wat toeneem en verskeie oliekoek- rou materiaalpryse wat afneem. Met 'n scenario van hoë etanol inmeng vlakke en olie pryse gaan die geel mielie prys met R169/ton styg en die soja oliekoek prys met R347/ton daal

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LIST OF ABBREVIATIONS

APR……………………………….. Agricultural Product Requirement model

B_5..Mandatory Bio-diesel blending ratio percentage

BFAP ………………………………Bureau for Food and Agricultural policy

DGS…………………………………Distillers Grains with Solubles

DDGS………………………………Dried Distillers Grains with Solubles

E_{10}…………………………………..Mandatory Ethanol blending ratio percentage

PRF…………………………………Protein Research Foundation

CHAPTER 1
Introduction

1.1 Background

The alternative energy industry is a complex one, and some of the industry-specific terminology can be misleading. In order to understand the bio-fuel industry, the entire alternative energy sector must be explained. In this section some of the most important terminology is explained, along with the different linkages of energy sources within the alternative energy industry.

Currently, numerous alternative energy sources are available globally. For purposes of this thesis, alternative energy is defined as an energy source that is an alternative to fossil fuels. Generally, this indicates energy sources that are non-traditional and have a low environmental impact. Fossil fuels are products such as crude oil, coal and natural gas, derived from the accumulated remains of ancient plants and animals and used as fuel.

Alternative energy can be divided into six groups, namely: solar, wind, geothermal, tidal, hydro and biomass. Figure 1.1 illustrates the different alternative energy sources available currently. For purposes of this thesis the focus is on biomass energy sources, more specifically ethanol. Østergård (2007) defines biomass as primary products like agricultural crops, wood or aquatic biomass, as well as secondary products like crop residues and organic waste, e.g. from households and agricultural industries. Biomass can be applied in different energy sectors: for heat and electricity production, as well as for transportation fuel. Jensen, Jakus and Menard (2004) state that biomass for bio-energy can include a few organic matters that are available on a renewable or chronic basis, including devoted energy crops and trees, agricultural food and feed crop residues, aquatic plants, wood and wood residues, animal waste and other waste materials. Biomass can be burned in order to create a fire that is a form of energy or it can be used to manufacture bio-fuel. ”Biomass production is a method based on transmission of energy from one organism to another in order to improve the individual’s condition” (Rejdak, 2007). Johnson (2003) explains that the main advantage of biomass is that it reduces global warming, air and water pollution, trade deficits and energy dependence. From the literature it can be seen that the production of biomass energy has become a global phenomenon.

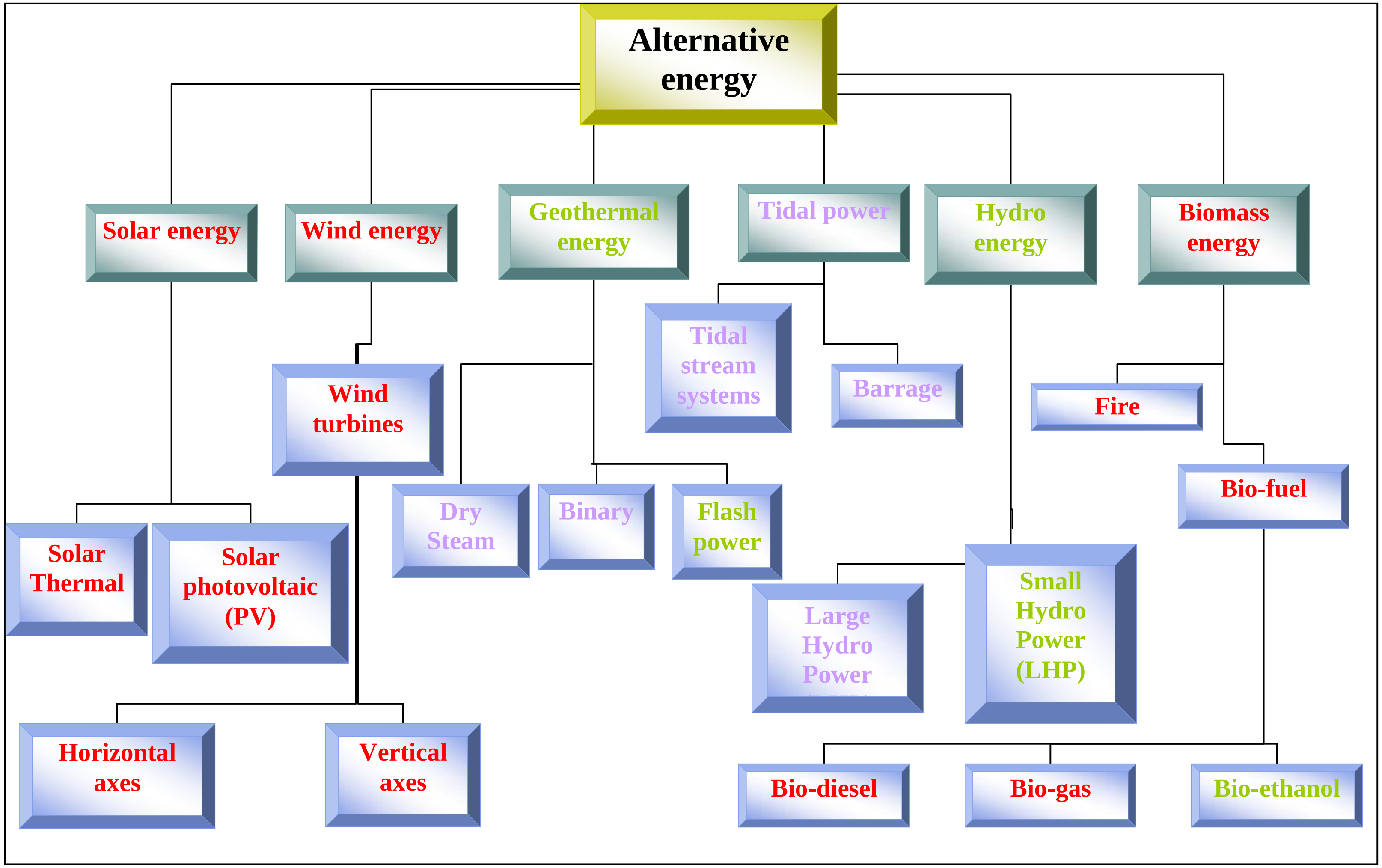

Figure 1.1: Schematic representation of different alternative energy sources

According to BioGateway (2007) there are three types of bio-fuel: **bio-ethanol**, **bio-diesel** and **bio-gas**. According to the US Environmental Protection Agency's Terms of Environment Dictionary (EPA, 2008) bio-fuels are: "Substitutes for traditional liquid, oil-derived motor vehicle fuels like gasoline and diesel, including mixtures of alcohol-based fuels with gasoline, methanol, ethanol, compressed natural gas and others." **Bio-diesel** can be produced from new or recycled vegetable oils, including oilseed crops and flax, as well as tall oils produced from wood pulp and forestry and agricultural residues. **Bio-gas** is produced by certain strains of bacteria, where in the absence of oxygen, biomass is broken down by the bacteria, such as animal manure and landfill waste, to produce a combustible gas made of methane (CH_4) and carbon dioxide (CO_2). **Bio-ethanol** is produced from the starch and cellulose components in biomass, which emit fewer greenhouse gases when burnt.

Albers (2006) explains that ethanol is a high-octane water-free alcohol produced from the fermentation of the sugars in various raw materials and converted starches. Ethanol is mainly produced from grains or crops rich in starch such as maize, wheat, sugarcane, sugar beet, cassava, etc. Ethanol can be used on its own as a fuel, but normally it is blended with petrol (gasoline) in concentrations of 5, 10 and up to 85 per cent. The three main advantages of using ethanol are: "Firstly, that it reduces the dependence on imports of foreign oil. This factor mainly has impacts on countries that do not have sufficient supplies of crude oil. Secondly, it has environmental benefits, including reduction of greenhouse gases and ground level ozone. Thirdly, ethanol is completely biodegradable and being renewable it helps to conserve fossil resources" (Viju, Kerr & Nolan, 2006). However, there are several challenges with the use of ethanol as an alternative fuel (energy) source. Firstly, it is costly to produce and use, because the production plant must be built on a large scale and the feedstocks are normally expensive. Another problem is that ethanol has a smaller energy density than gasoline. Viju *et al.* (2006) explain that energy density is the amount of energy stored in a region of space per unit volume. However, with new technologies and dedicated ethanol-engines, this challenge can be reduced to an acceptable point. Ethanol has been used as fuel in the United States since 1908 with the Model T Ford, which could be modified to run on either gasoline or pure alcohol. Henry Ford designed the famed Model T Ford to run on alcohol saying that it was "the fuel of the future" (Kovarik, 1998).

The tremendous need to develop ethanol production stems from high oil prices and uncertainties regarding future oil reserves, as well as the phenomenon of global warming. Although according to some critics, this is the idea that has largely been sold to the media. The reasons according to the critics are that, the corn-growers in the US lobbied for supportive policies to be passed so that corn prices can increase due to the increased demand. Then there are also some scientists that argue that the net energy balance of producing ethanol from maize is negative. For the purpose of this study this assumptions is rejected and the assumption is made that ethanol production will have environmental advantages.

This has led to countries considering alternative means of energy generation. The South African economy (like many others) is highly dependent on crude oil, and much of the agricultural sector has been suffering from low commodity prices since the year 2006. Because a significant amount of agricultural inputs is oil derived, the high oil prices also lead to food inflation and rising input costs. In addition, fluctuations in the SA grain prices form part of the initiative to develop an ethanol industry in order to stabilise the maize prices by establishing an alternative market. With these maize prices farmers found themselves in a price cost-squeeze situation, which was unprofitable. Over the past few years South Africa has had a surplus supply of maize and this surplus can be used for ethanol production. By creating a new demand for maize, ethanol production is one of the solutions when it comes to stabilising the maize price. The reasons mentioned above, along with the fact that the Department of Energy mentioned that research is needed on maize as a feedstock for ethanol production, resulted in the decision to focus this thesis on maize-based ethanol production.

Because of worldwide pressure calling for the reduction of harmful gases, there is an increase in demand for renewable fuels used to reduce these gases. South Africa ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 and the Kyoto Protocol (as a voluntarily signatory) in 2005. These international treaties are the main agreements that address the global concerns about climate change and air pollution (BFAP, 2005). The Kyoto Protocol states that all greenhouse gases must be reduced. The terms of this agreement are that these toxic gases must be reduced by 5.2% between the years 2008 and 2012. "Harmful petrol emissions can be reduced by up to 30 per cent through the blending of 10 per cent of ethanol" (Coleman, 2007). One of the most harmful emission gases is carbon dioxide (CO_2). Toxic octane enhancers such as lead, methylcyclopentadienyl manganese tricarbonyl (MMT) and methyl tertiary butyl ether (MTBE) can be successfully replaced with environmentally friendly ethanol.

The production of ethanol has an impact on various industries, with the two most important being the agricultural industry and the petroleum industry. This is mainly because the agricultural sector serves as an input provider for the ethanol industry, and the petroleum industry serves as an output source for the ethanol industry. Effects on the agricultural industry are mainly due to factors such as changes in the supply and demand of commodities, as well as changes in the animal feed industry as a result of ethanol by-product production. The animal feed industry has been impacted by the introduction of an animal feed raw material known as distiller's grains with solubles (DGS), which is a by-product of the ethanol industry. This by-product is high in protein and can substitute various other raw materials used in animal feed ratios.

1.2 Problem statement and motivation

Ethanol production is likely to have an impact on the animal feed industry mainly because of the introduction of ethanol production by-products used as animal feed. The by-product DGS – known as distiller's dried grains with solubles (DDGS) when dried – is a protein-rich raw material, and when balanced into animal feed is likely to lead to changes in commodity prices, changes in the consumption of different animal feed raw materials, and changes in feed costs mainly because it would substitute imported protein-rich raw materials used in animal feed. If maize is used as a feedstock in ethanol production, this means that maize supply would decrease in the feed industry, which would have effects on the animal feed industry.

Globally various researchers have studied the economic effects of bio-fuel production. Authors such as Banse, Van Meijl, Tabeau and Woltjer (2007), Dixon, Osborne and Rimmer (2007), Reilly and Paltsev (2007), Birur, Hertel and Tyner (2008) and Hertel, Tyner and Birur (2008) argued that since bio-fuels are mostly produced from agricultural commodities, their effects are largely felt in agricultural markets with major land use. Almost all of these articles have over-emphasised the impact of bio-fuels on agricultural markets, due to the fact that they ignored the role of by-products resulting from the production of bio-fuels. Authors who have addressed DDGS are Tokgoz, Elobeid, Fabiosa, Hayes, Babcock, Yu, Dong, Hart and Beghin (2007), Babcock (2008) and Tyner and Taheripour (2008), but they only quantified the impact of bio-fuel production on agricultural markets and not the sectors within the agricultural sector. This means that they only looked at effects such as land use and commodity yields.

In South Africa bio-fuel research projects mainly focus on feasibility studies. Lemmer (2006), for instance, investigated the impact of wheat-based ethanol production in the Western Cape Province, while Albers (2006) examined the feasibility of maize-based ethanol production in South Africa, and the Department of Minerals and Energy (DME, 2006) investigated the feasibility of bio-diesel and ethanol production with various feedstocks.

The problem with these studies is that they presented the effects of DGS as a by-product in terms of the quantities that would be produced and the possible substitution of protein raw materials, for example, but they did not mention the actual effects within the animal feed industry. Albers (2006) touched on the impact, but under the assumption of foreign ethanol production figures, and did not include an in-depth analysis of changes within the animal feed industry. Another shortcoming with the analysis of Albers (2006) is that no price shifts were taken into account, thus rendering the data static. Dunn (2005) conducted a more in-depth study on the impact of DDGS, but with the same shortcoming as Albers (2006), namely that he did not use equilibrium prices. Dunn (2005) used different prices with different scenarios, but did not use a specific equilibrium price and did not take into account that other commodities would also be subject to price changes. The BFAP Team also conducted three reports, in al three reports BFAP (2005), BFAP (2007) and BFAP (2008) a similar study as this thesis were done,, but these reports had shortcomings. The shortcoming of the BFAP reports is that fixed aggregate feed rations were used and only the net effects on the various feed grains were illustrated. The benefit of these reports is that equilibrium prices were simulated dynamically.

In light of the literature referred to above, there is a need to quantify the impact of maize-based ethanol production on the South African animal feed industry in a state where prices are in an equilibrium position. It is important to know the possible impact that the introduction of DDGS would have, mainly because it could have an effect on policy and trade decisions. DDGS from ethanol production will most likely become a new protein source in South Africa and is becoming a leader globally as a protein animal feed raw material. It is important to determine the effects of this new protein source and how it would impact on the animal feed industry. The introduction of DDGS can lower protein imports, because currently South Africa is a net importer of protein (AFMA, 2007). The results of this thesis can help industry experts to adjust their animal feed rations and also keep their stakeholders informed as to what they can expect to happen within various feed sectors.

1.3 Objectives

The primary objective of this study is to quantify the economic impact that renewable fuel (ethanol from maize) production will have on the South African animal feed industry.

In order to achieve the primary objective, the following secondary objectives must be reached:

(a) Estimate the total oilcake consumption per animal species for 2007 in South Africa, and subsequently forecast the per capita consumption of animal final products (beef, mutton, milk, etc.) for 2015.

(b) Simulate equilibrium data for 2015 in order to put the results in a dynamic state. This objective can be satisfied by means of constructing a scenario for 2015 with drivers and uncertainties.

(c) Estimate the consumption changes of animal feed raw materials for 2015, the consumption of DDGS for different species, and the projected change in total feed costs with the introduction of DDGS for 2015.

(d) Analyse whether the correct base data for the Niewoudt/Mcguigan model has been used and subsequently make recommendations.

1.4 Chapter outline

Chapter 2 is an overview of the bio-fuel industry, as well as the animal feed industry – more specifically the ethanol industry – along with a description of the various possible impacts that this industry may have, such as economic and industry impacts. The overview encompasses the global region, as well as local industries. This chapter also contains an in-depth discussion of DDGS and its impact. It is important to thoroughly understand the industries in question in order to understand the possible impacts. **Chapter 3** indicates the different methodologies used in order to arrive at the relevant results, as well as the incorporation of the different methodologies used. The data used for the different methodology techniques is reflected and explained in this chapter, followed by methodology used by others to get similar results. **Chapter 4** is a summary of all the results from the different methodologies, as well as an incorporated summary of results. The final chapter, **Chapter 5**, includes the final conclusions and recommendations in view of possible policymaking.

CHAPTER 2
Overview of the ethanol and animal feed industries

2.1 Introduction

The overview will endorse an understanding of how the two industries work and various aspects that are important to observe in these industries will be highlighted. Thus it will be important to look at the ethanol industry, the South African feed industry, and the by-products of ethanol production used as animal feed. Currently there is no shortage of literature on ethanol production, whereas literature addressing the effects thereof on the animal feed industry is limited.

2.2 Ethanol industry

The ethanol industry is the primary focus of this thesis, with the analysis centred round maize-based ethanol rather than the entire bio-fuel industry. However, to conduct a proper analysis, it is important to understand the industry as a whole and how it works. This specific section explains the industry and the effects of ethanol production in depth according to various literature studies.

2.2.1 Ethanol

According to Albers (2006) ethanol is a high-octane water-free alcohol produced from the fermentation of the sugars in various raw materials and the conversion thereof into starches. Ethanol is mainly produced from grains or crops rich in starch, like maize, wheat, sugar cane, sugar beet, cassava, etc. Ethanol can be used on its own as a fuel, although this is not recommended, and it is normally blended with petrol (gasoline) in concentrations of 5, 10 and up to 85 per cent (E_5, E_{10}, E_{85}).

There are three main advantages to using ethanol: Firstly, it reduces the dependence on imports of crude oil, which has a significant impact on countries that have insufficient supplies of crude oil. Secondly, it has environmental benefits, including the reduction of greenhouse gases and ground-level ozone. Thirdly, ethanol is completely biodegradable and, being renewable, it helps to conserve fossil resources (Viju *et al.*, 2006).

However, there are several challenges when it comes to using ethanol as an alternative fuel (energy) source. Firstly, it is costly to produce and use, because the production plant must be built on a large scale and the feedstocks are normally expensive, and globally ethanol production would not be feasible if subsidies were not in place. Another problem is that ethanol has a smaller energy density than gasoline. Some of the debates are that some scientists argue that the net energy balances of producing ethanol from maize is negative and some argues that with new technologies and dedicated ethanol-engines, this challenge can be reduced to an acceptable point.

2.2.2 International ethanol market

EUBIA (2007) states that Ethanol is probably the most widely used alternative automotive fuel in the world, mainly due to Brazil's decision to produce fuel alcohol from sugar cane, but also due to its use in North America as an octane enhancer of gasoline in small percentages. The world's largest ethanol producers are Brazil and the USA, together producing more than 65% of global ethanol, followed by Europe with 13%. "Fuel ethanol is produced in Brazil mainly from sugar cane and in the USA from maize" (EUBIA, 2007).

According to Lau (2004) the US ethanol industry has steadily grown since the 1970s. "In 2007 the US was the largest producer with 183 billions of liters and Brazil with 170 billions of liters produced" (RFA, 2007). This increase in production is mostly due to various drivers, such as those explained by Zilberman and Rajagopal (2007):

1. **Advanced energy security**.
2. **Job creation –** Ethanol is more labour intensive than other energy technologies on the basis of per unit of energy delivered (Kammen, Kapadia & Fripp, 2004).
3. **Similar physical and chemical properties to crude oil** – Ethanol has similar liquid state, viscosity and combustion characteristics to those of petrol and diesel.
4. **Renewable source**.
5. **More environmentally friendly**.
6. **Increase in farm income** – According to Martinot (2005), the past few years have witnessed both a remarkable increase in the price of oil and an increase in the production of bio-fuels like ethanol and bio-diesel.

Dunn (2005) states that the ethanol industry has seen extraordinary changes in the past few years, mainly due to the fact that the maize conversion ratio changed from 8.3 litres per bushel to 10.5 litres per bushel and the production capacity changed from 3.8 billion litres to 15.1+ billion litres, largely as a result of technology improvements. (Other changes that have occurred are reflected in Table 2.1 below.) According to Trostle (2008) global grain consumption for ethanol in 2000/2001 was 7%, which increased to 30% in 2007/2008 – a remarkable change that was mainly due to the drivers in the ethanol industry. These drivers had a snowball effect, and better technologies for ethanol plants and feedstock were developed. All these factors led to the changes described by Dunn (2005) and illustrated in Table 2.1 below.

Table 2.1: Summary of changes in the ethanol industry over the past two decades

	Then (mid 1980s to early 1990s):	Now:
Industry structure	Concentrated structure	Top 3 firms hold about 30%
	Top 3 firms held about 80% of production	71 total firms (and rising) (44 co-op)
	About 20 firms total	
Production capacity	3.8 billion litres	15.1+ billion litres
Plant construction cost	$2.5/GAL* production capacity	$0.98/gal* production capacity
Maize conversion to ethanol ratio	8.3 litres per bushel	10.5 litres per bushel
Plant labour requirements	52 full-time staff	32 full-time staff
Labour costs	$0.15/gallon (1998)	$0.05/ gallon
Operating days per year	310-320	350-360

Source: Dunn (2005)

According to F.O. Licht (2008) there are 119 ethanol plants in the US, of which 49 of the 119 are farmer-owned plants. The RFA (2007) states that in 2007 the US was the largest producer with 183,7 billion litres of ethanol produced annually, followed by Brazil with 170 billions litres. According to Trostle (2008) global ethanol production increased by 309% between 2004 and 2007, with a further 57% growth projected for 2007 to 2012. With an annual production of 454,000 million litres, Spain is the leading producer in the European region. The sector's success in Spain can be explained by the fact that Spain does not collect tax on ethanol. According to the EUBIA (2007) the introduction of the E85 infrastructure in Europe started in Sweden around the year 2000, but it is only in the last two years that the E85 infrastructure has been expanded to other European Union (EU) countries such as Germany, France and Ireland.

2.2.3 Local ethanol market[1]

According to Coleman (2007) and at the time of writing this thesis, the first ethanol plant in South Africa was planned to be in production by 2009. This is due to be followed by seven additional ethanol production plants scheduled for construction in the Free State, North West and Mpumalanga provinces. There is also speculation of plants (from another company) to be built in the Western Cape Province and in Hoopstad, situated in the Free State Province.

[1] Keep in mind that these are not defined plans and they can change over the course of time.

Figure 2.1 illustrates where these Ethanol-Africa plants are due to be situated. According to Coleman (2007) the intention is to use the dry-milling process to produce ethanol in South Africa.

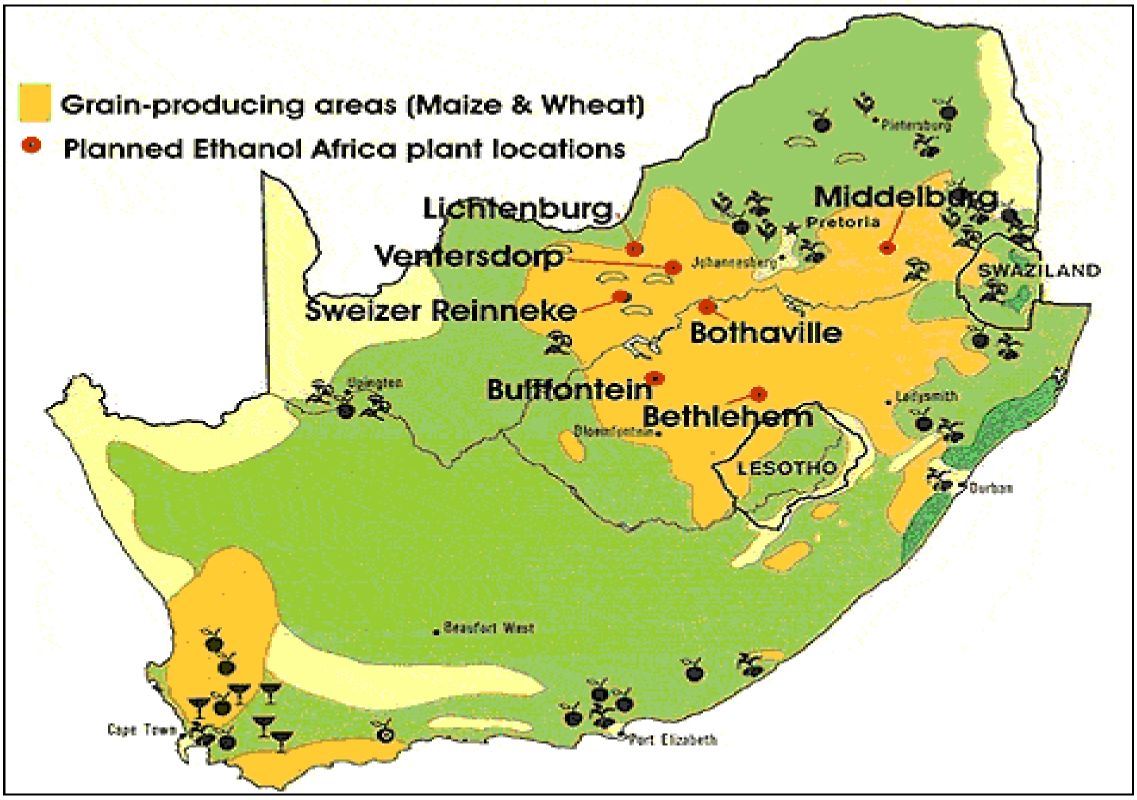

Figure 2.1: Proposed locations of Ethanol-Africa plants
Source: Coleman (2007)

According to Makenete, Lemmer and Kupka (2006) there are a few locations identified for plants that are more profitable than others. Makenete *et al*. (2006) indicated the following factors to be taken into account in choosing a specific location:

- Transporting the maize to the bio-fuel plant.
- Transporting the ethanol to the nearest petroleum refineries.
- Transporting the DDGS to the main feedlots.

The locations are also chosen due to their close proximity to:

- Maize-growing areas
- Infrastructure
- Refinery locations
- Major feedlots.

Figure 2.2 reflects that Sasolburg is the most feasible location because of the local SASOL refinery, followed by Secunda, also on account of the presence of a refinery. In third place is Bothaville, mostly because it is situated in the centre of the maize triangle.

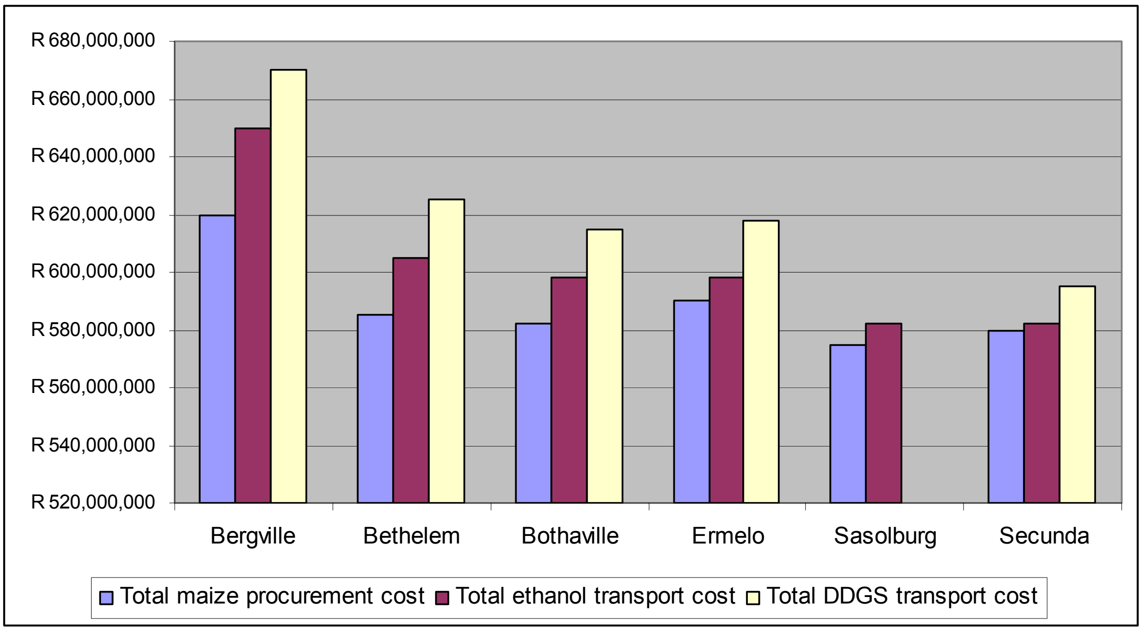

Figure 2.2: Maize to ethanol: Total supply chain cost comparison
Source: Makanete *et al.* (2006)

In the BFAP (2005) report, the BFAP team conducted research on the profitability of ethanol under various scenarios. BFAP (2005) came to the conclusion that ethanol production would be profitable in an environment where there is a growing global economy and high oil prices; however the opposite is true for a lower oil price and a slowing world economy.

“The risks that the ethanol industry will face need to be clearly understood. The behavior of factors like rainfall, the producer price of agricultural commodities, the exchange rate and the oil price will ultimately be the key to the success of ethanol production in South Africa” (BFAP, 2005).

However BFAP (2007) indicated that it would not be profitable to produce ethanol in South Africa without support incentives in place. With the 2006 production year averages BFAP (2007) indicated that a maize based plant will make a loss of 100 cents per litre.

“*Government policies will determine the success of the biofuel industry and whether it will boost the rural economy or invite foreign biofuel producers to come and stake their claim on this infant industry. A self-sustaining industry might be a long-term goal, but in a country with highly volatile prices in a highly deregulated market, as well as erratic weather conditions, the government will carefully have to consider the incentives, the costs and the welfare effects of a biofuel industry*” (BFAP, 2007).

2.2.4 Ethanol conversion technologies

Biochemical conversion is a fermentation process that is used to convert the starch in crops like maize, sugar cane, wheat, etc. into ethanol (alcohol). There are two main techniques used to produce ethanol in this manner, i.e. a dry-milling process and a wet-milling process, with the main difference being the method in which the maize is first broken down. In the wet-milling process the maize is broken down by soaking for 30–50 hours in a diluted sulphuric acid solution, which dissociates the maize and dissolves the starch (Albers, 2006). After soaking, the solids are separated from the solution, and only the dissolved starch is passed on to the fermentation process. Thereafter, the processing of the starch to ethanol is identical to the process used with dry-milling technology.

According to Albers (2006) the basic steps in the ethanol manufacturing process with both the dry-milling and wet-milling technologies are as follows:

1. The maize is processed, with various enzymes added to separate fermentable sugars.
2. Yeast is added to the mixture for the fermentation to produce alcohol.
3. The alcohol is then distilled to fuel-grade ethanol that is 85-95% pure.
4. For fuel and industrial purposes, the ethanol is denatured with a small amount of a displeasing or noxious chemical (typically gasoline) to make it unfit for human consumption.

The dry-milling process has an overall better energy balance than the wet-milling process, and as a result the dry-milling process has become the process of choice for ethanol production from maize (Jacques *et al*, 2003). The dry-milling process as explained by Albers (2006) is graphically explained in Figure 2.3.

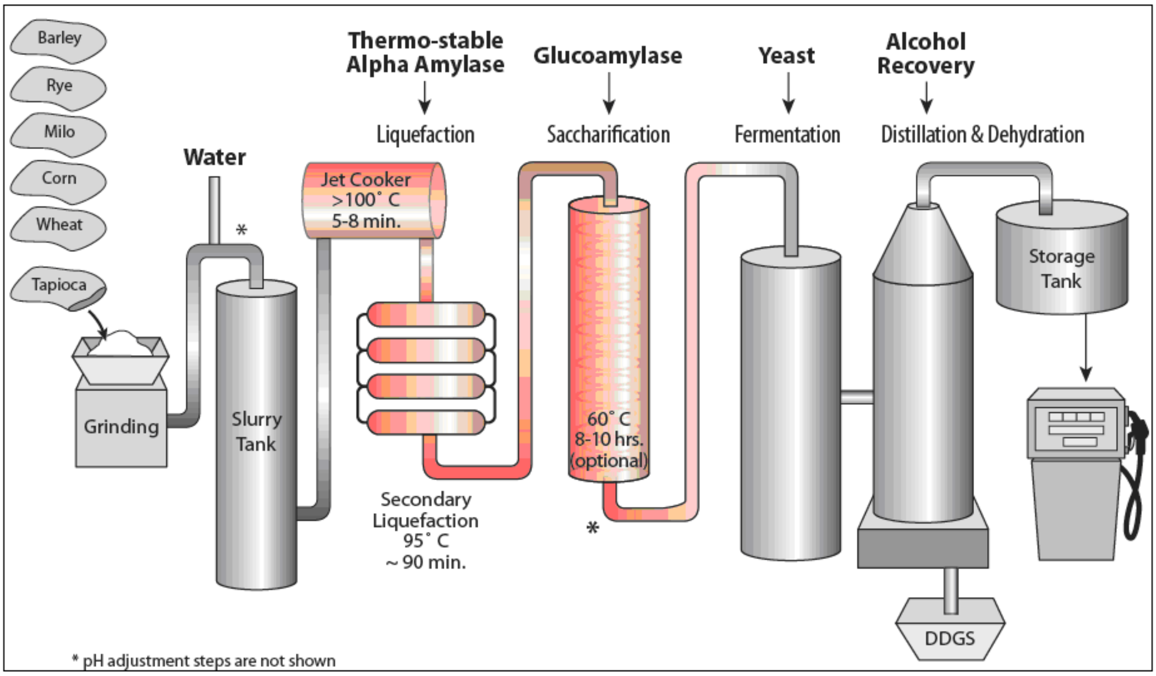

Figure 2.3: The dry-milling ethanol production process
Source: Albers (2006)

Ethanol production plant technology is one of the fastest growing markets in the world, due mainly to the enormous demand for cleaner-burning fuels. Because of this growing demand, ethanol production conversion technology changes on a regular base. According to various literature sources, the following are emerging technologies that can be expected in the future:

- **Cellulosic ethanol:** "Cellulosic ethanol is produced from the transformation of nongrain or nonfruit parts of phytomatter into ethanol. Phytomatter is compiled out of cellulose such as stem, wood, grass, leaves, etc." (Zilberman & Rajagopal, 2007). With cellulosic ethanol the US ethanol industry is developing and increasing the availability of different feedstocks used for ethanol production. Zilberman and Rajagopal (2007) explain that the conversion of feedstocks like maize stover, maize fibre and maize cobs will be the "bridge technology" that leads the industry to the conversion of other cellulosic feedstocks and energy crops such as wheat straw, switchgrass and fast-growing trees.
- **Fischer-Tropsch fuels:** These fuels are produced by catalytically converting carbon monoxide and hydrogen into liquid hydrocarbons (HC). According to Zilberman and Rajagopal (2007) this new technique is used in ethanol as well as bio-diesel production.
- **Biobutanol:** "Butanol is produced by a process called acetone butanol ethanol (ABE) fermentation. This process is used to convert biomass into butanol" (Zilberman & Rajagopal, 2007).

The RFA (2007) states that ethanol companies in the US are developing technology that removes the maize oil from the syrup prior to being mixed with the grains in the dryer. The extracted oil can then be used as a feedstock for bio-diesel production. “Removing the oil from the DDGS concentrates the protein and enhances the value of this important by-product as livestock feed” (RFA, 2007).

2.2.5 By-products from ethanol production

The by-products of ethanol production are carbon dioxide (CO_2) and distiller’s grains with solubles (DGS). These by-products form an equally important part of the ethanol plant’s income earnings. According to Taheripour, Hertel, Tyner, Beckman and Birur (2008) about 16 per cent of the revenue of maize-based dry-milling ethanol plants in the US comes from DDGS sales.

2.2.5.1 Carbon dioxide (CO_2)

According to Tiffany and Eidman (2003) CO_2 is a by-product of dry-milling ethanol production that can be collected during the fermentation process. The CO_2 can be further processed to remove any leftover alcohols and compressed to be marketed to other industries. The carbonated beverage industry is a primary consumer of CO_2, and it can also be used for refrigeration and other industrial uses.

2.2.5.2 Distiller’s grains with solubles (DGS)

According to Dunn (2005) maize is fermented with selected yeasts and enzymes to produce ethanol. “DDGS is the result of the drying and mixing of two of the by-products, DDS (distiller’s dried solubles) and DDG (distiller’s dried grains). Because of the near complete fermentation of starch, the remaining protein, fat, minerals and vitamins increase approximately three-fold in concentration compared to levels found in maize” (Dunn, 2005). According to Shurson and Dominy (2004) there is considerable variation in DDGS quality, nutrient composition and digestibility dpending on the source. Shurson and Dominy (2004) investigated these changes in quality and came to the conclusion that the quality depends on the source, the technology used, as well as the area of production.

2.2.6 Impact of ethanol production

A number of feasibility studies have been done locally, with the most significant being those done by Albers (2006), Lemmer (2006) and the Department of Minerals and Energy (DME, (2007). Lemmer (2006) exlpains that the introduction of an ethanol plant would add monetary value through the processing of the regional surplus of wheat into ethanol, DDGS and CO_2. This particular study by Lemmer aimed to quantify the feasibility of establishing a wheat-based ethanol plant in the Western Cape Province. Such a plant would use mainly wheat as a feedstock, because the Western Cape had a surplus of wheat at the time the study was conducted. According to Lemmer (2006) the introduction of an ethanol plant capable of producing 108 million litres of ethanol annually would imply a benefit of more than R302 million to the community and would create more than 150 jobs during the implementation and construction phase of the plant. In addition, 40 to 50 specialised jobs would be created for ongoing employment at the plant, and ethanol production would prove beneficial not only to the feedstock and ethanol producers, but also to the community. The study concluded that it would indeed be financially feasible to produce ethanol in South Africa at that specific point in time.

Albers (2006) conducted a study for Grain SA to investigate the feasibility of maize-based ethanol production in the Free State Province. That particular study revealed that a single ethanol plant with a capacity of 158 million litres per annum (3,752,97 tons of maize) would generate approximately 4,755 jobs, as well as R52 million in household income for plant and farm employees. For the 8 proposed plants, employment creation would reach 38,000 and an annual household income of R416 million would go to plant and farm employees. This particular study used maize as a feedstock and was based upon Ethanol Africa's proposed plants. The eventual conclusion was that according to the 2006 data, ethanol production in the Free State would be a financially feasible endeavour.

With the introduction of a bio-fuel industry strategy initiated by the DME in December 2006, a bio-fuel task team created a national feasibility study on bio-fuels. According to the DME (2007) if a bio-fuels industry were to be created with E_{10} (10% ethanol) and B_2 (2% bio-diesel) targets, R1,700 million in domestic products would be generated, which constitutes 0.11% of the current GDP. This would also generate at least 60,000 new jobs while terminating only 5,000 throughout the South African economy, and would generate a net increase of R1,700 million per annum in household income throughout the South African economy[2]. The DME (2007) also concluded that on the basis of 2006 data, it would be feasible to produce ethanol in South Africa. “In 2006 the average maize price was R935/ton, while currently in South Africa the maize price is around R1800/ton” (Grain SA, 2007). According to Jordaan, Grove and Alemu (2006) the price of yellow maize is the second most volatile grain price after that of white maize. The variation in input prices poses a challenge for ethanol plants. At present, this is a major problem within the industry, since high input prices mean it is no longer feasible to produce ethanol without subsidies.

BFAP (2007) confirmed that it would not be feasible without government support and intervention. With the necessary intervention BFAP (2007) concluded that the maize price and

[2] For both ethanol and bio-diesel

the total area planted will increase, these increases will have a down stream positive effect on the rural economy

2.3 Animal feed industry

In light of the production of by-products such as DDGS, it is important to understand the animal feed industry, because DDGS will substitute numerous imported protein-rich raw materials. The introduction of DDGS as a raw material leads to changes in the imports of protein feed – and South Africa is a net importer of protein feed. This section gives a brief overview of the international and local animal feed industry. It is important to identify the leaders and the most competitive countries in the global animal feed industry.

2.3.1 International

Total world feed output is approximately 614 million tons. The largest animal feed consumers are the USA, the EU, China and Brazil, which together produce 431 million tons of feed, accounting for 70% of world feed production. According to the IFIF (2007) North America is the biggest producer with 160 million tons, followed by the EU with 143 million tons.

The animal feed industry grew significantly between 1980 and 2004 (IFIF, 2007), increasing from 370 million tons to 614 million tons. The per capita feed used (kg/head) increased from 82kg to 96kg, which is an indication that the world population is moving towards a more protein-based diet. Table 2.2 reflects these changes in the animal feed industry. According to Koster (2008) it is estimated that there are 3,800 feed mills worldwide, which appear to produce 80% of all feed. This means an average production of 13,000 tons per mill per year.

Table 2.2: Global animal feed production

Year	***Population (billions)***	***Manufactured feed (million tons)***	***Per capita feed use (kg/head)***
1980	4.5	370	82
1985	4.9	440	90
1990	5.3	537	101
1995	5.6	590	105
1999	6	586	98
2000	6.1	591	97
2001	6.2	597	96
2002	6.3	604	96
2003	6.3	612	97
2004	6.4	614	96

Source: IFIF (2007)

According to the WHO (2008) developing countries are increasingly consuming more meat products. There are several factors driving the global demand for the animal feed industry – mainly the fact that the demand for animal feed is derived from the demand for final products, which is then affected by factors such as population growth and incomes measured by growth in GDP, feed grain prices, health and food safety issues, and environmental issues. These issues are explained in more detail below.

According to the WHO (2008) world population growth is one of two key underlying factors driving the animal feed industry globally. In concert with a growing world population, household incomes are rising, which in turn increases the demand for protein-based diets (the demand has been increasing steadily for the past 40 years). A rise in incomes combined with population growth has a compounding effect on the demand for animal feed. In 1980, according to the FAO (2007), world per capita meat consumption was just over 30kg per person per year, which increased to 41kg per person per year in 2005.

2.3.2 Local

AFMA (2007) states that the South African animal feed industry came into being in the early 1930s during the time of drought and depression. Circumstances stimulated scientific thoughts on the feeding of farm animals, and alternative feeding systems were developed that could make use of by-products of other industries. South Africa produced 8.6 million tons of animal feed in the 2005-06 marketing year. Table 2.3 reflects the quantities of various feed categories produced. Broilers are currently consuming the most animal feed with 2,554,885 tons. In South Africa the Western Cape is the leader in the production of animal feed (AFMA, 2007).

Table 2.3: National animal feed production during 2005/2006

Feed type	***National feed production (tons)***
Dairy	1,482,683
Beef & Sheep	2,487,130
Pigs	791,265
Layers	586,383
Broilers	2,554,885
Dogs	325,789
Horses	121,000
Ostriches	64,827
Aquaculture	325,4
Total	8,687,216

Source: AFMA (2007)

According to AFMA (2007) the production of animal feed in South Africa grew by 7.9% between 2003-04 and 2005-06. For purposes of this study, oilcake is one of the most important raw material categories to evaluate, mainly because oilcake is protein rich and DDGS is most likely to be used as a substitute. One of the most important raw materials in this category is soy oilcake. Soybean production in South Africa increased from 220,000 tons in 2004/05 to 263,000 tons in the 2005/06 marketing season (AFMA, 2007), which can be attributed to the more competitive price of soybeans compared to maize, as well as the research conducted by the Protein Research Foundation (PRF), which is now starting to show dividends. "*The PRF strives to make a significant contribution to the promotion of local production of protein, as well as the optimal utilization thereof, on a competitive basis, in order to satisfy the growing need for protein for animal production purposes, which will lead to an increase in the standard of living of all people in the RSA*" (PRF,2009). According to AFMA (2007) South Africa imports 63% (1,027,156 tons) of its oilcake, which makes South Africa a net importer. Imports of soy oilcake (soybeans and oilcake) showed a slight decrease of 8,800 tons from 648,478 to 639,678 tons in 2005/06 (AFMA, 2007).

Another important raw material is maize, mainly due to the fact that this study considers it to be the main feedstock used for ethanol production, and it is therefore important to look at its availability. South Africa experienced major overproduction of maize for the last two seasons, which continued through the 2005/06 AFMA year. According to Grain SA (2007) the closing stocks for the 2005/06 marketing year were 3.1 million tons.

2.3.3 DDGS as raw material in animal feed

According to Shurson and Noll (2005) the formal definition of DDGS is "the product obtained after the removal of ethyl alcohol by distillation from yeast fermentation of a grain or a grain mixture by condensing and drying at least 3/4 of the solids of the resultant whole stillage by methods employed in the grain distilling industry". The quality of DDGS is important mostly because of the correlation between poor quality and high mycotoxin levels. Shurson and Dominy (2004) state that there is considerable variation in DDGS quality, normally in terms of nutrient composition and digestibility, depending on the source. Unlike maize and other grains, there is no grading system to differentiate quality within ethanol by-product (DDGS) categories, and many ethanol plants and by-product marketers are opposed to developing such a system globally. According to Shurson and Noll (2005) attempts have been made in recent years in the USA to develop a system to differentiate quality and value among DDGS sources, but these attempts have failed. However, despite not having a grading system for DDGS in the USA, there is price differentiation based upon subjective colour evaluation. According to Shurson and Noll (2005) it is not uncommon to find a \$20 to \$30/ton market price differential between golden DDGS and darker coloured DDGS, where the darker the DDGS the higher the mycotoxin levels and therefore the lower the quality.

"A method to reduce nutrient variation is to develop a DDGS specification sheet for nutrient levels and physical characteristics" (Thaler, 2003). Dunn (2005) classifies DDGS as average-protein DDGS, low-protein DDGS and high-protein DDGS. Average-, low- and high-protein

DDGS contains 27.5%, 25% and 30% protein respectively. The remaining nutrient composition of all three types of DDGS is reflected in Table 2.4.

Table 2.4: Nutrient composition of DDGS

Nutrient	*Unit*	*Average*	*Low*	*High*
Moisture	%	11	14	7.5
Crude protein	%	27.5	25	30
Fat	%	9.5	8	11
Ash	%	5.5	8.5	3
ADF	%	12.5	18.5	7.5
NDF	%	36.5	40	33
RUP	%	12.4	11.3	13.5
ME pig	Kcal/kg	2783	2475	3089
ME poultry	Kcal/kg	2265	1925	2597
NE lactation	MJ/kg	7.97	7.01	8.92
ME feedlot	Kcal/kg	2850	2532	3163
Calcium	%	0.06	0.06	0.06
Phosphorus	%	0.68	0.68	0.68
Dig. p (poultry)	%	0.45	0.45	0.45
Dig. p (pig)	%	0.29	0.29	0.29
Tot lys	%	0.697	0.554	0.839
Dig. lys pig	%	0.495	0.393	0.596
Dig. lys poultry	%	0.453	0.36	0.545
Linoleic acid	%	5.2	4.4	6.1

Source: Dunn (2005)

As shown in Table 2.5 below, Shurson and Dominy (2004) described DDGS as having nutrient concentrations of up to 93% dry matter and up to 29% crude protein. According to Klopfenstein (2003) the protein in DDGS is 50% undergraded intake protein (UIP), also known as bypass protein, and 50% degraded intake protein (DIP).

Table 2.5: Nutrient concentration of DDGS

Nutrient	**Concentration range**
Dry matter	87-93%
Crude protein	23-29%
Crude fat	3-12%
Lysine	59-89%

Source: Shurson and Dominy (2004)

If DDGS is becoming increasingly available in the South African animal feed industry, it is important to look at the quality thereof, since pig and poultry diets are extremely sensitive to high mycotoxin levels, which is why Shurson and Dominy (2004) warn that dark-coloured DDGS should not be used in pig and poultry diets. Instead, they recommend the use of the new-generation DDGS, which is “lightly coloured with a sweet fermentation smell and is suitable for use in pig, poultry and ruminant diets” (Shurson & Dominy, 2004).

2.3.3.1 Ruminant diets

According to KCC (2005) DDGS is an excellent raw material for feedlot cattle. DDGS has an apparent energy value equal to maize grain when fed to finishing cattle at levels ranging from 10% to 20% of total ration dry matter. According to KCC (2005) DDGS can be included between 6% and 15%, serving primarily as a source of supplemental protein. According to the RFA (2007) rations for ruminant (beef and dairy) feed allow for up to 40% of the mixture to be DDGS.

Klopfenstein (2003) explains that in the ethanol production process a liquid is produced that is known as thin stillage, which is removed from the mash in the production process. This thin stillage can be reintroduced into the distillation process to extract residual ethanol or it can be used in feedlots. The thin stillage can substitute water in the feedlots, as it contains 5%-10% dry matter. Klopfenstein (2003) states that using thin stillage can reduce dry matter usage without any negative impact on animal performance. According to Loy (2007) cattle that were allowed access to thin stillage as their only water source gained weight 5.7% faster and consumed 5.8% less feed, thereby making them 11% more efficient than those with access to only water.

2.3.3.1.1 Beef diets

According to Trenkle (2005) DDGS has the following advantages when fed in cattle diets:

- DDGS is tasty and willingly consumed by cattle.
- Feeding DDGS does not change the quality or yield grades of carcasses.
- Feed costs can be reduced, provided that the cost of DDGS is not higher than the cost of maize grain.
- Yeast fermentation in the distillery process adds dried yeast cells high in vitamin B.
- 55% of protein is bypass protein for increased utilisation.

According to the KCC (2005) DDGS can compose up to 40% of dry matter. The recommended feeding levels of DDGS for beef cattle can be seen in Table 2.6 below.

Table 2.6: Recommended feeding levels for beef cattle

Ration	DDGS feeding level
Creep feeding	up to 20%
Feedlot cattle	up to 40%
Receiving/starting cattle	up to 20%
Litter cows	up to 35%

Source: KCC (2005)

"During a 299-day feeding trial, feeding DDGS at 10, 20 or 40% inclusion rates did not affect feedlot performance; it also did not affect carcass weight or yield grades negatively" (Trenkle, 2005). According to Shurson and Noll (2005) other potential uses of DDGS include its use as a creep feed for calves and nursing cows, as a supplement for grazing cattle, and as a supplement for low-quality forages and crop residues that might be fed to growing calves, gestating beef cows, or developing beef heifers.

2.3.3.1.2 Dairy diets

Schingoethe (2005) lists the following advantages of using DDGS in dairy cow diets:

- Good source of ruminally undegradable (bypass) protein.
- Good-quality protein although lysine is the first limiting amino acid.
- Production by dairy cows fed DDGS as the protein supplement is as high as or higher than when fed soybean meal.
- Replacing the starch in maize with the highly digestible fibre and fat in DDGS may lower the incidence of digestive upsets.

Shurson and Noll (2005) state that as long as a sufficient amount of fibre is provided by forages in the diet, using DDGS to constitute up to 20% of dry matter intake will not affect milk fat concentration. Feeding DDGS to dairy cattle can be beneficial, but according to Shurson and Noll (2005) the phosphorus concentration of the diet may be a factor to consider in order to minimise the excretion of phosphorus in the manure.

2.3.3.1.3 Sheep diets

According to Harpster (2007) DDGS does have some advantages when used in sheep diets. DDGS is a cost-competitive source of protein and energy in lamb rations. It is also an excellent feedstuff to add protein and energy to ewe rations, especially those based on lower quality roughage feedstuffs. DDGS also has low levels of copper, which will be beneficial for lamb diets.

According to the results of a study by Held (2006), when DDGS was fed with soyhulls, the average daily gain (ADG) in the lamb finishing phase was 0.34kg per day and dry matter intake was around 4% of animal body weight. When residual feed remaining in the feeder trough was removed on a weekly basis, fewer pounds of residual feed were removed from the DDGS/soyhulls feeders.

According to Schauer, Berg, Stamm, Stecher, Pearson and Drolc (2005) DDGS replaces up to 30% of the maize portion, improves lamb performance, and has no negative effect on the lamb carcass. Schauer *et al.* (2005) report that DDGS can be included at levels up to 15% of a finishing ration with no negative effect on lamb performance or carcass weight. "Higher inclusion levels may be economical but generally reduce intake and potential performance (may result from higher fat intake)" (Schauer *et al.,* 2005). Total calcium/phosphorus ratios are important to reduce the risk of urinary calculi, since DDGS increases phosphorus levels.

2.3.3.2 Swine diets

"DDGS can work well in swine rations at proper inclusion levels when the diets are balanced on digestible amino acids and phosphorus" (Thaler, 2003). Mycotoxins may affect reproduction, and therefore extra care must be taken when using DDGS in sow diets. "Mycotoxins are produced by molds either in the field or during storage. They can insistently impact pig and sow performance" (Thaler, 2003). The fermentation process does not destroy mycotoxins. As mentioned previously, lysine and other nutrients are threefold in the production process, and therefore mycotoxins are also threefold. "Since the maximum inclusion rate of both mycotoxins is 1 part per million (ppm) in the total diet, it does not take a large amount of mycotoxins to cause problems, especially for sows" (Thaler, 2003).

To properly incorporate DDGS in swine diets, the diets must be formulated on a lysine or digestible-lysine basis. "If the diets are balanced on crude protein, the diets will be grossly deficient in lysine and other essential amino acids, and pig performance will be substantially decreased" (Thaler, 2003). According to Shurson and Dominy (2004) DDGS can be effectively used in swine diets with maximum dietary inclusion rates of up to 50%. The recommended inclusion rates for the different diets are illustrated in Table 2.7 below:

Table 2.7: Swine inclusion rates

Ration	DDGS inclusion rates
Nursery pigs(> 15 lbs)	25%
Grow-finish pigs	20%
Lactating sows	20%
Gestating sows	50%

Source: Shurson and Dominy (2004)

It is recommended that inclusion is started at a lower level and then gradually increased to the maximum inclusion rate, especially for sows. According to a study by Shurson and Dominy (2004), immediately implementing a higher level of inclusion for sows resulted in a reduction in feed intake for about a week. According to Dunn (2005) up to 25% DDGS can be included in nursery diets for pigs, provided that the piglets weigh at least 7kg and the diet is formulated on a digestible amino acid basis. "For grow-finishing diets the inclusion of more than 20% DDGS will negatively influence fat quality. Sows can be fed diets containing up to 50% DDGS in gestation and 20% DDGS in lactation" (Dunn, 2005).

According to Shurson and Dominy (2004) DDGS has the following advantages in swine diets: DDGS reduces phosphorus (P) excretion in manure and does not affect air quality in swine facilities. This raw material contains 0.70% available P, which is 18 times more than the available P in maize (0.04%). Feeding DDGS may improve the health status of pigs.

2.3.3.4 Poultry diets

According to Harpster (2007), for best utilisation of DDGS a number of factors must be taken into consideration: The DDGS source must provide a complete and current nutrient profile. The diets must be formulated using digestible amino acids and set minimums for lysine, motioning plus cosine, threonine, tryptophan and arginine. Metabolisable energy values of at least 1,250 kcal/lb must be used and the phosphorus bio-availability must be adjusted to 65% (Harpster, 2007).

According to Noll (2007) this must be carefully taken into account, because some of the nutrient variability in DDGS may be due to the addition of different levels of solubles to the wet grains prior to drying. Varying the addition of solubles to the grains affects particle size, colour, as well as fat and mineral content. Noll (2007) explains that the use of high levels of DDGS will change the amino acid and mineral nutrient profile, as well as the amounts of ingredients being used.

According to Harpster (2007) DDGS does have the following advantages when used in poultry diets:

- High in energy, protein, amino acids and phosphorus.
- Economically priced: least cost formulation allows up to 20% DDGS inclusion depending on the price of ration ingredients (maize, soybean meal, fat, lysine and dicalcium phosphorus).

According to Noll, Parson and Dozier (2007) 10% DDGS can be included in broiler diets and 15% can be included in layer diets. Higher levels may be added with careful adjustment of amino acids and energy levels. “Diets should also be formulated by setting minimum acceptable levels for tryptophan and arginine due to the second limiting nature of these amino acids in DDGS protein”(Noll *et al.,* 2007) .

2.3.4 Other forms of DDGS usage

According to Shurson and Noll (2005) DDGS can be pelleted in order to facilitate handling and export. To make a good-quality pellet, about 20% soybean hulls are blended with DDGS before pelleting. However, the addition of soybean hulls increases the fibre content of the product and dilutes all the other nutrients.

2.4 Chapter summary

This chapter described the ethanol production process, as well as the advantages and disadvantages thereof. The growth in the ethanol industry over the past few years has been tremendous, and some of these growth figures and leading producer countries are explained in the section discussing the international situation. Locally there is speculation of ethanol plants, but nothing has been finalised as yet.

An overview of the animal feed industry internationally and locally was given, with a discussion and evaluation of the changes in the animal feed industry, as well as the leading producers.

An in-depth explanation of the importance of DDGS in various animal diets was also given. This section revealed that DDGS can be beneficial, although some animal diets are sensitive, meaning that the quality of the DDGS is important and must be regulated.

CHAPTER **3**

Methodology and data used

3.1 Introduction

In order to achieve the stated objectives, three models were used. These models and the linkages between them are explained in this chapter. The first part of the chapter explains which models were used globally to quantify the impact that bio-fuels will have. Thereafter an explanation of the models and their contribution to satisfying the objectives is given. The second part of the chapter reflects the data used and how it was quantified in order to retrieve the results.

3.2 Similar studies

This section focuses on research projects that are similar or related to this specific study. Not much literature on this specific subject is available, but the most important literature is mentioned and discussed in this section in terms of international as well as local research projects.

3.2.1 International

Various international studies, including those by Banse *et al.* (2007), Dixon *et al.* (2007), Reilly and Paltsev (2007), Birur *et al.* (2008) and Hertel *et al.* (2008), have used computable general equilibrium models and have addressed the economy-wide and environmental consequences of producing bio-fuels on a large scale. These studies mainly argue that since bio-fuels are mostly produced from agricultural sources, their effects are largely felt in agricultural markets with major land use and environmental consequences. Almost all of these studies have outlined the impact of bio-fuels on agricultural markets and have laregely ignored the role of by-products resulting from the production of bio-fuels. The inclusion of DDGS in models is extremely important, as proven by various studies.

For example, Tokgoz *et al*. (2007) incorporated DDGS as a substitute for maize into the agricultural model of the Centre for Agricultural and Rural Development (CARD) of the Iowa State University, showing that the inclusion of DDGS in the model significantly changes the results. Tokgoz *et al.* (2007) customised a version of the deterministic Food and Agricultural

Policy Research Institute (FAPRI) modelling system that contains models of supply and demand for all important agricultural products in all the relevant countries. Recent studies by Babcock (2008) and Tyner and Taheripour (2008) also incorporated by-products of bio-fuel production with their partial equilibrium models to quantify the economic impacts of bio-fuel production. Taheripour *et al.* (2008) also proved that DDGS is an important part of bio-fuels with the use of the GTAP model.

Tokgoz *et al.* (2007) projected the impact of US ethanol production and its impact on planted hectares, crop prices, livestock production and prices, trade and retail food costs. The projections were made using a multi-product, multi-country deterministic partial equilibrium model. The impact of higher oil prices, a drought situation combined with an ethanol mandate, and the removal of land from the Conservation Reserve Program (CRP) in the US, relative to baseline projections, was also presented. Tokgoz *et al.* (2007) used various assumptions for the baseline projections, including:

- No impact on trend yields from changes in planted hectares.
- No impact on meat quality from the feeding of DDGS at less than maximum inclusion rates.
- All potential bottlenecks involved in transporting ethanol, DDGS, maize and fertilizer are solved.
- Cellulosic ethanol is not competitive under current policy incentives.
- Livestock feeders respond to permanent feed cost increases to a greater degree than temporary feed cost increases, and only direct food price increases caused by increased feed costs are accounted for.

Tokgoz *et al.* (2007) concluded the following effects with higher oil prices:

- Expanded US ethanol production will cause long-run crop prices to increase.
- With higher feed costs, livestock prices will increase enough to cover the feed cost increases.
- Leading prices of retail meat, eggs and dairy would also increase.
- The effect of higher feed costs is that US food prices would increase by a minimum of 1.1%.
- Beef, pork, and poultry prices would rise by more than 4%, while egg prices would rise by 8%.

According to Tokgoz *et al.* (2007) the results of a model with a drought situation combined with a large mandate for continued ethanol production indicate the following:

- Significantly higher crop prices.
- Decrease in livestock production and higher food prices.
- Significant decrease in maize exports and an increase in feed costs, with a sharp increase in wheat feed.

According to Tokgoz *et al.* (2007) taking additional land out of the CRP would have the following effects:

- o Crop prices would be lowered in the short term, but because long-term maize prices are determined by ethanol prices and not by maize hectares, the long-term impact on commodity prices and food prices of a smaller CRP would be modest.
- o Most of the increased maize hectares are replacing the US soybean hectares, which are projected to decline to 28 million hectares.
- o Average soybean prices are projected to be above $7.00 per bushel.
- o With higher feed prices, livestock producers are assumed to reduce production to allow their higher production costs to be handed over to consumers. The livestock production is projected to enter a period of slower growth as these adjustments take place. "Although US exports of maize, soybeans, wheat, cotton and meat products are projected to decline or flatten, the competitiveness of US agriculture is largely unchanged because most of the rest of the world's producers also face sharply higher feed costs" (Tokgoz *et al.,* 2007).

According to Tokgoz *et al.* (2007) DDGS enters the rations of ruminant animals and replace mostly maize and soybean meal only to a limited extent. With a large US and international market for DDGS in ruminant feed rations, the DDGS price reflects its feed value in ruminant rations as a replacement for maize. Poultry and swine rations initially respond to a surplus of DDGS with relatively high inclusion rates, but as markets adjust and DDGS prices increase, these species eventually regress to a combination of maize/soybean meal diets. According to Tokgoz *et al.* (2007) the impact on cattle feed is as great as the impact on swine feed due to the fact that DDGS prices and maize prices are positively correlated. As the price of DDGS increases, poultry and swine producers continue to purchase maize and soybean meal and thus soybean prices increase rather than decrease.

Taheripour *et al.* (2008) introduced DDGS as a by-product of grain-based ethanol into the GTAP-0BIOB database, originally developed by Taheripour *et al.* (2007). Taheripour *et al.* (2008) also incorporated DDGS into the Global Trade Analysis Project model (GTAP-E) developed by Burniaux and Truong (2002) and modified by McDougall and Golub (2007) and Birur *et al.* (2008). The structure of the GTAP-E model was modified to handle the global production and consumption of bio-fuels and their by-products, more specifically DDGS. Taheripour *et al.* (2008) divided the world economy into 21 commodities, 20 industries and 18 regions and then quantified the global impact of the US Energy Independence and Security Act of 2007 and the European Union mandates for promoting bio-fuel production in the presence of DDGS. According to Taheripour *et al.* (2008) models with and without DDGS have different portraits from the economic impacts of international bio-fuel mandates for the world economy in 2015.

Taheripour *et al.* (2008) stated that both the GTAP-BIOB and the GTAP-E models demonstrate significant changes in the agricultural production pattern across the world due to the inclusion of DDGS:

- The model with DDGS shows smaller changes in the production of cereal grains and larger changes for oilseeds products in the US, and the opposite for Brazil.
- The US production of cereal grains with the introduction of DDGS increased by 10.2% (without DDGS 16.4%).
- The model with no DDGS predicts that the price of cereal grains will increase by 22.7% in the US during the period 2006 to 2015 (with DDGS 13. 7%).
- The model with no DDGS predicts that the price of oilseeds will increase by 62.5% in the EU during the period 2006 to 2015 (without DDGS 58.3%).

According to Taheripour *et al.* (2008) an important effect of the ethanol industry is that when ethanol production is boosted with government subsidies or positive oil price shocks, the production of by-products also increases and, as a reply to these changes, their prices decrease. These price decreases encourage livestock producers to use more DDGS in their production processes. On the other hand, a reduction in the price of by-products diminishes the growth rate of the ethanol industry. This means that by-products from ethanol production, such as DDGS, are shock absorbers and price adjusters.

3.2.2 Local

Dunn (2005) did a similar study as this one on the South African animal feed industry, using a normal least cost combination feed model. He used DDGS prices ranging from R100/ton up to R1500/ton and found that DDGS replaces some maize and maize by-products, but maize gluten feed and maize gluten meal are not freely available, and only the effect on maize and hominy chop consumption will be negative for the local maize industry. DDGS is competing with maize, maize by-products, wheat bran and sunflower meal, which means that DDGS substitutes these products. Dunn (2005) forecasts that based on these assumptions, poultry is likely to consume the most DDGS in South Africa and swine the least. He is of the opinion that the formal feed industry in South Africa would welcome DDGS as a new feed ingredient in the local market. The results of all the scenarios used by Dunn (2005) are illustrated in Figure 3.1.

It is clear from the literature that DDGS will have an impact on the South African animal feed industry, but in order to get the full effect there must be substitutions between raw materials because of changes in supply and demand.

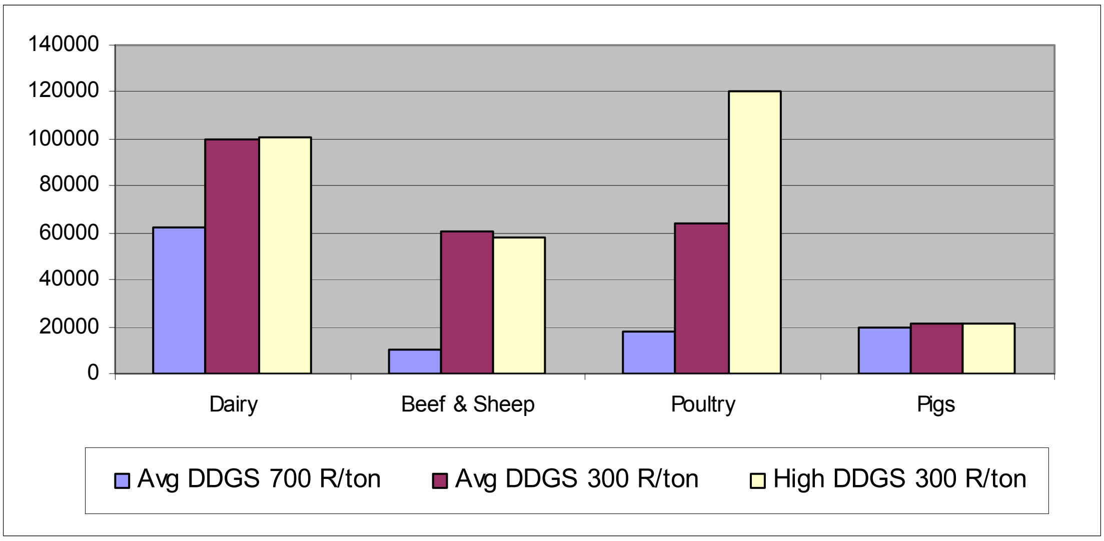

Figure 3.1: DDGS usage by species (ton/year)
Source: Dunn (2005)

3.3 Methodological framework

The three models used in this study are the Agricultural Products Requirements (APR) model (Briedenhann, 2001), the Bureau for Food and Agricultural Policy (BFAP) model (Meyer, Strauss & Funke, 2008) and the Nieuwoudt/McGuigan model (McGuigan, 2001). The APR model is used to simulate the effects on the consumption of animal feed in South Africa. The BFAP model is used to forecast equilibrium prices and to simulate new scenarios in the APR model, while the Nieuwoudt/McGuigan model is used to forecast the 2015 per capita consumption of final animal products such as beef, chicken, pork, mutton, eggs and milk, with different scenarios. With the results of the Nieuwoudt/McGuigan model, base factors can be incorporated into the APR mode for the year 2015. This section describes the models in detail to generate an understanding of the main functions of the models in the study. The description of the models is followed by an explanation of how the models are incorporated.

3.3.1 Bureau for Food and Agriculture Policy (BFAP) model

In order to estimate the raw material equilibrium prices for 2015, the BFAP model is used. "The BFAP sector model is a dynamic system of econometric equations, which has the ability to model cross-commodity linkages" (Meyer *et al.*, 2008). According to Meyer and Kirsten (2005) the first South African grain, livestock and dairy model was developed and operated by Meyer and Westhoff (2003). The model is a large-scale, multi-sector commodity-level simulation model described by Meyer *et al.* (2008) as having six field-crop, five livestock and five dairy commodities. A new fuel market section that includes petrol, diesel, ethanol and bio-diesel was also attached more recently. Some of these commodities are graphically explained in Table 3.1.

Table 3.1: Products used in the BFAP commodity model

Cereals	Oilseeds	Livestock and Dairy	Other
White Maize	Sunflowers	Chicken	Wine
Yellow Maize	Soybeans	Beef	Sugar
Wheat	Canola	Mutton	Potatoes
Sorghum	Cotton	Pork	Bio-fuels
Barley		Eggs	Horticulture
		Dairy	DDGS
		Wool	

Source: Meyer et *al.* (2008)

According to Meyer *et al.* (2008) the BFAP model simulates twenty-six commodities, with the linkages graphically shown in Figure 3.2. The commodities are divided into four groups, namely Bio-fuels, Livestock, Horticulture, and Field crops. Figure 3.2 also gives a list of variables used to introduce shocks into the model.

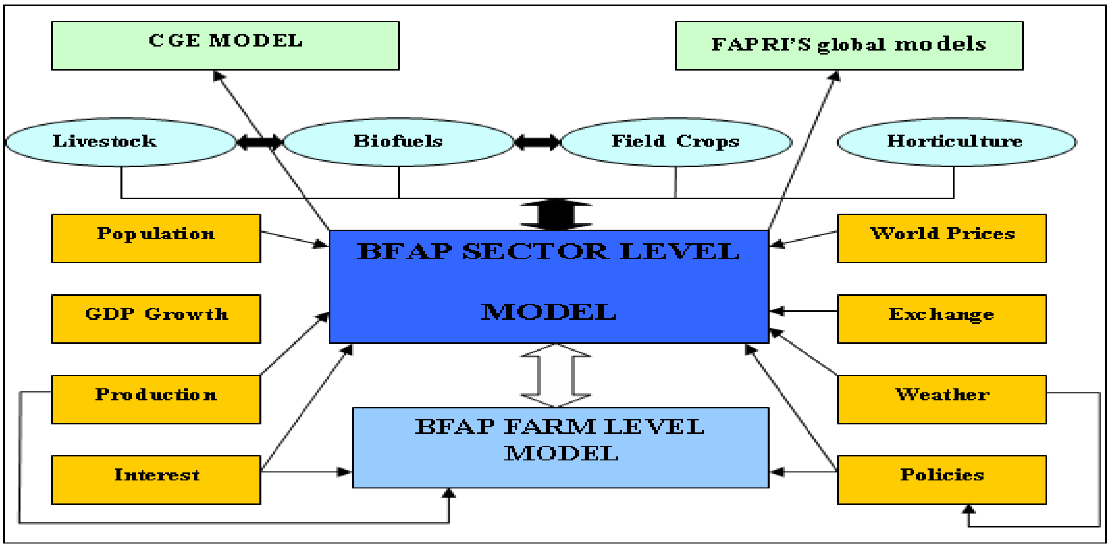

Figure 3.2: BFAP system of commodity models
Source: Meyer *et al.* (2008)

For the BFAP model, scenarios are used to project prices for 2015. According to Strauss (2006) the principle behind the use of scenarios is firstly to understand the key drivers and key uncertainties determining agricultural markets and policies. The BFAP team is an associate of the Institute for Future Research (IFR) and does regular scenario planning for various institutions within and outside of the agricultural industry of South Africa. For purposes of this study, the commodity model is used. The BFAP model is a dynamic model, whereas the APR model is static in nature, which is why the BFAP model is used to project the price changes of various raw materials with the introduction of DDGS.

3.3.2 Agricultural Products Requirements (APR) model

As mentioned previously, the base model for this study is a linear programming feed formulation model, referred to as the Agricultural Products Requirements (APR) model, as developed by Briedenhann (2001). The APR model is used to calculate the animal feed consumption at a minimum total cost in South Africa, given the availability of raw materials and their corresponding prices. The model divides the country into three specific regions, namely Cape (C), Interior (I) and Kwazulu-Natal (Z). The model takes into account the demand for various animal products based on the human population figures and thereby calculates the number of animals (per species) that need to be fed, based on the nutrient requirements of those animals and their feed conversion ratios.

Briedenhann (2001) states that the APR model can be divided into two main sections: The first section entials calculations of animal feed demand from per capita consumption of animal products, making use of animal performance data. The model calculates the total feed demand with sub-categories such as feed demand per region, animal requirements to meet animal product demand, and the animal product demand locally. Such data is reflected and explained in Figure 3.3.

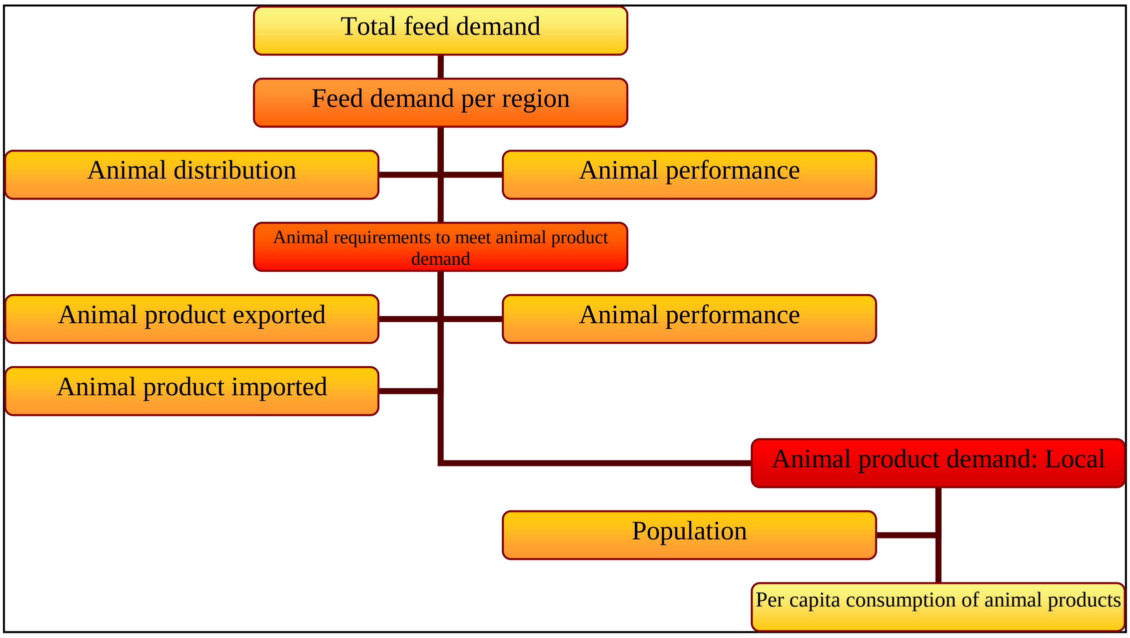

Figure 3.3: Representation of the model interrelationships for determining feed demand
Source: Briedenhann (2001)

The second section entails linear programming considering the animal feed demand, raw material availability and prices to determine raw material requirements. This process is graphically explained in Figure 3.4. Briedenhann (2001) argues that in order to determine the demand for raw materials, all categories of animal types that consume feed need to be considered, and these categories are listed in Figure A1 in the annexure. Each main category is divided into sub-categories and some are further divided into sub-sub-categories.

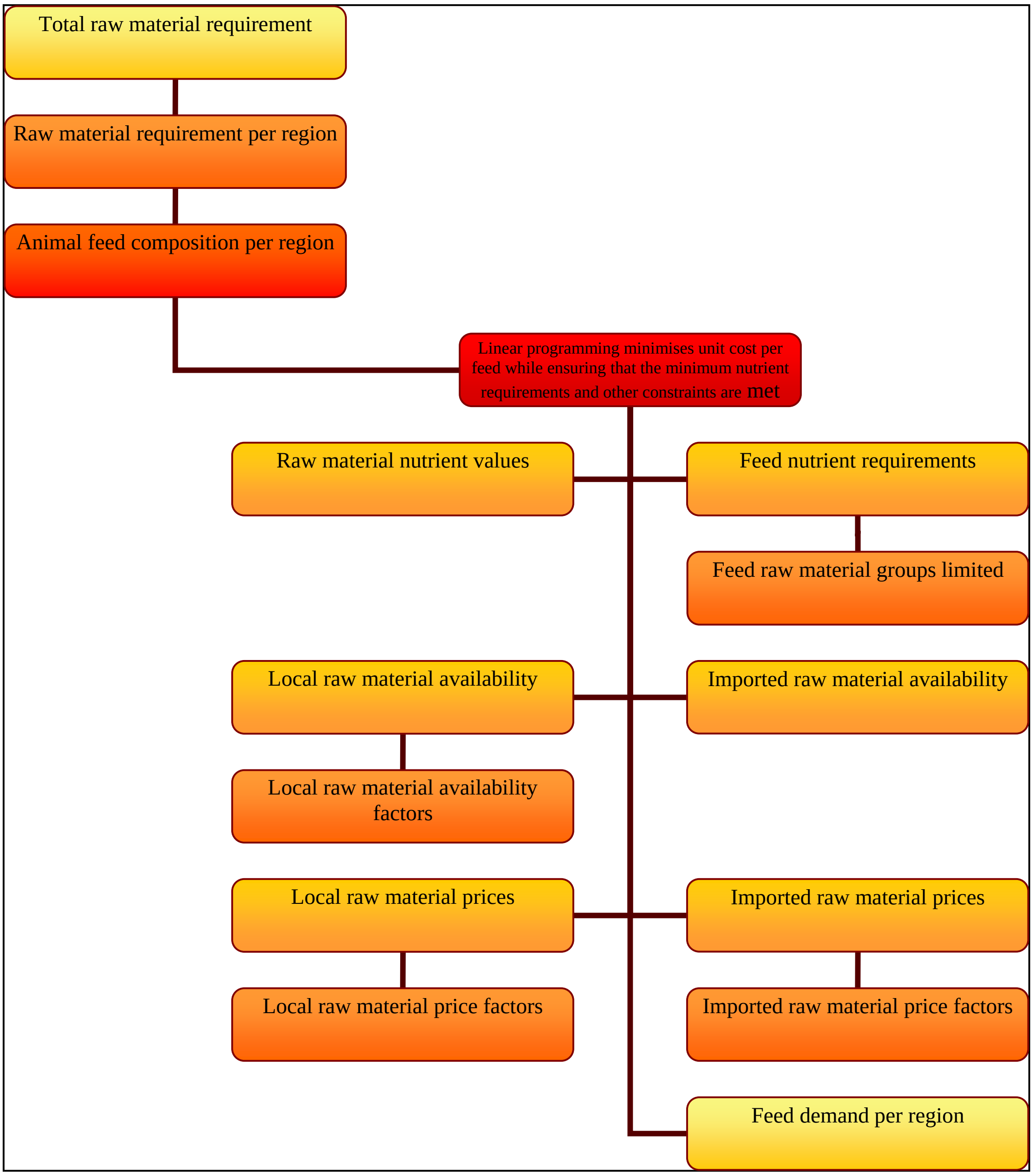

Figure 3.4: Representation of the model interrelationships for determining raw material demand
Source: Briedenhann (2001)

According to Briedenhann (2001) the effects of numerous parameters on raw material requirements can easily be shown using the APR model. These parameters include population growth rates, animal product imports and exports, animal performance and raw material prices together with raw material availability. The substitution between types of raw materials to fulfil requirements is driven by the following parameters:

- Raw material prices and components of raw material prices
- Animal distribution
- Raw material distribution and raw material availability

The APR model therefore integrates information about demand for animal products, animal performance, raw material availability and raw material price. The APR model is thus used to quantify the impact of maize-based ethanol production on the South African animal feed industry, mainly by illustrating the substitution effects from annual consumption of various protein-rich raw materials.

3.3.3 Nieuwoudt / McGuigan model

The Nieuwoudt/Mcguigan model is used to quantify the demand for protein in South Africa. In short the Nieuwoudt/Mcguigan model is an interactive spreadsheet model that is used to estimate protein animal feed demands for the future. According to McGuigan (2001) the model projects supply and demand and calculates equilibrium prices and consumption figures using price elasticities of demand and supply. McGuigan (2001) states that the demand projection is driven by population and income growth, where the supply is estimated according to past trends and the incorporation of estimated rates of technological progress in livestock production. A novel feature of the model is that it incorporates dynamic income elasticities of demand that are adjusted with real income figures.

Nieuwoudt (1998a) developed a mathematical projection model to consider some of the major demand components that may experience structural changes in South Africa during the next few decades. Originally the model was designed to project the demand for livestock products in South Africa for the years 2000, 2010 and 2020, but it can project the demand for any specified year. Projections of final product demand are made for beef, mutton, pork, poultry meat, eggs, fresh milk, milk powder and cheese. Nieuwoudt (1998a) argues that factors such as differences in the growth rates of different population groups, income elasticities and urbanisation are reasons for structural adjustments in the demand for food.

Nieuwoudt (1998b) improved the model by estimating the consumption of livestock products and then deriving feed consumption from consumption of the final livestock products. A livestock supply side is included in the model, and Nieuwoudt (1998b) applied the projected increase in final product consumption to their protein consumption, to project the protein consumption. Nieuwoudt (1998b) also introduced a low, high and average income growth in order to increase the quality of the projections.

McGuigan (2001) improved on the Nieuwoudt (1998b) model as follows:

- o The model was made interactive, thereby readily allowing for scenario analysis.
- o An international model was included.
- o The price of protein is rendered endogenous, as it is generated by an international model.
- o Income elasticities of demand are permitted to decline with GNP growth,
- o Rates of technological progress in livestock production are estimated and included.

McGuigan (2001) calculated the future demand for products by means of the following index:

$Index_{py}$ = 100*(DDF/CON)

Where:

$Index_{py}$ is the future demand for product p in year y

Con is the total consumption in base year for product p, calculated as:

$$CON = \sum_{pj} P_{pj} * C_{pj} \quad \text{(1)}$$

Where:

p = Beef, Mutton, Pork, Poultry meat, Eggs, Fresh milk, Milk powder, and Cheese

j = Urban blacks, Rural blacks, Asians, Coloureds and Whites

P = Population numbers

C = Per capita consumption

DDF_P is the projected future demand for product p in year y calculated as:

$$DDFp = \sum_{pj} \left[\left(\left(1 + I_{pj}\right)^{\wedge n} - 1\right) * E_{pj} + 1\right] * \left(1 + PG_{pj}\right)^{\wedge n} * C_{pj} \quad \text{(2)}$$

Where:

p, j and c = Same as above

n = Number of years from base year

I = Per capita income growth

E = Income elasticities

PG = Population growth rates

In order to estimate the future consumption of livestock products McGuigan (2001) uses the following technology index for the different species:

$$TI_{By} = (1 + tgr_B)^n \text{ ……………………………………………………………………………. } (3)$$

Where:

TI_{By} = Technology index for animal production in year y

Tgr_B = Compound growth rate for animal production resulting from genetic changes

n = Number of years from base year

McGuigan (2001) states that in order to project the future consumption of livestock products, a price index for intensively produced products (e.g. poultry, pork, eggs and dairy) is calculated by means of the following equations:

For poultry, pork and dairy:

$$PI_{py} = TI_{py} * IPI_y \text{ …………………………………………………………………………….. } (4)$$

Where:

PI_{py} = Price index for product p in year y

TI_{py} = Technology index for product p in year y

IPI_y = International protein price index

For eggs:

$$PI_{eggs} = (1 - 0.0147)^n * IPI_y \text{ ………………………………………………………………… } (5)$$

The consumption index is then calculated by means of the following equation:

$$FCon_p = (1 + (PE_p * (PI_p - 100)/100)) * DDF_p \text{ ……………………………………….. } (6)$$

Where:

$FCon_p$ = Future consumption index of product p in year y

PE_p = Price elasticity of demand for product p

DDF_P = Demand index for product p

Mcguigan (2001) explains that in order to project the future protein consumption for South Africa, the consumption indexes calculated (6) for intense feeding (e.g. pork, poultry and eggs) are multiplied by the base usage. Because beef, mutton and milk are produced extensively the feed consumption for these products is projected from the portion of the final product that requires intensive feeding as follows:

Beef and mutton:

$$PconI_a = (((Fcon_a / 100 * B) - B)/C + 1) * 100 \text{ …………………………………………… } (7)$$

a = Beef or mutton

B = Tons of beef produced

C = Tons of meat produced in feedlots

Milk:

$$PconI_m = (Fcon_m / 100 * D * 10^6 - 2022 * 10^6) * 0.45 * 0.125 / 1000)$$

m = Milk

D = Milk produced

The Niewoudt/McGuigan model generally uses four scenarios when projections are made: Scenario 1n: High income growth with tariffs (related to animal products) in place. Scenario 2n: High income growth with tariffs eliminated. Scenario 3n: Low income growth with tariffs in place. Scenario 4n: Low income growth with tariffs eliminated. Based on the description of the Niewoudt/McGuigan model above, it will be best suited to forecast per capita consumption of final products for 2015. These forecasts will be done with a base year of 2007 and with a scenario including maize-based ethanol production.

3.3.4 Incorporation of models

Because three different models are used, it is difficult to understand how each model accommodates the others. This section explains the incorporation of the models.

Figure 3.5 gives a graphical explanation of the model incorporation. Firstly, the Nieuwoudt/McGuigan model is used to predict future protein demand by means of predicting final product demands. This is important because animal feed goes hand in hand with the consumption of the final products. This means that the demand for animal feed is derived from the final demand for animal products. For example, if less beef is consumed by consumers, fewer cattle are fed by feedlots – resulting in less raw materials being used in animal rations.

Secondly, the per capita consumption calculated by the Nieuwoudt/Mcguigan model is then used in the APR model in order to quantify the primary objective of determining the economic impact of maize-based ethanol production on the South African animal feed industry for 2015. The only constraint is that the price and availability of the raw materials are assumed to remain constant in the same relation as in the base year, which means that the model is static in nature.

Thirdly, the BFAP model is used to simulate possible future price changes with the introduction of maize-based ethanol under a specific scenario. The BFAP model also simulates base factors for the APR model, such as population figures and exchange rates. The results/data from the BFAP model, together with the results of the Nieuwoudt/McGuigan model, are incorporated into the APR model. This means that the APR model is in a dynamic state and there is no static data in the model. The APR model is used to calculate the secondary objectives such as raw material substitution, species feed consumption substitution, and total feed costs for 2015. Figure 3.5 graphically explains the incorporation of the models.

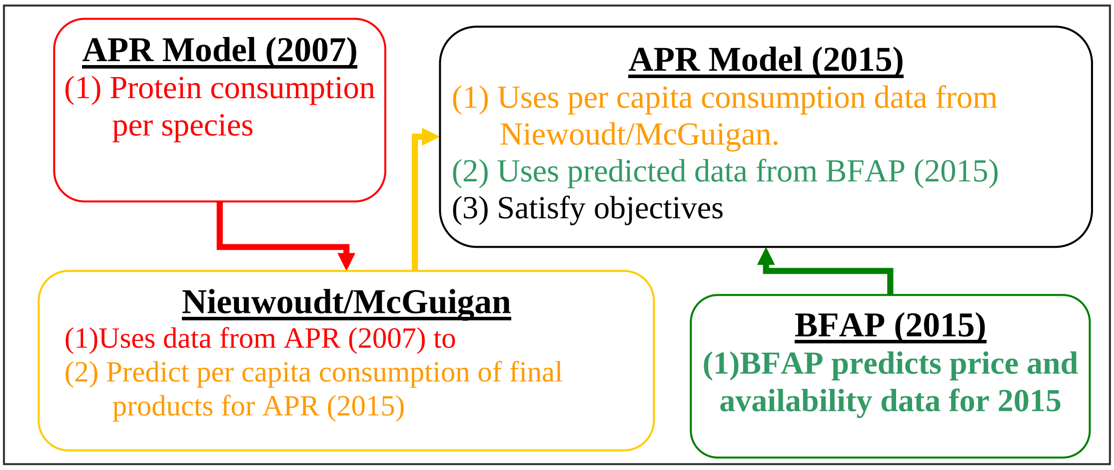

Figure 3.5: Graphical explanation of model incorporation

3.4 Data used

The data used in the models contributes in an important way to the methodology, mainly in terms of the interaction between the models. This section explains all the relevant data and how the data is incorporated in the three models.

3.4.1 BFAP data

In order to simulate the equilibrium prices and forecasts with the BFAP model, a baseline data set is used for the 2006/2007 year (i.e. April 2006 to March 2007) based on the AFMA chairman's report (AFMA, 2007). The AFMA year is used, because all the relevant data used in the base year of the APR model is found in this report. This data is used as a baseline to simulate the scenario and to generate price projections for the year 2015. Table 3.2 reflects some of the important raw materials prices used in the BFAP model as a baseline, as well as base factors such as population figures, exchanges rates and the per capita consumption of products. The prices and the base data used for the BFAP baseline are illustrated in Table B1 in the annexure.

Table 3.2: Raw material prices and base factors used for 2007

Description	Unit	Value
Raw Materials		
Maize Germ	R/ton	1000
Full-fat Soya	R/ton	2275
Barley	R/ton	1650
Maize, Yellow	R/ton	1261
Sorghum	R/ton	1000
Soya hipro oilcake	R/ton	2080
Sunflower hipro oilcake	R/ton	1350
Base Factors		
Per capita consumption chicken	kg / person	25.39
Per capita consumption beef	kg / person	16.13
Per capita consumption milk	kg / person	44
Per capita consumption eggs	kg / person	6.99
Per capita consumption pork	kg / person	3.78
Per capita consumption mutton	kg / person	3.22
Population	Millions	47.38
Exchange rate	Rand to US$	7.16

Source: AFMA (2007) and own calculations

3.4.1.1 Scenarios

In order to incorporate the BFAP model and the APR model, a scenario must be analysed to forecast equilibrium prices. The following drivers and uncertainties were listed for the scenario: The scenarios were quantified by means of the BFAP sector model housed at the Universities of Pretoria and Stellenbosch, the Department of Agriculture Western Cape, and the APR feed optimisation model that is maintained by the University of the Free State. The scenarios are used to understand the potential future in terms of the next 9 years (2007 to 2015) of protein for animal feed. A full document which was compiled for the PRF is illustrated in the Annexure section.

3.4.1.1.1 Scenario 1: Drivers

Strauss (2006) defines a driver as a factor or combination of factors of which the direction of change, enormity of change, as well as the impact of change is quite apparent. This scenario is characterised by the following drivers, along with assumptions:

1) Legislation

The balance between government policies on job creation against food inflation will continue as at present. The Department of Trade and Industry (DTI) and the National Department of Agriculture (NDA) are the main government institutions that will determine government policy that affects agriculture. Import tariffs on all meats remain in place and no changes are made. Land reform will continue at a slow pace and there would be no drastic changes with regard to these policies.

2) Population

The persistence of legal and illegal immigrants, together with the small positive growth rate of the local population, will cause a steady population growth. The impact of HIV/Aids is smaller than anticipated, due to the effective use of antiretroviral drugs.

3) Urbanisation

Urban areas are associated (expected) with a higher level of income and the maintaining of a better lifestyle due to an expected increase in the level of disposable income. Per capita disposable income plays an essential role in driving the food consumer to consume more value-added goods. The presence of urbanisation is expected to be associated with the change in consumption from starchy staples to that of more value-added goods, especially with regard to animal products. Urbanisation has a dampening effect on the growth of the population.

4) Disposable income

The slow pace of job creation will continue as at present. Expenditure patterns of black middle-income groups against the higher-class income group (“fat cats”) can shift to a more preferable point. New credit laws and higher interest rates will not negatively affect the consumption of basic food items, but rather luxury food items and the consumption of fast food and restaurant food.

5) Local profitability of the production of protein

The maize and soya price ratio is critical in producing protein profitably. Maize yields are increasing rapidly in contrast to soybean yields, which have remained fairly constant over the past decades. Maize and soybean yields are assumed to continue to follow the trend established over the past 5 years. The oil fraction of soybeans remains constant. The temporary duty rebate of soybeans for the extraction of soybean oil to be used in the production of bio-diesel is assumed to remain in place over the period of the scenario.

6) Bio-fuels

Government committed to the Kyoto Protocol on 16 February 2005. Bio-fuels are only a “drop in the ocean” of the global energy market, but have a potentially major impact on agricultural commodity markets. Bio-fuels in SA are not expected to have the positive impact on the labour market that government is hoping for. The technical constraints of blending ethanol into petrol are not being experienced.

7) Oilseed market (Vegetable oils and cake)

World demand for oilseeds will continue to exceed world supply for the next few years, drawing down on stocks and putting upward pressure on prices. Structural shifts in the local industry, as well as the expansion of soybean crushing facilities over the past few years, will remain and as a consequence soybeans will trade closer to import parity levels than in the past.

8) Crude oil market

Political instability in the Middle East will continue to exert upward pressure on oil prices. The Chinese economy will grow, but at a declining rate, whereas the Indian economy will grow at an increasing rate. Strong growth in the local economy will support the Rand and attract more foreign direct investment, while the gold price will remain high. The US economy is under pressure while Japan recovers slowly, whereas the EU economic recovery is not as rapid as that of Japan.

3.4.1.1.2 Uncertainties

Strauss (2006) defined uncertainties as a factor or combination of factors of which the direction, magnitude and impact of change are totally unpredictable. Key uncertainties are factors or combinations of factors that can change the outcome of a process dramatically and significantly from what is generally expected or predicted.

1) Bio-fuels

It is not known what the government strategy on blending rates, tax incentives, subsidies, tariffs on imported bio-fuel and the price formulation of bio-fuel will be. Will all the feedstock for bio-fuels be sourced locally? Will licensing for the production of bio-fuels be implemented?

2) Legislation

The political instability of the African National Congress (ANC) and the Congress of South African Trade Unions (COSATU) leads to the question of whether there will be a change with the new leaders in top positions in the country, or whether things will get worse. The impact of social policies of a “Welfare State”, grants and food stamps can increase the demand for protein along with food inflation.

3) Crude oil

Will an alternative source for crude oil be discovered? If there are no alternative crude oil sources, will any traditional crude oil sources be discovered?

4) Lack of electrical supply

Can Eskom come up with more sources of energy in the period of the scenario or will the struggle with power shortages and load shedding prevail?

5) Macro-economic shocks – USA, EU, China, Japan

Should one of these countries experience a significant macro-economic shock, such as a dramatic downturn in markets, world economic trends would change dramatically since the world economy is already under pressure in light of current high energy prices and high interest rates. This could influence exchange rates, inflation and therefore interest rates in South Africa.

3.4.1.1.3 Conclusion of scenario

Current general world economic trends continue over the next decade with the US and EU economies under pressure and those of China and especially India continuing to grow at a rapid pace. Oil prices remain high due to refinery constraints. Uncertainty surrounding the political situation in the Middle East remains. Supply problems with key oil suppliers like Iraq, Nigeria and Venezuela, as well as fuel shortages experienced in key fuel-consumer countries like the USA due to fuel type changes, remain in place.

If no significant alternative source of energy is discovered within the next decade and increases in oil prices fuel fears and uncertainty surrounding a possible downturn in the world economy due to expensive energy, this will have an impact on the gold price in terms of investors buying gold due to economic uncertainty. The increase in the gold price causes the Rand to be valued on average against the Dollar and the Euro around levels of R7/$ and R9.5/€ respectively. However, due to uncertainties in world markets with regard to energy prices and economic growth, the Rand remains highly volatile around the average exchange levels.

SA's economy continues to grow at a rate above 4%, with inflation having peaked at 7.4 % in the first quarter of 2008. The election of the new president in 2009 will cause no upset in the local economy, and sound fiscal and monetary policies will continue to draw foreign direct investment.

However, service delivery continues to be a problem, putting more strain on the infrastructure. As a result, more electrical outages occur and transportation costs increase rapidly as rail and road fail to meet local demand for transport. The transformation of land into the hands of PDI farmers continues at a slow pace and the target set for 2014 is not met. However, there are small pockets of emerging farmers where sizeable farming units are transformed successfully to produce more high-value crops and animal products.

Urbanisation alleviates some pressure on rural economies and the land reform programme. This phenomenon affects food security, however, and the changing habits of consumers who move to urban areas further increase the demand for higher-value goods such as oils and fats, dairy, meat and fish. The rate of population growth also declines as a result of urbanisation.

The existing levels of import tariffs remain in place for all meats, and SA remains a net importer of these products. High interest rates only have an impact on disposable income during 2008 and 2009, causing a dampening effect on high-value real disposable income against increase.

World demand for oilseeds continues to exceed world supply until 2013, drawing down on stocks and putting upward pressure on prices. Higher world prices for oil and cake transmit to domestic prices, thus securing positive crushing margins for soybean crushing-plant facilities. This implies that the structural shift that has occurred in the local crushing industry over the past few years with the expansion of local soybean crushing facilities remains the same and as a consequence soybeans trade closer to import parity levels than in the past. The soya/maize price ratio therefore increases, favouring soybeans. As a result, farmers shift maize fields into soya production over time.

However, the growth in soybean crushing facilities overwhelms the increase in local production and as a result, beans and cake are still imported. Maize yields increase slightly faster than soybean yields because of cultivar improvements, but due to the positive rotational effects of soybeans with other crops, farmers are inclined to continue with the increase in soybean plantings.

After the severe drought in 2007, weather patterns returned to normal in the 2008 production season. However, in 2014 the typical 9-year drought cycle repeats itself and the SA summer production region is severely affected. Although average temperatures increase globally, climate change does not affect yields drastically over the next decade because of cultivar improvements.

The bio-fuels strategy is announced towards the end of 2007, with reports that government only requires very low mandatory blending rates (B1 and E2) for the period 2009 – 2016. The reason for this is that government is careful not to cause an increase in food inflation, keeping to the Kyoto Protocol commitment, but at the same time creating employment opportunities where possible. Furthermore, no tariffs on imported bio-fuels are introduced, but the production of bio-diesel from soybeans is supported by the duty rebate on soybeans for the extraction of soybean oil to be used in the production of bio-diesel.

Due to the considerable lack of support from government, SASOL does not build its bio-diesel production facilities and bio-diesel is produced on a small scale by means of on-farm facilities. The E2 blending requirement is made up by a maize-to-ethanol processing plant.

In order to analyse the impact of ethanol production, Scenario 1 is used as a base scenario and a separate scenario is used to evaluate the impact of ethanol production. In order to evaluate the impact of ethanol production, the production in the separate scenario must be excluded. This means that the additional scenario is the same as Scenario 1, with the only difference being the elimination of ethanol production. In other words, what would the results be in 2015 if no ethanol production is taking place? This means that Scenario 1 would be composed of two scenarios:
1) Scenario 1w (Scenario 1 with ethanol production in place)
2) Scenario 1wo (Scenario 1 without ethanol production)
These scenarios are graphically explained in Figure 3.6.

3.4.1.2 Scenario 2

Once the base scenario is simulated in the BFAP and APR models, a scenario is created with two variables, i.e. the blending ratios and the crude oil price. The same methodology is used as in the base scenario, where the BFAP model is used to simulate equilibrium price projections for 2015, which are then simulated into the APR model, which is then used to generate the final results. The results from the second scenario are compared with the baseline scenario in order to determine the impact of high oil prices and different blending ratios on the animal feed industry. The blending ratios proposed by the draft strategy of 2006 were B_5 and E_{10}; whereas in Scenario 1 E_2 and B_1 are used because of uncertainties surrounding the strategy. With the sensitivity analysis the blending ratios are adjusted to the blending ratios proposed by the 2007 strategy, which are B_2 and E_8. The crude oil price increased dramatically from 2007 up until mid-2008. In order to quantify the sensitivity of these variables, new blending ratios and a higher crude oil price are inserted into the BFAP model.

The variables were adjusted in the scenario as follows:

- The ethanol blending ratios changed from E_2 to E_8 for 2015.
- The bio-diesel blending ratios changed from B_1 to B_2 for 2015.
- The crude oil price changed from \$80 to \$145 per barrel for 2015.

In order to evaluate the impact of ethanol production as with Scenario 1, an additional scenario is added to Scenario 2. This additional scenario has the same drivers and uncertainties as Scenario 2, with the only difference being the exclusion of ethanol production, and therefore Scenario 2 consists of the following two scenarios:

1) Scenario 2w (Scenario 2 with ethanol production in place)

2) Scenario 2wo (Scenario 2 without ethanol production)

In order to better understand the scenarios, they are explained graphically in Figure 3.6.

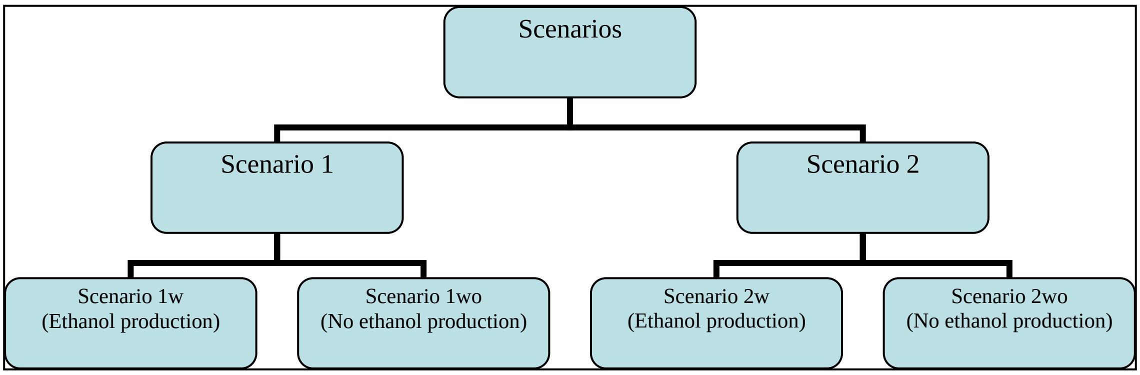

Figure 3.6: Graphical explanation of Scenario 1 and Scenario 2

3.4.2 APR model data

The equilibrium prices used in the APR model as input prices are simulated by the BFAP model in the scenario described above. The different raw material prices used in the APR model for the year 2015 are simulated with the BFAP model. A more detailed list of all the data used in the APR model is reflected in Annexure B2. These prices are in a state of equilibrium for 2015 after the inclusion of DDGS into the industry. In order to quantify the changes with the APR model, several base factors such as population and the exchange rate must be taken into consideration. These base factors are also predicted with the BFAP model. The per capita consumption of various products is part of the APR model’s base factors, which are incorporated from the McGuigan/Nieuwoudt model results.

An important variable is transport costs, mainly due to high petroleum prices. Table 3.3 reflects these transport costs used for the year 2015. The prices are calculated with the help of the $/barrel projected by the BFAP model. For Scenario 1 a crude oil price of $80/barrel is simulated by the BFAP model, while for Scenario 2 a crude oil price of $145/barrel is simulated. This means that the transport costs from the Interior region to the Cape region will increase from R750 to R1275 per ton, which is a 70 % increase in transport costs.

Table 3.3: Transport costs for 2015

Region	*Destination*	*Base*	*Scenario 1*	*Scenario 2*
		R/ton		
Cape, KwaZulu -Natal, Interior	Within region	160	200	340
Interior	Cape	610	750	1275
Cape	KwaZulu-Natal	775	950	1615
KwaZulu-Natal	Interior	310	380	645

Source: Own calculations

The APR model did not originally have DDGS as a primary raw material, and therefore the nutritional data of DDGS is inserted into the model to overcome this constraint. The nutritional data incorporated into the model is sourced from Dunn (2005) and is reflected in Table 3.4 below.

Table 3.4: Nutrient content of DDGS

Raw material	*Amount*	*Unit*
Protein	27	%
Fat	9	%
Fibre	9.1	%
DE Pigs	16.32	mj/kg
TDN	80	%
ME Poultry	10.6	mj/kg
Meth Total	0.6	%
Meth Avl Poultry	0.4	%
TSAA Total	0.6	%
TSAA Avl Poultry	0.75	%
Lysine Total	0.75	%
Lysine Avl Poultry	0.5	%
Na	0.48	%
Ca	0.17	%
P Total	0.72	%
P Avl	0.65	%

Source: Dunn (2005)

3.4.3.1 Niewoudt/McGuigan model data used

McGuigan (2001) used racial data in terms of population, population growth, income growth and income elasticities. Due to the lack of availability of data, and after private discussions with the PRF, who funded the thesis of McGuigan (2001), consensus was reached to change the data from racial groups to living standard measure (LSM) groups, as developed by the Bureau of Market Research (BMR). The LSM groups were compiled according to a set of 29 variables used as a scale to measure households' standard of living accordingly, from which the households were then assigned to groups of 1 - 10 LSM. Discussions with Van Aardt (2008) revealed that LSM groups are biased, mainly because of factors such as cultural preferences. Van Aardt (2008) suggested that income groups would be more effective than LSM groups. The following income groups are identified: R0 – R12 500, R12 501 – R50 000, R50 001 – R100 000, R100 001 – R 300 001, R300 000 – R500 000, R500 000 – R750 000 and R750 000 +. These income groups are classified as the total income per household. Various assumptions were made about this data set – one of which was that the data would perform better because there would not be variations in the consumption of products within the various groups.

Figures 3.7 – 3.10 indicate that these assumptions are not true, mainly because there is too much variation between the racial groups within the specific income groups. This is most probably due to cultural preferences, for example Asians spend much more on mutton than other groups, whereas their expenditure on pork is a small portion of the total pork expenditure. Racial groups are also not sufficient, mainly due to variations within racial groups. For example, the Zulu and Sotho groups are both classified as Africans, but they do not consume the same types of food. It is therefore evident that more work is needed in order to retrieve the best data. It cannot be definitively stated that one data set is better than another. For this reason, the data used for the Nieuwoudt/McGuigan model consists of data from the APR model, as well as two sets of base data: a) Racial group data; and b) Income group data.

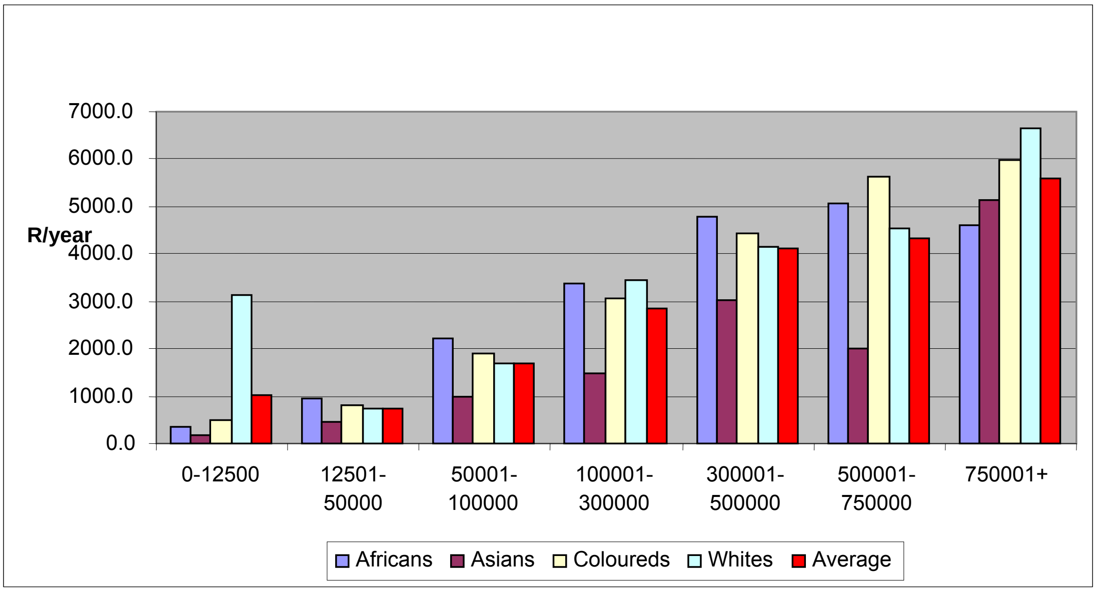

Figure 3.7: Household expenditure of racial groups within specified income groups: Beef
Source: BMR (2008)

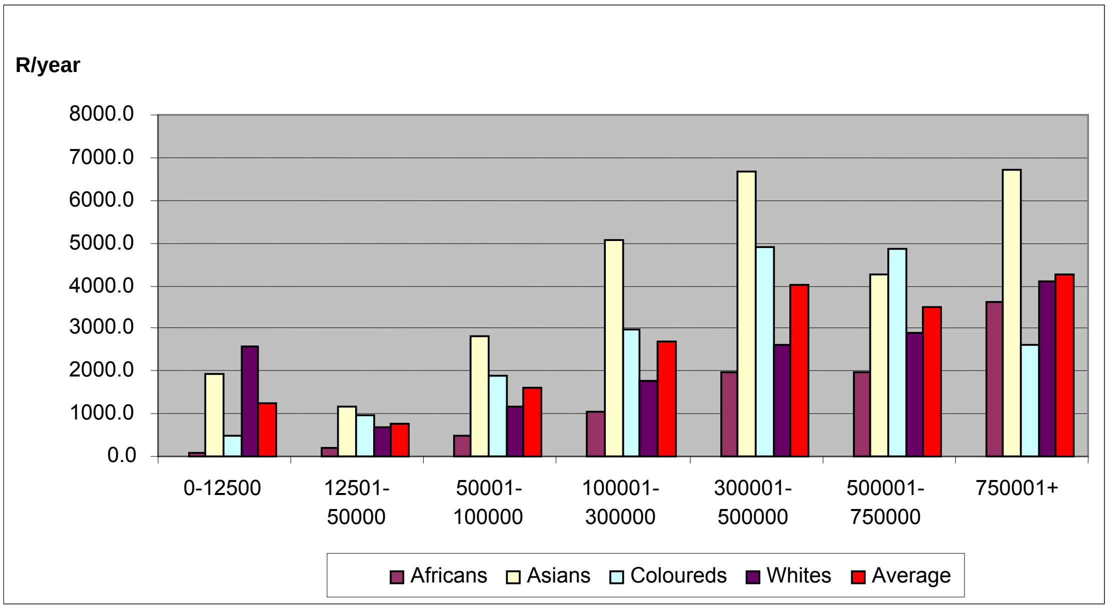

Figure 3.8: Household expenditure of racial groups within specified income groups: Mutton
Source: BMR (2008)

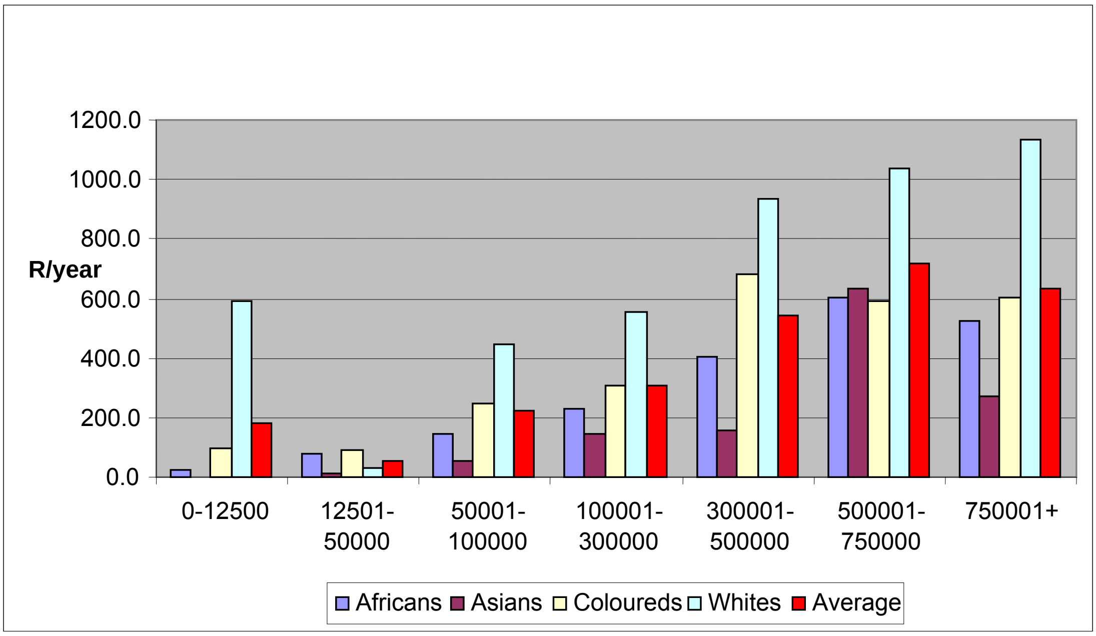

Figure 3.9: Household expenditure of racial groups within specified income groups: Pork
Source: BMR (2008)

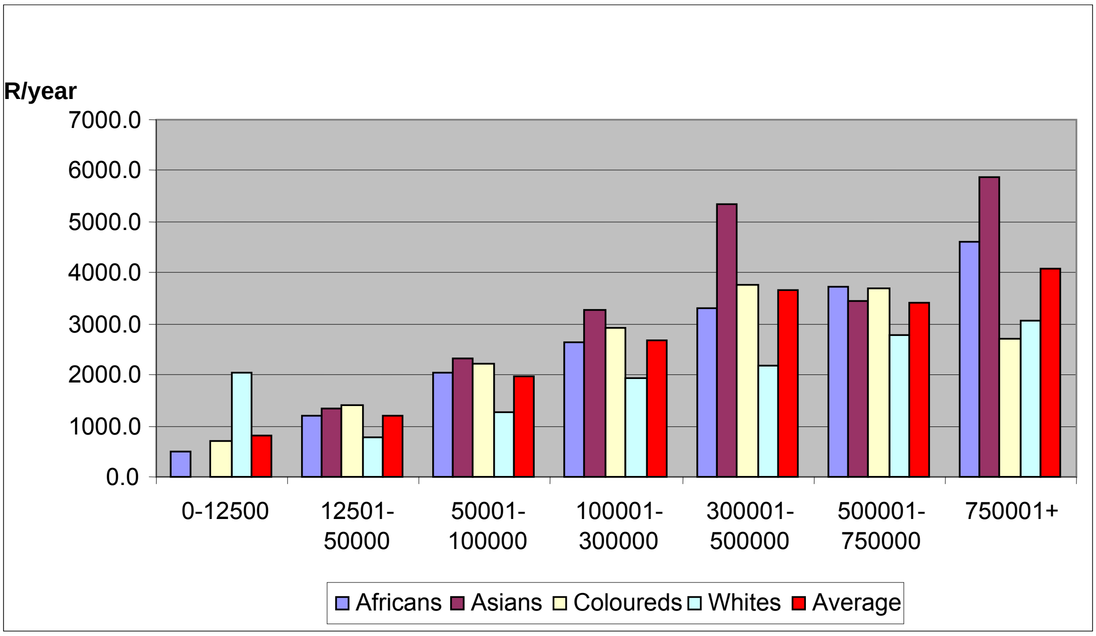

Figure 3.10: Household expenditure of racial groups within specified income groups: Poultry
Source: BMR (2008)

The racial data set consists of population data, population growth data, expenditure data, income elasticity data, income growth data, and data on import tariffs on meat for the specified racial groups. This data is reflected in Table C1 in the annexure. The income group data set consists of population data, population growth data, expenditure data, income elasticity data, income growth data, and data on import tariffs on meat for the specified income groups. Currently there is no significant data on population growth and income growth data for the income group set, and so to overcome this constraint, the racial data was used to get a weighted average for the income group. Example 1 explains these calculations.

Example 1:
Income group R0 -R12501 consists of 83% Africans, 2% Asians, 8% Coloureds and 7% Whites. Income growth for the racial groups is as follows: 2.8% Africans, 2.8% Asians, 2.8% Coloureds and 1.5% Whites (McGuigan, 2001).
R0 -R12501 income growth rate = (0.028*83%) + (0.028*2%) + (0.028*8%) + (0.015*7%)
This method is used with income group population growth rates, as well as income growth rates. All data used for income groups is reflected in Table C2 in the annexure. Because both data sets are used, this means that sub-scenarios must be incorporated. With the introduction of racial and income groups the scenarios will be as follows:

1) Scenario 1wr (Scenario 1 with ethanol production and racial group data)
2) Scenario 1wor (Scenario 1 without ethanol production and with racial group data)
3) Scenario 1wi (Scenario 1 with ethanol production and income group data)
4) Scenario 1woi (Scenario 1 without ethanol production and with income group data)

5) Scenario 2wr (Scenario 2 with ethanol production and racial group data)
6) Scenario 2wor (Scenario 2 without ethanol production and with racial group data)
7) Scenario 2wi (Scenario 2 with ethanol production and income group data)
8) Scenario 2woi (Scenario 2 without ethanol production and with income group data)

This concludes to a total of eight combinations generated out of two main scenarios that will be viewed in order to satisfy the primary and secondary objectives. These eight scenarios are explained graphically in Figure 3.11.

3.5 Chapter summary

Not much literature is available on this specific subject, although a few researchers have conducted studies on this subject, but with different areas of relevance. The first section of this chapter describes these studies and thoroughly explains the international as well as local scenarios.

In the methodology framework, three models are used: the APR model, the BFAP model and the Nieuwoudt/McGuigan model. The second section of this chapter gives a description of these models, along with their advantages for this specific study. Understanding how these models are incorporated is a complex endeavour, mainly due to the fact that one model's output data results in the next model's input data. This section therefore explains the incorporation of the models to allow for a better understanding thereof.

The third section explains all the relevant data along with the incorporation of the data into the models. Along with these data sets are different sets of scenarios, which are described in this section together with a summary of the scenarios to conclude the methodology and data for this specific study.

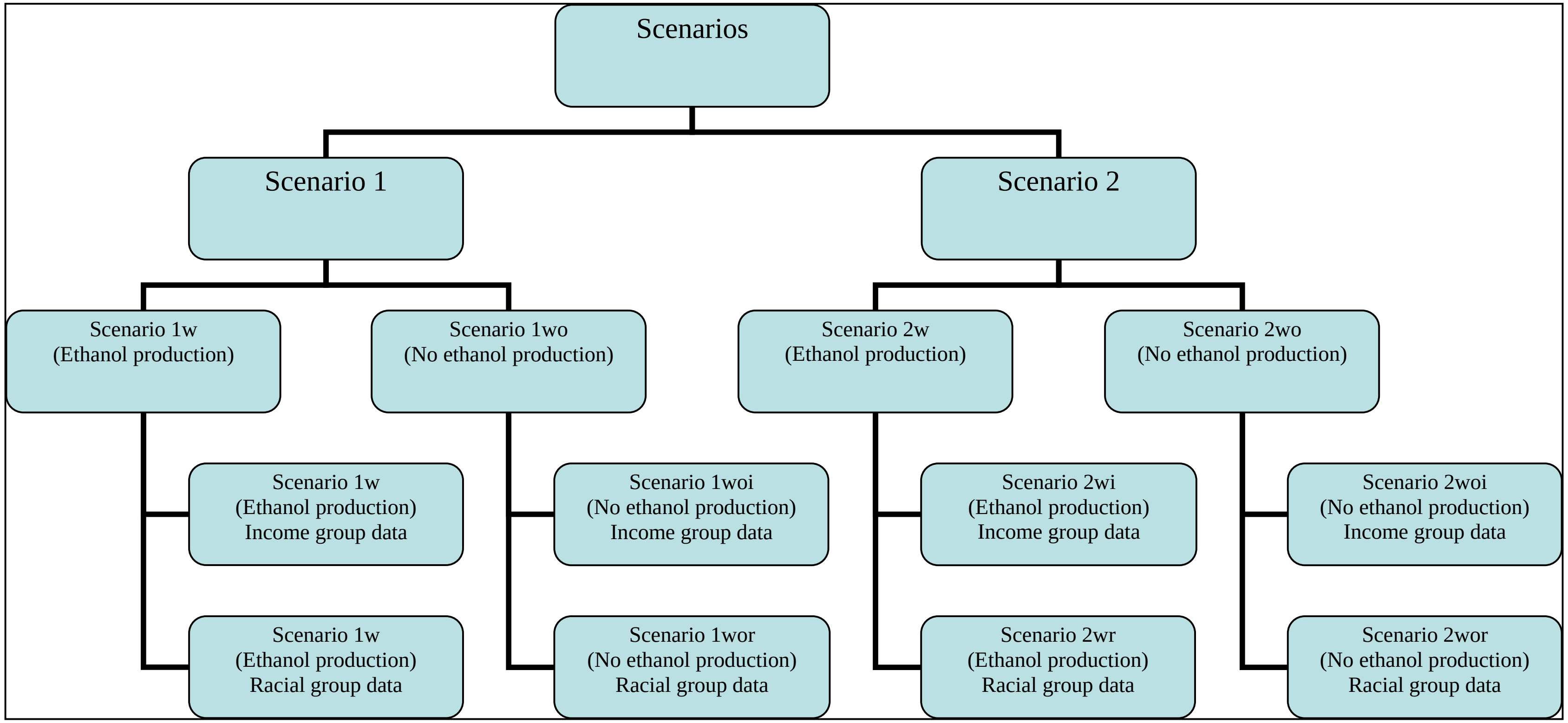

Figure 3.11: Summary of scenarios used in the methodology

CHAPTER 4

Results

4.1 Introduction

This chapter consists of four sets of simulated results from the three models used. The first set is the protein feed consumption for different species in the base year, followed by the per capita consumption of final animal products for the year 2015 in the second set. The third set of results contains the equilibrium prices simulated with the BFAP model for the year 2015, whereas the last set contains results such as raw material substitution and species DDGS consumption, along with changes in feed costs retrieved from the APR model, which are used to satisfy the primary objective.

4.2 Base year protein raw material consumption per animal species

In order to determine the per capita consumption of final animal products for the year 2015 by means of the Nieuwoudt/McGuigan model, the base year animal protein feed consumption per species is needed. The APR model calculates this protein consumption with the help of the base year data discussed in Chapter 3 and illustrated in Annexure B2. Raw materials such as those illustrated in Table 4.1 and animal species such as broilers, layers, sheep, cattle (dairy and beef) are used to determine the protein consumption. Table 4.1 reflects the protein consumption calculated within the APR model. Broilers consume the most protein raw materials (38%) followed by dairy cattle and layers. In total 1,806,227 tons of protein animal feed in the base year are consumed. A more detailed list of raw materials consumed per specie is given in Table 4.1.

Table 4.1 Protein animal feed raw material consumption within different species for 2007

Species	Soya Hi pro	Soya Full fat	Sunflower Hi pro	Cotton Hi pro	Canola Hi pro	Gluten 60	Fish meal
	tonnes						
Broilers	348281	255640	0	0	0	26040	13838
Broiler breeders	108513	0	9287	0	134	0	0
Layers	170476	0	32078	10047	287	0	0
Sheep	0	0	18377	2933	0	0	0
Cattle (Beef)	0	0	37610	98783	0	0	0
Pigs	137050	0	50736		9038	0	14023
Cattle (Dairy)	54338	0	160106	17633	6405	0	0
Ostriches	2015	0	2467	2210	2832	0	0
Horses	5973	0	12960	650	304	0	0
Aquaculture	776	0	0	0	0	0	1302
Pets	69140	0	27569	0	0	0	0
Total	**896562**	**255640**	**351190**	**132256**	**19000**	**26040**	**29163**

Total protein animal feed consumption per specie in base year

Species	**2007 base year (tonnes)**
Beef Cattle & Sheep	157703
Broilers	848679
Pigs	220277
Layers	212888
Dairy Cattle	238482
Pets	96709
Horses	19887
Other	11602
Total	**1,806,227**

4.3 Per capita consumption of final animal products for 2015

The base year protein consumption calculated within the APR model as illustrated in Table 4.1 is incorporated into the Nieuwoudt/McGuigan model in order to calculate the protein consumption index. As mentioned in Chapter 3 the data normally used in the Niewoudt/McGuigan model is racially based, whereas a more recent trend is to use household-level data on income groups. Before per capita consumption can be calculated, projections must be made in order to determine whether there are significant differences between these two data sets. This is done by forecasting the protein demand for 2010, 2015 and 2020 for the two data sets. The Nieuwoudt/McGuigan model uses four scenarios, alternating income growth and import tariffs in order to do projections:

1n) High income growth with import tariffs on meat in place.

2n) High income growth with import tariffs on meat eliminated.

3n) Low income growth with import tariffs on meat in place.

4n) Low income growth with import tariffs on meat eliminated.

Keep in mind that these scenarios are not the scenarios mentioned in Chapter 3, but instead are scenarios within the Niewoudt/McGuigan model. All of these scenarios mentioned above are only used to evaluate the differences between the racial and the income group sets. Only Scenario 1n will be used for the incorporation of the rest of the models.

The four scenarios are used to forecast the protein demand for the two data sets. With the income group data set in Scenario 1n the total growth in protein animal feed for 2010, 2015 and 2020 is 6%, 13% and 20% respectively, which changes to -6%, 0% and 4% if tariffs is eliminated. With the racial group data set in Scenario 1n the total protein animal feed consumption growth for 2010, 2015 and 2020 is 8%, 20% and 32% respectively, and if the import tariffs on final products is eliminated, the growth for the specific years is -4%, 4% and 12% respectively. All of the results for Scenario 1n and 2n are reflected in Table 4.2 for income group data, whereas for racial group data it is reflected in Table 4.3.

With the income group data set in Scenario 3n the total growth in protein animal feed consumption for 2010, 2015 and 2020 is 3%, 6% and 9% respectively and with the elimination of import tariffs on final products it is -8%, 5% and -3% respectively. With the racial group data set with import tariffs on final products in place, the total growth for 2010, 2015 and 2020 is 3%, 5% and 7% respectively, whereas with the elimination of these import tariffs total growth is -8%, -6% and -4% respectively. All of the results for the income group data in Scenario 3n and Scenario 4n are reflected in Table 4.4, while the results for the racial group data set are reflected in Table 4.5.

From the results can be seen that there are differences between the two data sets. In Chapter 3 it is concluded that both the data sets have efficiency problems and that one is not better than the other. This is why all of the results will be measured with income group data, as well as racial group data. With the Niewoudt/Mcguigan model various consumption indexes are forecasted for various animal final products, as previously mentioned in Chapter 3. In order to simulate these indexes only Scenario 1n in the Niewoudt/Mcguigan model will be used, mainly because it has the same preferences as Scenario 1 and Scenario 2, as mentioned in Chapter 3, i.e. high income growth and the maintenance of tariffs. The consumption indexes simulated for chicken and beef with income group data are 106 and 110 respectively, whereas the indexes with income group data are 109 and 117 respectively. This is a difference of 3% for chicken and 7% for beef. These differences are mainly because of differences in the base year per capita consumption between the two data groups. With racial group data, people consume more beef and chicken than with income group data.

The remaining final product consumption indexes did not have significant differences and were almost the same. Table 4.7 reflects these indexes as simulated.

Table 4.2: Projected protein demand for 2010, 2015 and 2020 under high income growth with income group data

Scenario 1n (High income growth; Tariffs are maintained)									
	High Income Growth 2007 to 2010			High Income Growth 2007 to 2015			High Income Growth 2007 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,856,489	1.83%	6%	1,990,264	1.6%	13%	2,102,777	1.39%	20%
Beef	192,447	3.4%	10%	214,510	2.6%	23%	230,779	2.2%	32%
Poultry	886,983	1.9%	6%	953,628	1.6%	14%	1,011,875	1.4%	21%
Pork	206,321	2.3%	7%	224,989	1.9%	17%	240,315	1.7%	25%
Eggs	225,261	2.0%	6%	243,764	1.8%	15%	259,491	1.6%	22%
Milk	218,262	0.9%	3%	226,158	0.8%	6%	233,102	0.7%	10%
Other	127,215	0.0%	0%	127,215	0.0%	0%	127,215	0.0%	0%
Scenario 2n (High income growth; Tariffs are eliminated)									
	High Income Growth 2007 to 2010			High Income Growth 2007 to 2015			High Income Growth 2007 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,652,479	-2.05%	-6%	1,749,978	-0.1%	0%	1,833,878	0.32%	4%
Beef	174,297	0.0%	0%	174,297	0.0%	0%	174,297	0.0%	0%
Poultry	717,269	-5.1%	-15%	771,162	-1.1%	-8%	818,264	-0.2%	-2%
Pork	190,174	-0.5%	-1%	207,381	0.9%	7%	221,508	1.1%	15%
Eggs	225,261	2.0%	6%	243,764	1.8%	15%	259,491	1.6%	22%
Milk	218,262	0.9%	3%	226,158	0.8%	6%	233,102	0.7%	10%
Other	127,215	0.0%	0%	127,215	0.0%	0%	127,215	0.0%	0%

Table 4.3: Projected protein demand for 2010, 2015 and 2020 under high income growth with racial group data

Scenario 1n (High Income Growth; Tariffs are maintained)									
	High Income Growth 2007 to 2010			High Income Growth 2007 to 2015			High Income Growth 2006 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,905,510	2.72%	8%	2,105,729	2.3%	20%	2,312,857	2.13%	32%
Beef	203,740	5.3%	17%	239,749	4.1%	38%	273,771	3.5%	57%
Poultry	917,108	3.0%	9%	1,027,262	2.6%	22%	1,144,495	2.4%	36%
Pork	203,093	1.7%	5%	214,377	1.3%	11%	224,871	1.2%	17%
Eggs	229,668	2.7%	8%	254,516	2.3%	20%	281,045	2.2%	33%
Milk	220,771	1.3%	4%	231,872	1.1%	9%	243,506	1.1%	15%
Other	131,130	1.0%	3%	137,953	0.6%	8%	145,169	1.0%	14%
Scenario 2n (High income growth; Tariffs are eliminated)									
	High Income Growth 2007 to 2010			High Income Growth 2007 to 2015			High Income Growth 2006 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,684,695	-1.41%	-4%	1,826,945	0.5%	4%	1,976,799	0.91%	12%
Beef	174,297	0.0%	0%	174,297	0.0%	0%	174,297	0.0%	0%
Poultry	741,630	-4.0%	-12%	830,707	-0.1%	-1%	925,509	0.8%	10%
Pork	187,199	-1.0%	-3%	197,600	0.3%	2%	207,273	0.6%	7%
Eggs	229,668	2.7%	8%	254,516	2.3%	20%	281,045	2.2%	33%
Milk	220,771	1.3%	4%	231,872	1.1%	9%	243,506	1.1%	15%
Other	131,130	1.0%	3%	137,953	0.6%	8%	145,169	1.0%	14%

Table 4.4: Projected protein demand for 2010, 2015 and 2020 under low income growth with income group data

Scenario 3n (Low income growth; Tariffs are maintained)									
	Low Income Growth 2007 to 2010			Low Income Growth 2007 to 2015			Low Income Growth 2007 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,805,096	0.88%	3%	1,863,187	0.7%	6%	1,915,954	0.66%	9%
Beef	178,911	0.9%	3%	182,641	0.6%	5%	185,820	0.5%	7%
Poultry	867,147	1.1%	3%	903,408	0.9%	8%	936,466	0.8%	12%
Pork	198,525	1.0%	3%	205,609	0.8%	7%	211,898	0.7%	10%
Eggs	217,478	0.9%	3%	224,331	0.7%	6%	230,739	0.7%	9%
Milk	215,819	0.5%	2%	219,982	0.4%	3%	223,816	0.4%	5%
Other	127,215	0.0%	0%	127,215	0.0%	0%	127,215	0.0%	0%
Scenario 4n (Low income growth; Tariffs are eliminated)									
	Low Income Growth 2007 to 2010			Low Income Growth 2007 to 2015			Low Income Growth 2007 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,619,027	-2.71%	-8%	1,665,895	-0.7%	-5%	1,708,666	-0.22%	-3%
Beef	174,297	0.0%	0%	174,297	0.0%	0%	174,297	0.0%	0%
Poultry	701,228	-5.8%	-16%	730,551	-1.7%	-13%	757,284	-0.8%	-10%
Pork	182,988	-1.8%	-5%	189,518	-0.2%	-2%	195,314	0.1%	1%
Eggs	217,478	0.9%	3%	224,331	0.7%	6%	230,739	0.7%	9%
Milk	215,819	0.5%	2%	219,982	0.4%	3%	223,816	0.4%	5%
Other	127,215	0.0%	0%	127,215	0.0%	0%	127,215	0.0%	0%

Table 4.5: Projected protein demand for 2010, 2015 and 2020 under low income growth with racial group data

Scenario 3n (Low income growth; Tariffs are maintained)									
Low Income Growth 2007 to 2010				Low Income Growth 2007 to 2015			Low Income Growth 2006 to 2020		
	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth	Protein Feed (tons)	Annual Growth	Total Growth
Total	1,814,374	1.05%	3%	1,851,571	0.6%	5%	1,881,668	0.52%	7%
Beef	181,546	1.4%	4%	181,420	0.5%	4%	180,305	0.3%	3%
Poultry	865,093	1.0%	3%	879,668	0.6%	5%	890,188	0.5%	6%
Pork	200,018	1.2%	4%	205,663	0.8%	7%	209,955	0.7%	9%
Eggs	219,790	1.2%	4%	226,345	0.8%	7%	232,211	0.7%	10%
Milk	216,797	0.7%	2%	220,522	0.5%	4%	223,839	0.4%	5%
Other	131,130	1.0%	3%	137,953	0.6%	8%	145,169	1.0%	14%
Scenario 4n (Low income growth; Tariffs are eliminated)									
Low Income Growth 2007 to 2010				**Low Income Growth 2007 to 2015**			**Low Income Growth 2006 to 2020**		
	Protein Feed (tons)	**Annual Growth**	**Total Growth**	**Protein Feed (tons)**	**Annual Growth**	**Total Growth**	**Protein Feed (tons)**	**Annual Growth**	**Total Growth**
Total	1,625,946	-2.57%	-8%	1,660,039	-0.7%	-6%	1,688,902	-0.31%	-4%
Beef	174,297	0.0%	0%	174,297	0.0%	0%	174,297	0.0%	0%
Poultry	699,567	-5.9%	-17%	711,353	-2.0%	-15%	719,860	-1.2%	-14%
Pork	184,365	-1.5%	-4%	189,567	-0.2%	-2%	193,524	0.0%	0%
Eggs	219,790	1.2%	4%	226,345	0.8%	7%	232,211	0.7%	10%
Milk	216,797	0.7%	2%	220,522	0.5%	4%	223,839	0.4%	5%
Other	131,130	1.0%	3%	137,953	0.6%	8%	145,169	1.0%	14%

Table 4.6: Consumption indexes for various animal products

Product	Indexes	
	Income group data	Racial group data
Chicken	106	109
Beef	110	117
Milk	103	104
Eggs	106	108
Pork	107	105
Mutton	98	95

With the indexes mentioned in Table 4.6 the per capita consumption for the different animal products in 2015 is calculated by means of taking the base year per capita consumption and multiplying it with the index. These per capita consumptions are indicated in Table 4.7 below. In Table 4.6 the index is 106, which means that there is a 6% increase in chicken consumption from the base year up to the projected year of 2015.

Table 4.7: Per capita consumption for the year 2015

	Income group	Racial group
Product	Kg/person	
Chicken	34.59	35.57
Beef	17.97	19.12
Milk	60.91	61.51
Eggs	11.42	11.63
Pork	4.11	4.03
Mutton	4.75	4.62

4.4 Raw material equilibrium prices and macro-economic factors for 2015 – BFAP model

With the BFAP model various raw material prices are simulated for 2015. These prices are simulated under the different scenarios that were mentioned in Chapter 3: Scenario 1w (including ethanol production) and Scenario 1wo (excluding ethanol production). The next scenarios are Scenario 2w (including ethanol production), where the crude oil prices and the blending ratios increase, and Scenario 2wo (exclusion of ethanol production). Keep in mind that Scenario 1 has low blending ratios and low oil prices, whereas Scenario 2 has high blending ratios and high oil prices. Because the income data and racial data will have no effect on prices, they are not used within the BFAP model.

4.4.1 Scenario 1w and Scenario 1wo

Scenario 1w, which includes ethanol production, simulates the prices of the raw materials DDGS, soya hi pro, sunflower hi pro and full-fat soya at R1609, R3708, R3056 and R3254 respectively. The remaining prices, as well as the import prices for this specific scenario, are illustrated in Table 4.8. In Scenario 1wo where there is no ethanol production the simulated prices for soya hi pro, sunflower hi pro and full-fat soya are R3708, R3070 and R3256 respectively. If the two scenarios are compared in Table 4.8 the effect of ethanol production on raw material prices can be seen, since because of the *ceteris paribus* effect the only difference is the ethanol production. The price of yellow maize drops by 6.7% from Scenario 1w to Scenario 1wo, while the price of sunflower hi pro rises by 0.4%. This means that ethanol production raises the price of yellow maize and lowers the price of sunflower hi pro.

Table 4.8: Predicted raw material prices for 2015 with Scenario 1w and Scenario 1wo

	Scenario 1w		Scenario 1wo	
Raw material	Local price (R/ton)	Import price (R/ton)	Local price (R/ton)	Import price (R/ton)
DDGS	1609		0	
Fish meal hi pro	6249		6249	
Full-fat canola	3531		3533	
Full-fat soya	3254		3256	
Barley	2802		2802	
Maize, white	1707	2776	1679	2776
Maize, yellow	1690	2474	1577	2474
Sorghum	1489		1479	
Wheat	3476		3476	
Soya hi pro oilcake	3708	3743	3708	3743
Sunflower hi pro oilcake	3056	2922	3070	2922

4.4.2 Scenario 2w and Scenario 2wo

In Scenario 2w the raw material prices increased dramatically, mainly because of the increase in the crude oil prices that drive commodity prices upwards, as well as transport costs. Table 4.9 reports the prices simulated with the BFAP model for Scenario 2w and Scenario 2wo. The raw material prices simulated in Scenario 2w for DDGS, soya hi pro, sunflower hi pro and full-fat soya are R1954, R4303, R3346 and R4984 respectively. With the exclusion of ethanol production the raw material prices simulated in Scenario 2wo for soya hi pro, sunflower hi pro and full-fat soya are R4650, R3480 and R4986 respectively. Comparing the scenario that includes ethanol production with the scenario that excludes ethanol production will highlight the effect of ethanol production on raw material prices for Scenario 2. The price of yellow maize drops by 7% from

Scenario 2w to Scenario 2wo, whereas the prices of sunflower hi pro and soya hi pro rose by 4% and 8% respectively. This means that ethanol production raises the price of yellow maize and lowers the price of sunflower hi pro and soya hi pro. The effect in Scenario 2 as a whole is greater than in Scenario 1, mainly because the blending ratio increases in Scenario 2 (from 2% to 8%), resulting in an increase in the amount of ethanol produced.

Table 4.9: Predicted raw material prices for 2015 with Scenario 2w and Scenario 2wo

	Scenario 2w		Scenario 2wo	
Raw material	**Local price (R/ton)**	**Import price (R/ton)**	**Local price (R/ton)**	**Import price (R/ton)**
DDGS	1954		-	
Fish meal hi pro	8372		8372	
Full-fat canola	5789		5791	
Full-fat soya	4984		4986	
Barley	4105		4105	
Maize, white	2390	4247	2349	4247
Maize, yellow	2417	3772	2248	3772
Sorghum	1912		1898	
Wheat	4857		4857	
Soya hi pro oilcake	4303	5602	4650	5602
Sunflower hi pro oilcake	3346	3236	3480	3236

4.4.5 Macro-economic results from the BFAP model

In the APR model, base data such as the R/$ exchange rate and the South African population is used. In addition to raw material prices, the BFAP model also simulates macro-economic factors such as those mentioned above, as required by the APR model. It is important to keep in mind that ethanol production in South Africa does not change these macro-economic factors and that there is no difference between Scenario 1w and Scenario 1wr or between Scenario 2w and Scenario 2wr. This is why the macro-economic factors will only be mentioned for Scenario 1 and Scenario 2. The exchange rates in Scenario 1 and Scenario 2 are R9,82 and R10,42 respectively, while the South African population for 2015 is given as 48.74 million for both scenarios.

4.5 Effect of ethanol production on raw materials – APR model

Various consumption changes within the different raw materials took place with the introduction of ethanol production and DDGS, including:

- Consumption substitution within the different raw materials

- o DDGS consumption of various species
- o Changes in feed costs

In light of the fact that no definite decision could be made in terms of whether the income or racial group data set would be the best to use, both these data sets are used within the scenarios. The APR model is used to quantify the changes in consumption of raw materials with the following scenarios:

- o Scenario 1wi (with DDGS and income group data)
- o Scenario 1wr (with DDGS and racial group data)
- o Scenario 1woi (without DDGS and with income group data)
- o Scenario 1wor (without DDGS and with racial group data)
- o Scenario 2i (with DDGS and income group data)
- o Scenario 2r (with DDGS and racial group data)
- o Scenario 2oi (without DDGS and with income group data)
- o Scenario 2or (without DDGS and with racial group data)

Keep in mind that the scenarios are the same as mentioned in Section 4.4, except with an additional two sub-scenarios.

4.5.1 Raw material consumption substitution

With the introduction of DDGS resulting from the production of ethanol, substitution between animal feed raw materials takes place. Such substitution is highly dependent on the price, availability and quality of the DDGS. This section clearly illustrates all these changes for each scenario.

4.5.1.1 Scenario 1 with income group data

Table 4.10 reflects the changes in consumption of the most important raw materials from the base year to the specific scenario along with the substitution of raw materials as a result of the introduction of DDGS. From Table 4.10 it can be seen that with Scenario 1wi the consumption of yellow maize, wheat middlings, cotton and soya hi pro increases from the base year to 2015 by 64%, 50%, 77% and 24% respectively – keeping in mind that this is not the effect of ethanol production, but the effect of the scenario. This means that there is a total growth of 40.4% in consumption of raw materials from base to 2015 for Scenario 1wi. This total growth is not only for the raw materials mentioned in Table 4.10, but for all the animal feed consumed in South Africa. With the exclusion of ethanol production in Scenario 1woi the consumption of yellow maize, wheat middlings, cotton and soya hi pro increases betwen 2007 and 2015 by 65%, 50%, 77% and 30% respectively. The total growth in animal feed consumption from 2007 to 2015 is

3,912,176 tons, which is a 40% total growth for this period. The substitution effect between raw materials as a result of ethanol production is illustrated by means of comparing the scenarios that include DDGS and the scenarios that exclude DDGS. If Scenario 1woi and Scenario 1wi are compared, the following substitutions take place:

- o Sunflower hi pro and fish meal consumption increases by 1%
- o Soya hi pro and lucerne consumption decreases by 6% and 14% respectively

Table 4.10: Consumption and substitution of raw materials in Scenario 1wi and Scenario 1woi

Raw material	Base year	1wi	% change from base	1woi	% change from base	% change from 1woi – 1wi
	tons			tons		
Maize, yellow	4288915	7048949	64%	7068531	65%	0%
Sorghum	7000	9240	32%	9240	32%	0%
Maize germ	610400	763000	25%	763000	25%	0%
Wheat middlings	793898	1192463	50%	1192463	50%	0%
Maize gluten 20	116756	154118	32%	154118	32%	0%
Maize gluten 60	26040	34373	32%	34373	32%	0%
Cotton	210178	372902	77%	372900	77%	0%
Sunflower hi pro	351190	461469	31%	455906	30%	1%
Soya	255640	303700	19%	303700	19%	0%
Fish meal	29162	43355	49%	42962	47%	2%
Soya hi pro	896563	1113099	24%	1169605	30%	-6%
Lupins	14400	15000	4%	15000	4%	0%
Canola	21000	23000	10%	23000	10%	0%
Lucerne	400108	403184	1%	461205	15%	-14%
Poultry by-products	94376	124576	32%	124576	32%	0%
Feather meal	23553	26775	14%	26775	14%	0%
Meat-bone meal	8361	11039	32%	11039	32%	0%
Blood meal	2408	3604	50%	3604	50%	0%
Molasses	374278	482050	29%	482050	29%	0%
DDGS	0	127100		0		
TOTAL	**9667137**	**13579551**	**40%**	**13579313**	**40%**	**0%**

4.5.1.2 Scenario 1 with racial group data

Table 4.11 reflects the changes in consumption of the most important raw materials from the base to the specific scenario along with the substitution of raw materials as a result of the introduction of DDGS. In Scenario 1wr, from 2007 to 2015 the consumption of yellow maize, wheat middlings, cotton and soya hi pro increases by 54%, 50%, 73% and 16% respectively. The total growth for this specific scenario from 2007 to 2015 is 44%. With the exclusion of ethanol production in Scenario 1wor the consumption of raw materials such as yellow maize, wheat middlings, cotton and soya hi pro increases by 50%, 50%, 70% and 20% respectively from base to 2015. In this period of time the total animal feed consumed increases by 44%. If Scenario 1wor and Scenario 1wr are compared, the effect of ethanol production is highlighted. The following substitutions take place with ethanol production:

- Yellow maize, cotton and sunflower hi pro consumption increases by 6%, 3% and 2% respectively.
- Gluten 20, soya hi pro and lucerne consumption decreases by 3%, 4% and 7% respectively.
- The remaining raw materials stayed relatively the same.

This means that with ethanol production, the consumption of raw materials such as yellow maize, cotton and sunflower hi pro increases, whereas the consumption of raw materials such as gluten 20, soya hi pro and lucerne decreases.

Table 4.11: Consumption and substitution of raw materials in Scenario 1wr and Scenario 1wor

Raw material	Base year	1wr	% change from base	1wor	% change from base	% change from 1wor – 1wr
	tons			tons		
Maize, yellow	4288915	6609691	54%	6438241	50%	6%
Sorghum	7000	9240	32%	9240	32%	0%
Maize germ	610400	763000	25%	763000	25%	0%
Wheat middlings	793898	1192463	50%	1192463	50%	0%
Maize gluten 20	116756	166172	42%	169522	45%	-3%
Maize gluten 60	26040	34373	32%	34373	32%	0%
Cotton	210178	362900	73%	357699	70%	3%
Sunflower hi pro	351190	396067	13%	389340	11%	2%
Soya	255640	303700	19%	303700	19%	0%
Fish meal	29162	44618	53%	44419	52%	1%
Soya hi pro	896563	1041141	16%	1072621	20%	-4%
Lupins	14400	15000	4%	15000	4%	0%
Canola	21000	23000	10%	23000	10%	0%
Lucerne	400108	251560	-37%	279595	-30%	-7%
Poultry by-products	94376	124576	32%	124576	32%	0%
Feather meal	23553	26775	14%	26775	14%	0%

Meat-bone meal	8361	11039	32%	11039	32%	0%
Blood meal	2408	3604	50%	3604	50%	0%
Molasses	374278	428677	15%	424361	13%	2%
DDGS	0	127100		0		
TOTAL	**9667137**	**13935392**	**44%**	**13908163**	**44%**	**0%**

4.5.1.3 Scenario 2 with income group data

The total DDGS production increases in Scenario 1 mainly because of the increase in blending ratios. Table 4.12 reflects that in Scenario 2 a total of 281,546 tons of DDGS are produced, while all of the tons produced are consumed as animal feed in both scenarios. With Scenario 2wi the consumption of various raw materials increases from 2007 to 2015. The consumption of raw materials such as yellow maize, cotton and sunflower hi pro increases by 64%, 78% and 75% respectively, while the consumption of lucerne decreases by 68%. The total growth in animal feed consumption from the base year up to 2015 is 43%. In Scenario 2woi, where ethanol production is excluded, the consumption of yellow maize, cotton and sunflower hi pro as animal feed increases by 70%, 77% and 78% respectively from the base year up to 2015. Lucerne consumption showed the opposite trend and decreased by 48%, while total animal feed growth is 43%. If Scenario 2woi and Scenario 2wi are compared, the substitution effect as a result of ethanol production can be seen. With the introduction of DDGS the substitution effects are as follows:

- Yellow maize consumption decreases by 6%.
- Sunflower hi pro and fish meal consumption decreases by 3% and 5% respectively.
- Soya hi pro and lucerne consumption decreases by 13% and 20% respectively.

According to Scholtz (2008) DDGS has above-average acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) levels and this is the main reason why DDGS substitutes lucerne, which also has an average protein level of around 16%.

Table 4.12: Consumption and substitution of raw materials in Scenario 2wi and Scenario 2woi

Raw material	Base year	2wi	% change from base	2woi	% change from base	% change from 2woi – 2wi
	tons			tons		
Maize, yellow	4288915	7032736	64%	7295429	70%	-6%
Sorghum	7000	9240	32%	9240	32%	0%
Maize germ	610400	763000	25%	763000	25%	0%
Wheat middlings	793898	1192463	50%	1192463	50%	0%
Maize gluten 20	116756	154118	32%	154118	32%	0%
Maize gluten 60	26040	34373	32%	34373	32%	0%
Cotton	210178	373351	78%	372902	77%	1%
Sunflower hi pro	351190	615417	75%	626402	78%	-3%
Soya	255640	303700	19%	303700	19%	0%
Fish meal	29162	40297	38%	41582	43%	-5%
Soya hi pro	896563	1013250	13%	1125934	26%	-13%
Lupins	14400	15000	4%	15000	4%	0%
Canola	21000	23000	10%	23000	10%	0%
Lucerne	400108	127570	-68%	206115	-48%	-20%
Poultry by-products	94376	124576	32%	124576	32%	0%
Feather meal	23553	26775	14%	26775	14%	0%
Meat-bone meal	8361	11039	32%	11039	32%	0%
Blood meal	2408	3604	50%	3604	50%	0%
Molasses	374278	490101	31%	489505	31%	
DDGS	0	281546		0		
TOTAL	**9667137**	**13802039**	**43%**	**13869313**	**43%**	**0%**

4.5.1.3 Scenario 2 with racial group data

Table 4.13 reflects the consumption of raw materials along with the raw material substitutions as a result of the introduction of DDGS. With Scenario 2wr the consumption of yellow maize, cotton and sunflower hi pro increases by 68%, 78% and 87% respectively, whereas lucerne consumption decreases by 52% from the base year to 2015, with a total growth of 47% in animal feed consumption for this period. In Scenario 2wor, where ethanol production is excluded, the total animal feed consumption growth from the base year to 2015 is 46%, while the consumption of raw materials such as yellow maize, cotton and sunflower hi pro increases by 74%, 77% and 88% respectively. Lucerne consumption shows a decrease of 34% for the specific projected period. Comparing Scenario 2wor (which excludes ethanol production) with Scenario 2wr, the following substitutions take place:

- o Yellow maize consumption decreases by 6%.
- o Sunflower hi pro and fish meal consumption decreases by 1% and 2% respectively.
- o Soya hi pro and lucerne consumption decreases by 11% and 18% respectively.

With all the scenarios, there was no significant change in total consumption, mainly due to the fact that the change was minor at less than 1%. The effects on all the raw materials are displayed in Table 4.13.

Table 4.13: Consumption and substitution of raw materials in Scenario 2wr and Scenario 2wor

Raw materials	Base year	2wr	% change from base	2wor	% change from base	% change from base 2wor - 2wr
	tons			tons		
Maize, yellow	4288915	7202866	68%	7461714	74%	-6%
Sorghum	7000	9240	32%	9240	32%	0%
Maize germ	610400	763000	25%	763000	25%	0%
Wheat middlings	793898	1192463	50%	1192463	50%	0%
Maize gluten 20	116756	154118	32%	154118	32%	0%
Maize gluten 60	26040	34373	32%	34373	32%	0%
Cotton	210178	373351	78%	372902	77%	1%
Sunflower hi pro	351190	656294	87%	659450	88%	-1%
Soya	255640	303700	19%	303700	19%	0%
Fish meal	29162	40666	39%	41142	41%	-2%
Soya hi pro	896563	1059604	18%	1154315	29%	-11%
Lupins	14400	15000	4%	15000	4%	0%
Canola	21000	23000	10%	23000	10%	0%
Lucerne	400108	191187	-52%	262418	-34%	-18%
Poultry by-products	94376	124576	32%	124576	32%	0%
Feather meal	23553	26775	14%	26775	14%	0%
Meat-bone meal	8361	11039	32%	11039	32%	0%
Blood meal	2408	3604	50%	3604	50%	0%
Molasses	374278	507000	35%	506404	35%	
DDGS	0	281546		0		
TOTAL	**9667137**	**14166889**	**47%**	**14121555**	**46%**	**0.32%**

4.5.2 Consumption of DDGS within different species

In Scenario 1wi, dairy cattle consume the most DDGS with 23,654 tons followed by broilers with 20,584 tons. Scenario 1wr shows that dairy cattle consume the most DDGS with 47,553 tons followed by pigs with 44,061 tons. The rest of the consumption figures for the different species in Scenario 1wi and Scenario 1wr can be viewed in Figure 4.1 and Figure 4.2.

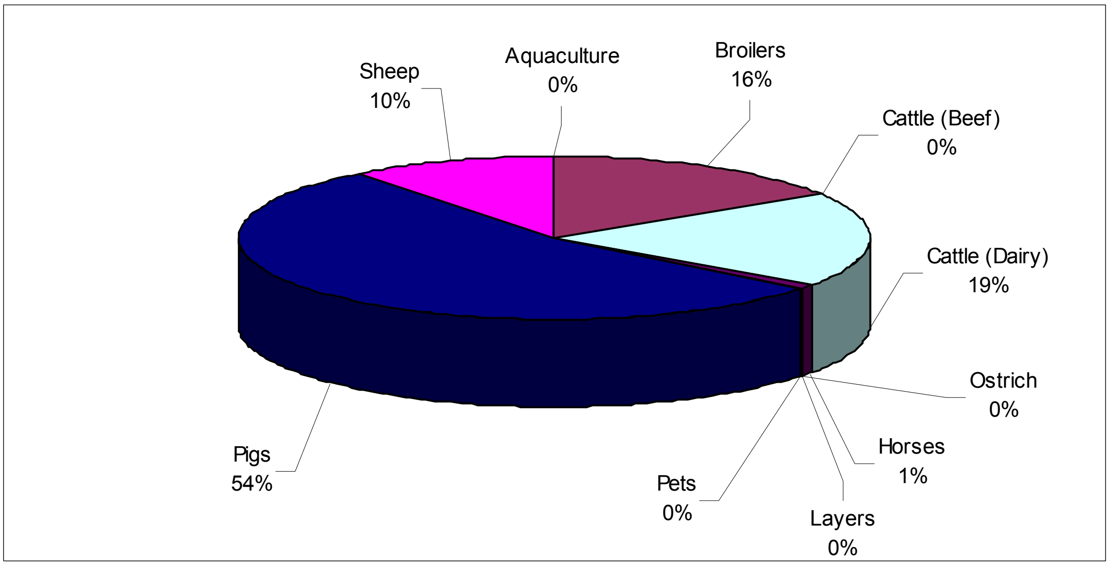

Figure 4.1: Consumption of DDGS by different species in Scenario 1wi

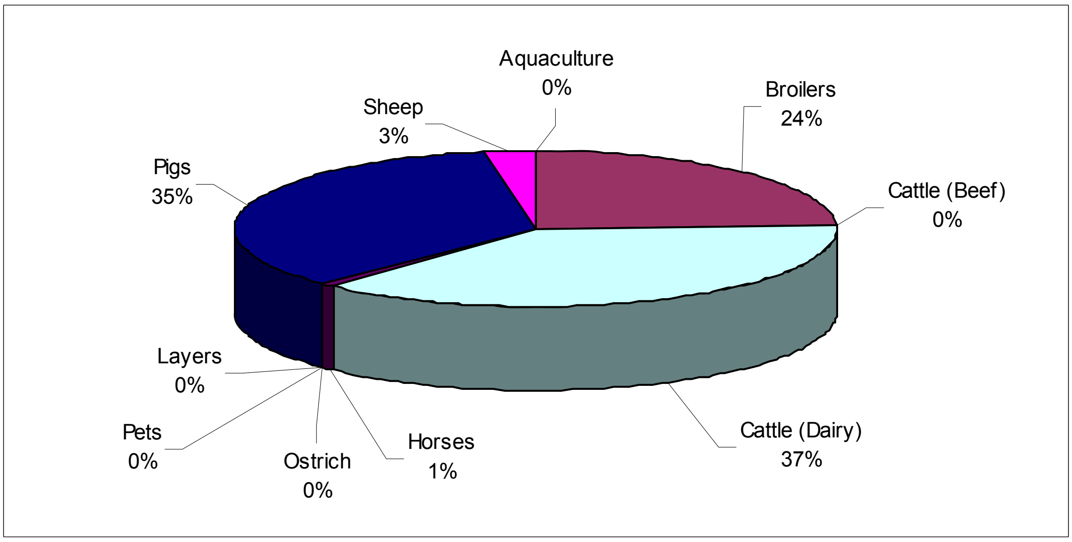

Figure 4.2: Consumption of DDGS by different species in Scenario 1wr

According to Scenario 2wi broilers consume the most DDGS with 170,746 tons followed by pigs with 67,491 tons. In Scenario 2wr broilers consume 58% of all the DDGS, which is 163,811 tons, followed by pigs with 25% (69,087 tons). The rest of the consumption figures for the different species in Scenario 2wi and Scenario 2wr are shown in Figure 4.2 and Figure 4.3.

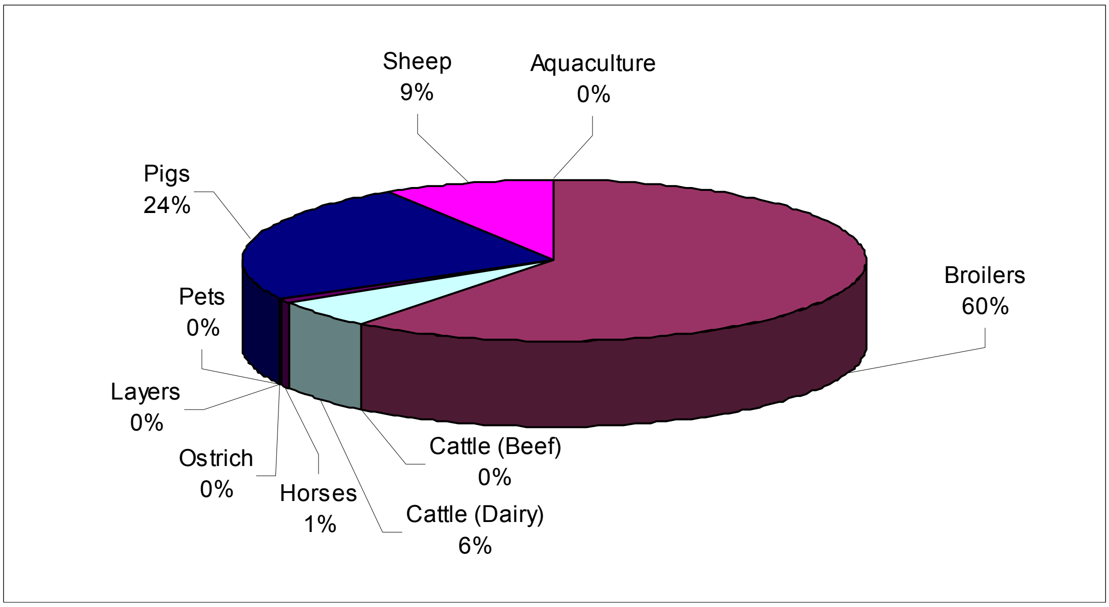

Figure 4.3: Consumption of DDGS by different species in Scenario 2wi

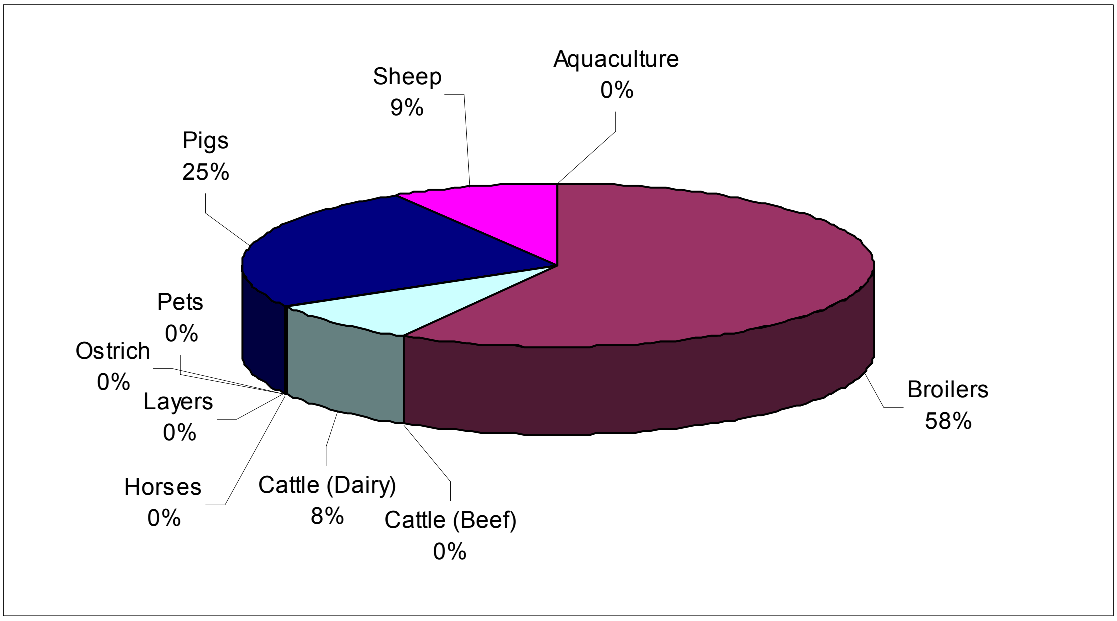

Figure 4.4: Consumption of DDGS by different species in Scenario 2wi

The dominant DDGS-consuming species are pigs, broilers and dairy cattle. The consumption figures for all the different species are reflected in Table 4.14 below.

Table 4.14: DDGS consumption per species

Species	1wi	1wr	2wi	2wr
	tons		tons	
Aquaculture	0	0	0	0
Broilers	20584	30850	170746	163811
Cattle (Beef)	0	0	0	0
Cattle (Dairy)	23654	47553	15622	22860
Horses	1044	1044	2254	1055
Layers	0	0	0	0
Ostriches	130	130	201	262
Pets	0	0	323	80
Pigs	68418	44061	67491	69087
Sheep	13270	3462	24909	24391
Total	**127100**	**127100**	**281546**	**281546**

With the change in blending ratios some of the species consumed more DDGS than other species, indicating the sensitivity to changes in DDGS availability. The species most sensitive to changes in DDGS availability are broilers, dairy cattle, pigs and sheep this is mainly due to the sensitivity levels of micotoxin. With the increase in DDGS production, broilers consume 44% more DDGS in the racial group data scenario, while with the income group data scenario 34% more DDGS is consumed. With dairy cattle there is a decrease of 13% and 29% with the respective scenarios. The remaining sensitivities for both data sets can be seen in Figure 4.5.

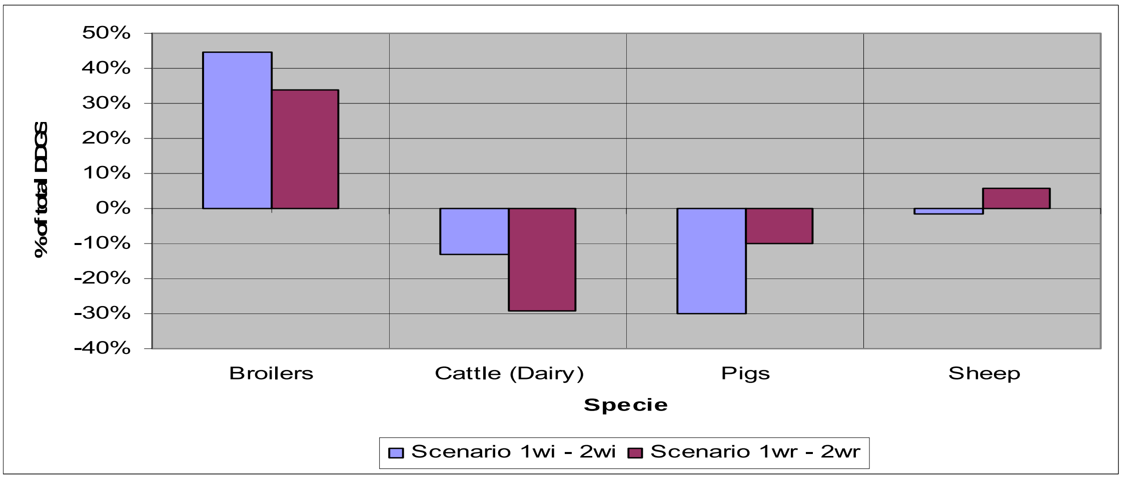

Figure 4.5: Sensitivity of DDGS consumption to a change in blending ratios

4.5.3 Changes in feed costs

The total animal feed cost increases from the base year to the scenario as follows:

- In Scenario 1wi, total costs increase by 35% (R 8.1 billion increase)
- In Scenario 1wr, total costs increase by 39% (R 9 billion increase)
- In Scenario 1woi, total costs increase by 37% (R 8.5 billion increase)
- In Scenario 1wor, total costs increase by 41% (R 9.4 billion increase)

Figure 4.6 shows the total animal feed costs for Scenario 1. These increases mentioned above are mainly due to an increase in demand for products, as well as an increase in the exchange rate together with an increase in transport costs.

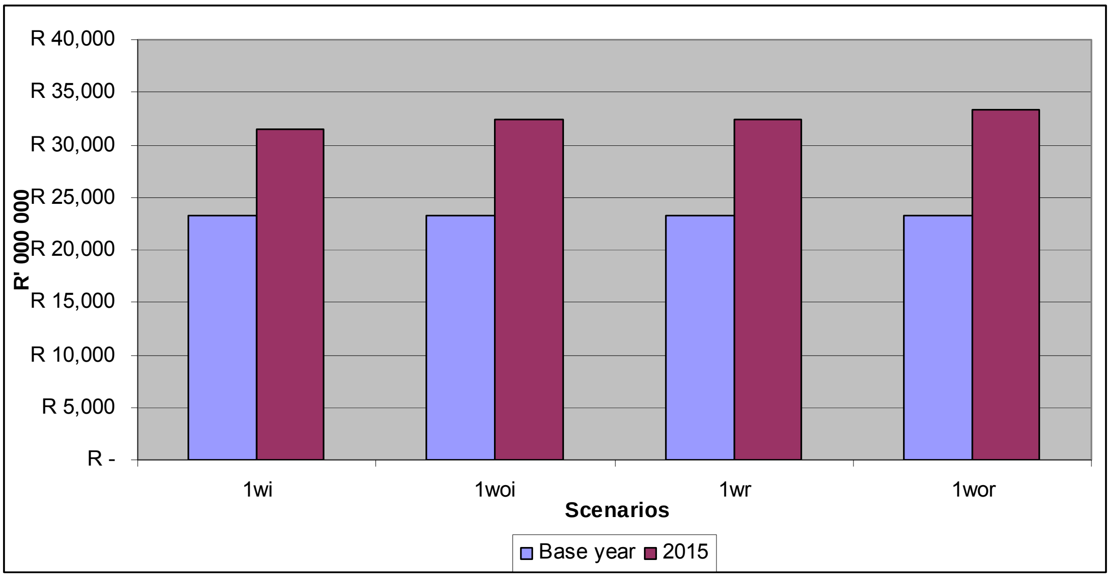

Figure 4.6: Total animal feed costs for Scenario 1

The total animal feed costs for all the scenarios in Scenario 2 are illustrated in Figure 4.7. The following changes in animal feed costs take place:

- In Scenario 2wi, total costs increase by 92% (R 21.4 billion increase)
- In Scenario 2wr, total costs increase by 96% (R 22.3 billion increase)
- In Scenario 2woi, total costs increase by 94% (R 22.9 billion increase)
- In Scenario 2wor, total costs increase by 98% (R 23.2 billion increase)

The increase in animal feed costs in Scenario 2 is more prominant than in Scenario 1. In Scenario 2 it is not because of a change in demand, but mostly because of a higher exchange rate combined with higher transport costs.

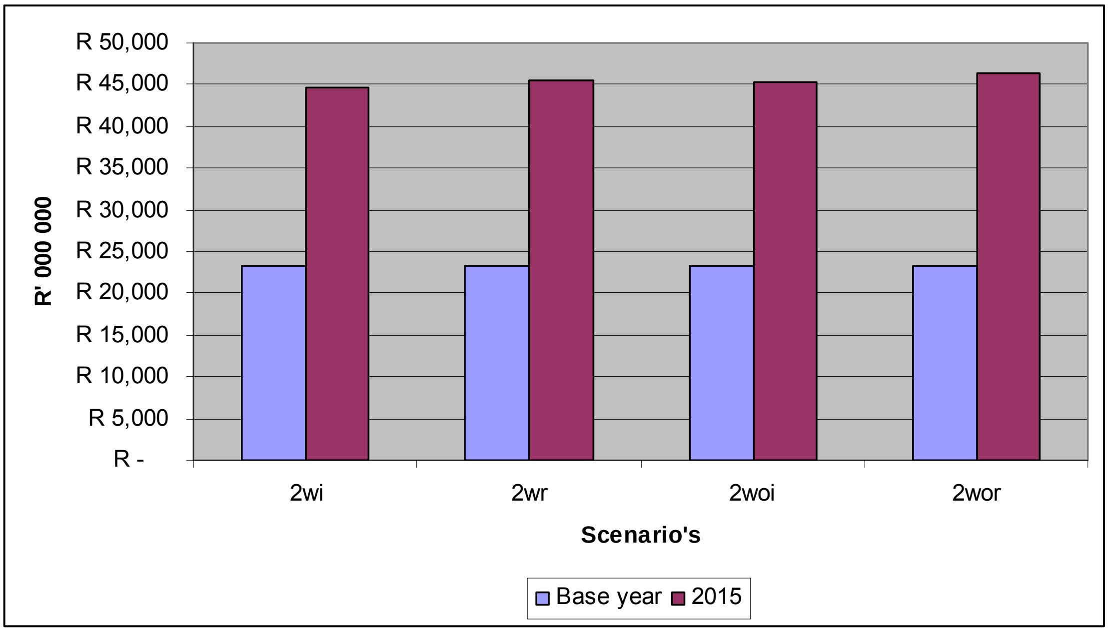

Figure 4.7: Total animal feed cost for Scenario 2

4.5.3.1 Effect of ethanol production on feed costs

In Scenario 1 the total animal feed cost increases from Scenario 1wi to Scenario 1woi by 1.2%, which is an increase of R384,221,362 compared to Scenario 1wr to 1wor, where there is also an increase of 1.2%, which represents an increase of R401,514,112. The total animal feed costs as well as the feed cost changes for the different scenarios in Scenario 1 are reflected in Table 4.15.

Table 4.15 Total animal feed costs for Scenario 1

Cost	1wi	1wr	1woi	1wor	% change from with - without DDGS	
	Rand				Income	Racial
Total animal feed	31,429,585,905	32,335,030,575	31,813,807,267	32,736,544,687	1.2%	1.2%

In Scenario 2 the total animal feed cost increases from Scenario 2wi to Scenario 2woi with R879,296,512, which is an increase of 2%. An increase of 2% from Scenario 2wr to Scenario 2wor is shown, which is an amount of R894,997,969. Table 4.16 reflects the total animal feed costs for Scenario 2 along with the changing percentages.

Table 4.16 Total animal feed costs for Scenario 2

Cost	2wi	2wr	2woi	2wor	% change from with - without DDGS	
	Rand				Income	Racial
Total animal feed	44,667,582,019	45,563,203,394	45,546,878,531	46,458,201,363	2%	2%

4.6 Chapter summary

In this chapter all of the relevant results for the three models are explained. In the first section the Niewoudt/McGuin model results are discussed. These results show that there are differences between the two data sets, but both data sets have problems and further research is still needed. The results also indicate the growth in per capita consumption of products for various animal products.

The second section contains the results of the BFAP model, such as the projected exchange rate and population figures for 2015, as well as the raw material equilibrium prices for the projected year under various scenarios. In this section the price substitution effect as a result of the introduction of ethanol production is also explained.

The results of the APR model are explained in the third section, which contains results for various scenarios such as the raw material consumption substitution, the consumption of DDGS within different species, and the changes in the total animal feed costs as a result of the introduction of DDGS into the animal feed industry.

CHAPTER 5

Conclusion and recommendations

5.1 Introduction

This study focuses on the economic impact of maize-based ethanol production on the South African animal feed industry. In the past few years the world has witnessed a substantial increase in the global ethanol production capacity. In light of this growth, various researchers locally and globally have conducted research into ethanol production, but little work has been done on quantifying the likely economic impacts that ethanol production will have on the animal feed industry. These impacts include substitution of animal feed raw materials, the sensitivity of raw material prices, changes in feed costs, and DDGS consumption of different animal species.

These impacts are evaluated for a South African scenario by means of combining three models, i.e. the Nieuwoudt/McGuigan model, the BFAP model and the APR model. These models are linked by using outputs of one model as inputs into the next in order to achieve the stated objectives.

5.2 Nieuwoudt/McGuigan model results

In order to satisfy objective A, as mentioned in Section 1.3, which is the projection of per capita consumption data, a new base data set is evaluated with the Niewoudt/McGuigan model in order to project the per capita consumption of final animal products. The current data set used in the model is a racially classified data set (e.g. Whites, Africans, Asians and Coloureds), while the new data set is classified according to household income. The hypothesis is that people do not consume according to their race but rather according to what they can afford (i.e. as allowed by their disposable income). With the evaluation of these two data sets it is found that in both of the data sets there are considerable variations in the consumption of products between the various groups. For example, Asians in the income group R 100 001 – R 300 000 still prefer mutton above other products, while in terms of racial groups Asians still consume the most mutton. Thus a decision was made to use both the data sets in order to compare the results from the Nieuwoudt/Mcguigan model. With the projection of the per capita consumption it is found that the racial group set is higher than the income group set, mainly because with the racial group data set in the base, consumers prefer to consume more beef and chicken than with the income group set. Both sets of per capita consumptions of final products projected with the Nieuwoudt/McGuigan model under a scenario with high income growth and tariffs maintained are used to simulate equilibrium prices for 2015 by means of using the BFAP model.

5.3 BFAP model results

The BFAP model results consist of macro-economic indicators simulated under various scenarios for 2015 along with equilibrium prices. These projected figures are then used in order to satisfy objective B, as mentioned in Section 1.3, which is to project equilibrium prices for 2015. The hypothesis is that price shifts within raw materials would take place with the introduction of DDGS into the animal feed industry, mainly due to shifts in demand and supply of raw materials.

5.3.1 Macro-economic indicators

In order to simulate the equilibrium prices for 2015, the BFAP model uses all of the scenarios mentioned in Section 3.5.3.1. In the results the macro-economic variables for all the scenarios remained the same, because ethanol production in South Africa is too small to have an impact on the exchange rate or on oil prices. This is the main reason why the macro-economic variables are kept the same. It is also clear that the production of ethanol will not have an impact on the population figures, which is mainly why the population figures stayed the same.

5.3.2 Raw material equilibrium prices for Scenario 1

Scenario 1 is divided into four different sub-scenarios, which are explained in Chapter 3. The BFAP model only uses two of these four scenarios, mainly because the BFAP model does not use data from the Niewoudt/McGuigan model and there is no need to have the sub-scenarios of race and income. With the introduction of DDGS into the animal feed industry, the demand for various imported protein raw materials decreases while the demand for maize increases. This means that if the demand decreases, the price would also decrease and *vice versa*.

In Scenario 1 only 127,000 tons of DDGS at R1561/ton are introduced into the animal feed industry. With this introduction various price changes take place, such as: The price of yellow maize increases by 6.7%, while the price of sunflower hi pro decreases by 0.4%. It is found that 127,000 tons are not enough to cause enormous price shifts within raw materials, and ethanol production would not have a major impact on the raw material prices at such a relatively low level of availability.

5.3.3 Raw material equilibrium prices for Scenario 2

In Scenario 2 the production of ethanol increases because of an increase in the mandatory blending ratios. Scenario 2 produces 281,000 tons and the DDGS sells for R1954/ton. With the introduction of DDGS into the animal feed industry the price of yellow maize increases by 7%, while the prices of sunflower hi pro and soya hi pro decrease by 4% and 8% respectively. This means that with the introduction of DDGS the demand for yellow maize increases due to the fact that maize is used as feedstock for ethanol production, while the demand for the two oilcakes (sunflower and soya) decreases, which means that DDGS is substituting these raw materials. Still, with the increase in the production of ethanol, there is no significant change in the prices of the raw materials, but the hypothesis that price shifts will take place is accepted on the basis of the minor changes taking place.

5.4 APR model results

The APR model is used to satisfy objective C, as mentioned in Section 1.3, which is to simulate the changes in the consumption of animal feed raw materials for South Africa with the introduction of DDGS. In this study the model is used to quantify the substitution effect of raw material consumption along with the total animal feed costs. The APR model also simulates which animal species consume DDGS and how much thereof they consume.

5.4.1 Raw material consumption substitution

With the APR model, the per capita consumption of final products calculated with the Niewoudt/McGuigan model is used as base factor. This means that all of the scenarios mentioned in Chapter 3 will be used to perform the required analysis.

5.4.1.1 Scenario 1

As mentioned in Section 5.3, with the introduction of DDGS as a raw material into the animal feed industry, various substitutions of raw materials will take place. This means that less of a particular raw material will be consumed while more of other raw materials will be consumed. In Scenario 1 with the income group data set the consumption of sunflower hi pro and fish meal increases by 1%, while the consumption of soya hi pro and lucerne decreases by 6% and 14% respectively. DDGS and products such as soya hi pro and lucerne are substitutes, which mean that if the demand for DDGS increases, the demand for soya hi pro will decrease. This is why there is a decrease in the consumption of soya hi pro as animal feed. The other factor is that DDGS is much cheaper than the imported soya hi pro and this is why the consumption of soya hi pro decreases.

Almost the same effects as with the income group data set are found with the racial group data set. The consumption of yellow maize increases by 6% and sunflower by 2%, while the consumption of gluten 20, soya hi pro and lucerne decreases by 3%, 4% and 7% respectively. These consumption changes are mainly because DDGS and products such as soya hi pro and lucerne are substitutes, which means that if the demand for DDGS increases, the demand for soya hi pro will decrease. The total animal feed consumed does not change much, mainly due to the fact that ethanol production does not change the per capita consumption of final animal products. This means that the demand for final animal products stays the same, meaning that there are no changes in the demand for animal feed because the same number of animals will be fed in Scenario 1w and Scenario 1wo. This is why the only changes in feed tons are between raw materials with the introduction of animal feed.

The overall conclusion of Scenario 1 at the specific blending rates is that the ethanol production capacity is too small to have a significant impact on the consumption of raw materials as animal feed.

5.4.1.2 Scenario 2

With Scenario 2 there is an increase in ethanol production, which will also result in an increase in the demand effects. Ethanol production increases because of an increase in the blending ratios. With this increase, 281,000 tons of DDGS are introduced into the animal feed industry. In Scenario 2 with the income data set, the consumption of yellow maize as animal feed decreases by 6% while the consumption of fish meal, soya hi pro and lucerne decreases by 5%, 13% and 20% respectively. The consumption of yellow maize decreases mainly because DDGS is cheaper than yellow maize. In Scenario 1 the price difference between yellow maize and DDGS was not as significant as with Scenario 2. The rest of the raw materials decrease mainly due to the fact that DDGS is more price-competitive.

With the racial group data set, almost the same effects as with the income group data set are found. The consumption of yellow maize, soya hi pro and lucerne as animal feed decreases with the introduction of DDGS as animal feed. The effect of ethanol production on the substitution of raw materials is more intense in Scenario 2 than in Scenario 1. Still, the effect on the animal feed industry is not as intense, and the only raw material that is significantly affected is lucerne.

Lucerne has an average protein content, but is mostly used as a substitute for fibre. According to Scholtz (2008) DDGS has above-average acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) levels, which is the main reason why DDGS substitutes lucerne.

With a blending ratio of 2% and the introduction of 127,000 tons of DDGS, the overall effect is still too small to cause enormous changes in the total animal feed industry. The only raw material affected in a significant manner is lucerne.

5.4.2 DDGS consumption by different species

As described in Chapter 2, some of the animal species cannot consume DDGS if the quality of the DDGS is poor. With this section the main idea was to evaluate which animal species consume the most DDGS and which animals are sensitive to the introduction of DDGS at given price levels of protein raw materials.

5.4.2.1 Scenario 1

With the income group data set, pigs consume the most DDGS followed by dairy cattle, while with the racial group data set dairy cattle consume the most followed by pigs. This difference is mainly due to the fact that with the racial group data set the demand for final animal products is greater than with the income group data set. These differences are important to know, because in Scenario 1wi pigs consume 54% of the total DDGS produced. This means that pig producers must look into research on including DDGS in diets, as well as what the effects will be when DDGS is included in diets. The DDGS produced in South Africa must be of a high standard, otherwise it cannot be used as animal feed, mainly because swine diets are most sensitive to mycotoxine levels. The same applies to dairy cattle producers in South Africa.

5.4.2.2 Scenario 2

In Scenario 2 with the income group data set, broilers consume 60% of the total DDGS produced in South Africa followed by pigs, while with the racial group data set this remains the same, with broilers consuming the most followed by pigs. According to various literature sources, swine and broiler diets are most sensitive to poor-quality DDGS, and in this specific scenario both these species are the dominant consumers of DDGS. The fact that the species with the most sensitive diets are consuming the most DDGS highlights the importance of ethanol producers in South Africa producing high-quality DDGS in order to market it to the animal feed industry.

5.4.2.3 Consumption sensitivity of different species to the introduction of DDGS

The species most sensitive to changes in the availability of DDGS are broilers, dairy cattle and pigs. With the increase in DDGS production from Scenario 1 to Scenario 2, broilers consume 44% more DDGS with racial group data and 34% more with income group data, while the consumption thereof by dairy cattle and pigs decreases. This means that broiler producers must consider including DDGS in their animals' diets merely because if the production of ethanol increases and the availability of DDGS increases, then broilers become the dominant consumer of DDGS.

5.4.3 Changes in animal feed costs

The total cost of animal feed in South Africa varies due to the fact that there is an increase in the demand for animal feed, as well as aspects such as increasing transport costs and exchange rates. In this section the total feed costs from the base year to the projected year 2015 are evaluated for both scenarios along with changes in total animal feed costs in South Africa as a result of the introduction of DDGS into the animal feed industry locally.

5.4.3.1 Scenario 1

In Scenario 1 with the income group data set it is found that with ethanol production in place, the total animal feed cost increases by 35% and with the racial group data set there is an increase of 39% from the base year up to the projected year, keeping in mind that the demands of the racial group data set are higher. Without ethanol production and with the racial group data set, the total animal feed cost increases by 41%, whereas with the income group data set it increases by 37%.

The increases are mainly due to the increase in the crude oil price from $65/barrel to $85/barrel. This is an increase of 31% in transport costs, as well as various other production costs. Another factor is that more animal feed is demanded for the projected year, which accounts for a growth of 40% for the income group data and 44% for the racial group data.

5.4.3.2 Scenario 2

With the income group data set and with ethanol production, the total animal feed cost from the base year to 2015 increases by 92%, while with the racial group data it increases by 96%. With the exclusion of ethanol production the income group data shows an increase of 94%, while the racial group data shows an increase of 98%.

The total animal feed costs increase dramatically in Scenario 2 compared to Scenario 1 mainly due to the fact that the crude oil price rises from $65/barrel to $145/barrel. This causes an enormous increase in transport costs, as well as an increase in the input costs of producing these raw materials. Another factor is the exchange rate that depreciates from $/R7.12 to $/R10.49, which raises the price of imported raw materials. In Chapter 2 it is mentioned that most of the oilcake consumed as animal feed in South Africa is imported, which means that the prices of all oilcakes increase with the increase in exchange rate.

5.4.3.3 Effect of ethanol production on total animal feed costs

If the scenarios with ethanol production are compared to the scenarios without ethanol production, the effect on total animal feed costs is highlighted. With Scenario 1 both data sets (income and racial) indicate that the total animal feed costs decrease by 1.2% when ethanol is produced. This means that ethanol production lowers the total cost of animal feed. In Scenario 2 there is a decrease of 2% in total animal feed costs when ethanol is produced, which indicates that ethanol production has a cost-decreasing effect on the animal feed industry in Scenario 2. The effect of Scenario 2 is greater than the effect with Scenario 1, mainly due to the fact that the availability of DDGS increases from Scenario 1 to Scenario 2.

Some of the research done in the USA came to the opposite conclusion, mainly due to the fact that the USA is not a net importer of protein animal feed. In South Africa the total feed costs decrease due to the fact that DDGS replaces protein feed that is currently being imported.

5.5 Recommendations

With the ethanol production figures of Scenario1 and Scenario 2, there is no significant effect on the animal feed industry. The prices of raw materials change only by a small percentage. The consumption of raw material substitutes experiences the same effect as the prices of raw materials, with no significant changes taking place, with the exception of lucerne consumption, which decreases by 20%. In terms of feed costs, the animal feed industry will see a 2% change and the conclusion can be drawn that ethanol production will have a minor affect on the animal feed industry in South Africa. The reason for the small cost effect is that DDGS will also be produced at a price and does not come free of charge – it can only substitute expensive raw materials, and more maize is needed for ethanol production.

In terms of the Niewoudt/McGuigan model data sets, the hypothesis of consumers consuming according to their disposable income is rejected, mainly due to the fact that there is still significant variation in the consumption of different animal products in both data sets. Thus, further research is needed with more efficient data, and it is recommended that data be classified under cultural groups. There is also a need for more practical research to determine the effect that DDGS consumption will have on the diets of species such as broilers, swine and dairy cattle in South Africa.

If the bio-fuels industry strategy proposed by the DME is implemented, the effect on the South African animal feed industry will not be major if ethanol is produced with maize. Further research is still needed to determine the possible effect on food security, but when it comes to animal feed, ethanol production can take place without any negatives effects, provided that the quality of the DDGS is of a global standard.

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Annexures

Annexure A

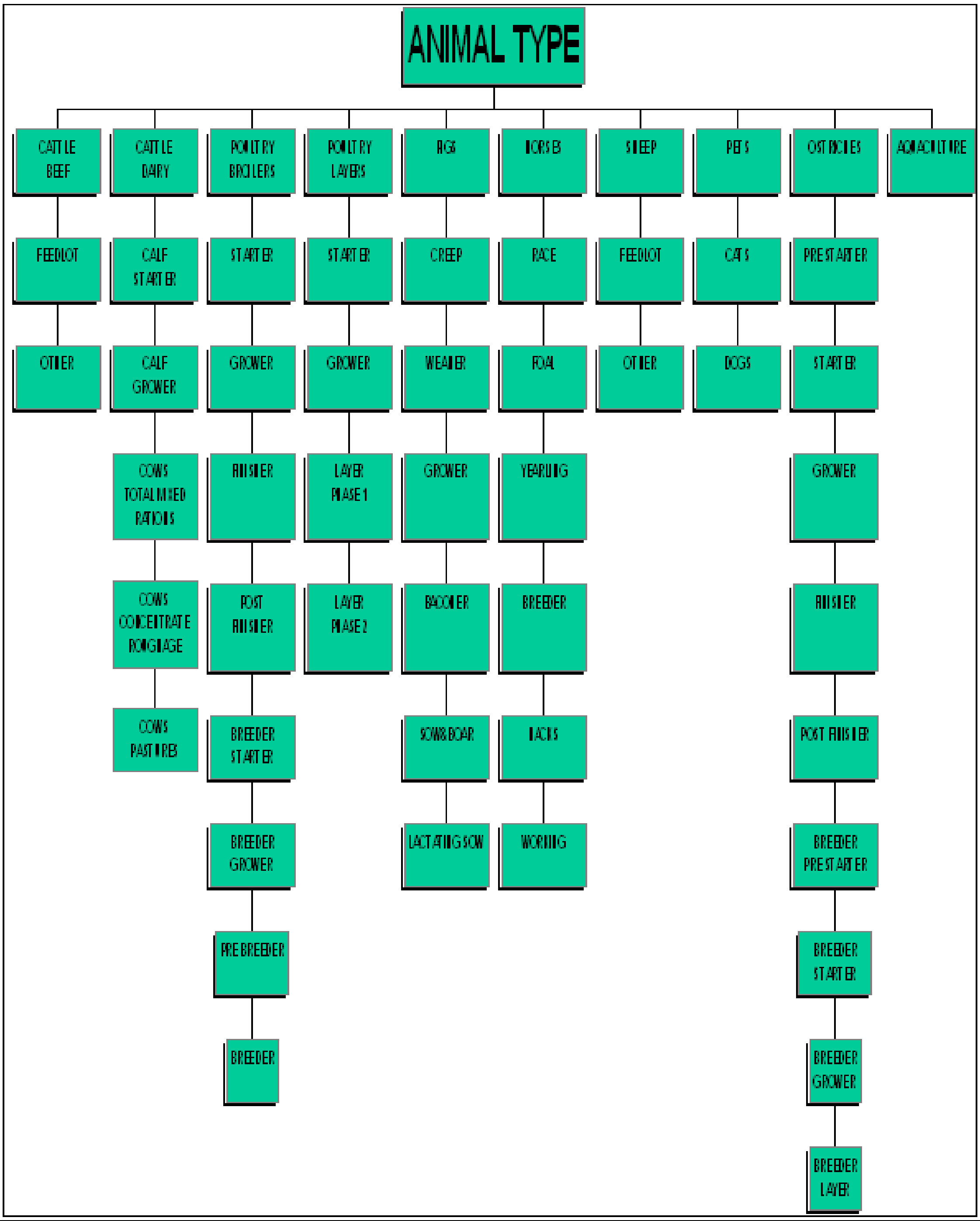

Figure A1: Categories of livestock to be considered in the APR model
Source: Briedenhann (2001)

Annexure B

Table B1: Most important data used in the 2007 BFAP baseline model

Base Factors		**2007**
Base Factors	*Factor*	
Consumption	*Base year*	2007
Exchange rate	*Base year*	2007
Exchange rate	*Exchange Rate (Rand to US$)*	7.16
Population	*Base year*	2007
Population	*Population (millions)*	47.35
Population	*% Increase per annum*	0.54
Base Per Capita Consumed		**Actual**
Per capita consumption chicken		25.39
Per capita consumption cattle beef		16.13
Per capita consumption milk		44
Per capita consumption eggs		6.99
Per capita consumption pork		3.78
Per capita consumption mutton		3.22
RM Prices		**R/ton**
Byprod Industry		
Acid oil		6700
CMS molasses		1900
Molasses		1900
Byprod Milling		
Maize Germ		1000
Wheat Middlings		1800
Byprod Wet Mill		
Maize Gluten 20		880
Maize Gluten 60		3000
Fish meal		
Fish meal hi pro		6200
Fish meal lo pro		6200
Full-fat		
Full-fat Canola		2900
Full-fat Cotton		1800
Full-fat Soya		2275

Grain		
Barley		1650
Maize White		1289
Maize Yellow		1260.97
Oats		1400
Sorghum (Interior)		1000
Sorghum (KZN)		1350
Lupins		
Lupins		1500
Oilcake		
Canola Oilcake		1340
Cotton Oilcake		1600
Soya Hi pro Oilcake		2080
Sunflower Hi pro Oilcake		1350
Other		
Lucerne		1500
Milk Replacers		6000
Roughage		2000
Rendering		
Blood meal		3000
Feather meal		3000
Meat-bone meal		2400
Poultry Byprod		3200
Basic RM prices		***R/ton***
Additives		
Carophyll R		85000
Carophyll Y		45000
Coccidiostats		20000
Marigold 20%		30000
Pronutrients		20000
Viamins/Minerals		30000
Amino acids		
Lysine		11000
Methionine		13000
Threonine		36000

Minerals		
Dicalcuim P		2900
Limestone		550
Monocalcium P		2750
Salt		400
NPN		
Ammonium CI		3000
Urea		2600
RM Transport cost	***Destination***	***R/ton***
Cape	*Cape*	160
Cape	*Interior*	610
Cape	*KZN*	775
Interior	*Cape*	610
Interior	*Interior*	160
Interior	*KZN*	310
KZN	*Cape*	775
KZN	*Interior*	310
KZN	*KZN*	160

Sources: AFMA (2007) and Briedenhann (2007)

Table B2: Base factors for APR model

APR Base year data		**2007 Actual**
Base Factors	***Factor***	
Consumption	*Base year*	2007
Exchange rate	*Base year*	2007
Exchange rate	*Exchange Rate (Rand to US$)*	7.16
Exchange rate	*% Increase per annum*	0
Population	*Base year*	2007
Population	*Population (millions)*	47.35
Population	*% Increase per annum*	0.54
Base Per Capita Consumed		**Kg/person**
Per capita consumption chicken		25.39
Per capita consumption cattle beef		16.13
Per capita consumption milk		44
Per capita consumption eggs		6.99
Per capita consumption pork		3.78
Per capita consumption mutton		3.22
Animal Distribution	***Region***	**%**
Aquaculture		
Standard	*Cape*	20
Standard	*Interior*	80
Standard	*KZN*	0
Broilers		
Standard	*Cape*	32
Standard	*Interior*	53
Standard	*KZN*	15
Breeder	*Cape*	32
Breeder	*Interior*	53
Breeder	*KZN*	15
Cattle beef		
Feedlot	*Cape*	23
Feedlot	*Interior*	57
Feedlot	*KZN*	20
Other	*Cape*	23
Other	*Interior*	57
Other	*KZN*	20

Cattle Dairy		
Calves	*Cape*	20
Calves	*Interior*	30
Calves	*KZN*	50
Cows Conc/Rough	*Cape*	13
Cows Conc/Rough	*Interior*	82
Cows Conc/Rough	*KZN*	5
Cows Pasture	*Cape*	5
Cows Pasture	*Interior*	53
Cows Pasture	*KZN*	42
Cows TMR	*Cape*	38
Cows TMR	*Interior*	55
Cows TMR	*KZN*	7
Horses		
Horses	*Cape*	47
Horses	*Interior*	43
Horses	*KZN*	10
Layers		
Breeder	*Cape*	45
Breeder	*Interior*	43
Breeder	*KZN*	12
Standard	*Cape*	45
Standard	*Interior*	43
Standard	*KZN*	12
Ostriches		
Breeder	*Cape*	94
Breeder	*Interior*	6
Breeder	*KZN*	0
Standard	*Cape*	94
Standard	*Interior*	6
Standard	*KZN*	0
Pigs		
Breeder	*Cape*	33
Breeder	*Interior*	53
Breeder	*KZN*	14
Standard	*Cape*	33
Standard	*Interior*	53
Standard	*KZN*	14

Pets		
Cats	*Cape*	14
Cats	*Interior*	77
Cats	*KZN*	9
Dogs	*Cape*	14
Dogs	*Interior*	77
Dogs	*KZN*	9
Sheep		
Feedlot	*Cape*	48
Feedlot	*Interior*	50
Feedlot	*KZN*	2
Other	*Cape*	48
Other	*Interior*	50
Other	*KZN*	2
Various		
Various	*Cape*	20
Various	*Interior*	60
Various	*KZN*	20
Animal Factors	***Factor***	**Actual**
Aquaculture		
Standard	*Avg Slaughter Weight*	2
Standard	*Feed Conversion*	5
Broilers		
Breeder	*Rearing Period (wks)*	18
Breeder	*Rearing Consumption (kgs)*	10
Breeder	*Mortality to Point of Lay (%)*	5
Breeder	*Egg Production per Hen Housed*	150
Breeder	*Breeder Feed Consumption (gr/day)*	165
Breeder	*Rejected Eggs %*	9
Breeder	*Hatchability %*	80
Standard	*Avg Slaughter Weight (kgs)*	1.7
Standard	*Slaughter Out Percent %*	72
Standard	*Feed Conversion Ratio*	1.82
Cattle beef		
Feedlot	*Avg Slaughter Weight (KGS)*	385
Feedlot	*Slaughter Out Percent %*	56
Feedlot	*Feed Conversion Ratio*	6.2
Feedlot	*Avg Feedlot Weight Gain (kgs)*	143
Feedlot	*Percentage of Cattle %*	68
Other	*Avg Slaughter Weight (KGS)*	375
Other	*Slaughter Out Percent %*	56

Other	*Feed Conversion Ratio*	1.5
Other	*Percentage of Cattle %*	32
Cattle Dairy		
Calves	*Calves Per Cow in Milk*	0.75
Calves	*Heifers Per Cow in Milk*	0.57
Calves	*Calf Feed Consumption (kgs/day)*	3
Calves	*Heifer Feed Consumption (kgs/day)*	2
Cows Conc/Rough	*Percentage Cows in Milk %*	80
Cows Conc/Rough	*In-milk Cow Production (lt/day)*	14
Cows Conc/Rough	*In-milk Cow Consumption (kg/day)*	6
Cows Conc/Rough	*Dry Cow Consumption (kg/day)*	2
Cows Conc/Rough	*% Total Cows*	26
Cows Pasture	*Percentage Cows in Milk %*	80
Cows Pasture	*In-milk Cow Production (lt/day)*	14
Cows Pasture	*In-milk Cow Consumption (kg/day)*	6
Cows Pasture	*Dry Cow Consumption (kg/day)*	2
Cows Pasture	*% of Total Cows*	16
Cows TMR	*Percentage Cows in Milk %*	80
Cows TMR	*In-milk Cow Production (lt/day)*	14
Cows TMR	*In-milk Cow Consumption (kg/day)*	6
Cows TMR	*Dry Cow Consumption (kg/day)*	2
Cows TMR	*% of Total Cows*	58
Horses		
Horses	*% Consuming Feed Concentrates*	45
Horses	*Feed Consumption Foal (kgs/day)*	3
Horses	*Feed Consumption Yearling (kgs/day)*	3
Horses	*Feed Consumption Breeder (kgs/day)*	3
Horses	*Feed Consumption Hack (kgs/day)*	2
Horses	*Feed Consumption Racehorse (kgs/day)*	3
Horses	*Feed Consumption Working (kgs/day)*	3
Horses	*Foal%*	5
Horses	*Yearling %*	6
Horses	*Breeder %*	4
Horses	*Hack %*	73
Horses	*Racehorse %*	7
Horses	*Working %*	5
Layers		
Breeder	*Rearing Period (wks)*	18
Breeder	*Rearing Consumption (kgs)*	6.8
Breeder	*Mortality to Point of Lay (%)*	5
Breeder	*Egg Production per Hen Housed*	275
Breeder	*Breeder Feed Consumption (gr/day)*	105
Breeder	*Egg Weight (gr)*	60
Breeder	*Rejected Breeder Eggs %*	9
Breeder	*Hatchability %*	80
Standard	*Rearing Peiod (wks)*	18

Standard	*Rearing Consumption (kgs)*	6.8
Standard	*Mortality to Point of Lay (%)*	5
Standard	*Egg Production per Hen Housed*	275
Standard	*Feed Consumption (gr/day)*	105
Standard	*Egg Weight (gr)*	60
Standard	*Unsaleble Eggs %*	6
Ostriches		
Breeder	*Rearing Consumption (kgs)*	2400
Breeder	*Mortality to Point of Lay (%)*	15
Breeder	*Birds Per Hen per Annum*	20
Breeder	*Breeder Feed Consumption (kgs/day)*	4
Standard	*Avg Slaughter Weight (KGS)*	95
Standard	*Feed Conversion Ratio*	4.3
Pigs		
Breeder	*Piglets Marketed Per Sow Per Annum*	17
Breeder	*Sow Per Boar*	16
Breeder	*Pregnant Sow Feed Cons (kgs/day)*	2.5
Breeder	*Lactating Sow Feed Cons (kgs/day)*	6
Breeder	*Pregnant Sow Days*	275
Breeder	*Lactating Sow Days*	90
Breeder	*Boar Feed Cons (kgs/day)*	2
Breeder	*Growing Breeder Feed Cons (kgs)*	80
Breeder	*Replacement Tempo Per Annum %*	33
Standard	*Porker Weight at Slaughter (kgs)*	68
Standard	*Baconner Weight at Slaughter (kgs)*	90
Standard	*Porkers Marketed Percentage %*	50
Standard	*Baconers Marketed Percentage %*	50
Standard	*Slaughter Out Percent %*	73
Standard	*Feed Conversion Ratio*	3.1
Pets		
Cats	*% of pets*	3
Cats	*% of Body Mass Consumed per Day*	2.5
Cats	*% of Cats Fed Dry Cat Food*	10
Dogs	*Avg Cat Weight (kgs)*	3
Dogs	*% Pets*	97
Dogs	*% of Body Mass Consumed per Day*	2.5
Dogs	*% of Dogs Fed Dry Pet Food*	50
Dogs	*Avg Small Dog Weight (kgs)*	5
Dogs	*% Small Dogs*	51
Dogs	*Avg Medium Dog Weight (kgs)*	15
Dogs	*% Medium Dogs*	22
Dogs	*Avg Large Dog Weight (kgs)*	30
Dogs	*% Large Dogs*	27
Sheep		
Feedlot	*Avg Slaughter Weight (kgs)*	40
Feedlot	*Slaughter Out Percent %*	56

Feedlot	*Feed Conversion Ratio*	6
Feedlot	*Avg Feedlot Weight Gain (kgs)*	20
Feedlot	*% Feedlot Sheep*	36
Other	*Avg Slaughter Weight (kgs)*	40
Other	*Slaughter Out Percent %*	56
Other	*Supplement Consumption (kgs)*	1
Other	*% Other Sheep*	64
RM Distribution	***Region***	**%**
Byprod Industry		
Acid oil	*Cape*	22
Acid oil	*Interior*	61
Acid oil	*KZN*	17
CMS Molasses	*Cape*	0
CMS Molasses	*Interior*	50
CMS Molasses	*KZN*	50
Molasses	*Cape*	0
Molasses	*Interior*	20
Molasses	*KZN*	80
Byprod Milling		
Maize Germ	*Cape*	3
Maize Germ	*Interior*	80
Maize Germ	*KZN*	17
Wheat Middlings	*Cape*	29
Wheat Middlings	*Interior*	55
Wheat Middlings	*KZN*	16
Byprod Wet Mill		
Maize FF	*Cape*	11
Maize FF	*Interior*	89
Maize FF	*KZN*	0
Maize Gluten 20	*Cape*	11
Maize Gluten 20	*Interior*	89
Maize Gluten 20	*KZN*	0
Maize Gluten 60	*Cape*	11
Maize Gluten 60	*Interior*	89
Maize Gluten 60	*KZN*	0
Fish Meal		
Fish Meal hi pro	*Cape*	100
Fish Meal hi pro	*Interior*	0
Fish Meal hi pro	*KZN*	0
Fish Meal lo pro	*Cape*	100
Fish Meal lo pro	*Interior*	0
Fish Meal lo pro	*KZN*	0
Full-fat		
Full-fat Canola	*Cape*	100
Full-fat Canola	*Interior*	0

Full-fat Canola	*KZN*	0
Full-fat Cotton	*Cape*	0
Full-fat Cotton	*Interior*	90
Full-fat Cotton	*KZN*	10
Full-fat Soya	*Cape*	10
Full-fat Soya	*Interior*	50
Full-fat Soya	*KZN*	40
Grain		
Barley	*Cape*	96
Barley	*Interior*	4
Barley	*KZN*	0
Maize White	*Cape*	0
Maize White	*Interior*	98
Maize White	*KZN*	2
Maize Yellow	*Cape*	1
Maize yellow	*Interior*	94
Maize Yellow	*KZN*	5
Oats	*Cape*	66
Oats	*Interior*	34
Oats	*KZN*	0
Sorghum	*Cape*	0
Sorghum	*Interior*	100
Sorghum	*KZN*	0
Tritcale	*Cape*	100
Tritcale	*Interior*	0
Tritcale	*KZN*	0
Wheat	*Cape*	35
Wheat	*Interior*	64
Wheat	*KZN*	1
Lupins		
Lupins	*Cape*	100
Lupins	*Interior*	0
Lupins	*KZN*	0
Oilcake		
Canola Oilcake	*Cape*	100
Canola Oilcake	*Interior*	0
Canola Oilcake	*KZN*	0
Cotton Oilcake	*Cape*	0
Cotton Oilcake	*Interior*	100
Cotton Oilcake	*KZN*	0
Groundnut	*Cape*	100
Groundnut	*Interior*	0
Groundnut	*KZN*	0
Soya hi pro Oilcake	*Cape*	0
Soya hi pro Oilcake	*Interior*	100
Soya hi pro Oilcake	*KZN*	0

Soya lo pro	*Cape*	0
Soya lo pro	*Interior*	100
Soya lo pro	*KZN*	0
Soya med pro	*Cape*	0
Soya med pro	*Interior*	100
Soya med pro	*KZN*	0
Sunflower hi pro Oilcake	*Cape*	0
Sunflower hi pro Oilcake	*Interior*	70
Sunflower hi pro Oilcake	*KZN*	30
Sunflower lo pro oilcake	*Cape*	0
Sunflower lo pro oilcake	*Interior*	70
Sunflower lo pro oilcake	*KZN*	30
Sunflower med pro Oilcake	*Cape*	0
Sunflower med pro Oilcake	*Interior*	70
Sunflower med pro Oilcake	*KZN*	30
Other		
Lucerne	*Cape*	0
Lucerne	*Interior*	100
Lucerne	*KZN*	0
Milk Replacers	*Cape*	0
Milk Replacers	*Interior*	100
Milk Replacers	*KZN*	0
Roughage	*Cape*	0
Roughage	*Interior*	0
Roughage	*KZN*	0
Rendering		
Blood meal	*Cape*	32
Blood meal	*Interior*	53
Blood meal	*KZN*	15
Feather meal	*Cape*	32
Feather meal	*Interior*	53
Feather meal	*KZN*	15
Meat-bone meal	*Cape*	32
Meat-bone meal	*Interior*	53
Meat-bone meal	*KZN*	15
Poultry Byprod	*Cape*	32
Poultry Byprod	*Interior*	53
Poultry Byprod	*KZN*	15
RM Prices	**Region**	**R/ton**
Byprod Industry		
Acid oil	*Cape*	6700
Acid oil	*Interior*	6700
Acid oil	*KZN*	6700
CMS Molasses	*Cape*	1900
CMS Molasses	*Interior*	1900

CMS Molasses	*KZN*	1900
Molasses	*Cape*	1900
Molasses	*Interior*	1900
Molasses	*KZN*	1900
Byprod Milling		
Maize Germ	*Cape*	Unlimited
Maize Germ	*Interior*	1000
Maize Germ	*KZN*	Unlimited
Wheat Middlings	*Cape*	1800
Wheat Middlings	*Interior*	1800
Wheat Middlings	*KZN*	1800
Byprod Wet Mill		
Maize FF	*Cape*	Unlimited
Maize FF	*Interior*	Unlimited
Maize FF	*KZN*	Unlimited
Maize Gluten 20	*Cape*	880
Maize Gluten 20	*Interior*	880
Maize Gluten 20	*KZN*	880
Maize Gluten 60	*Cape*	3000
Maize Gluten 60	*Interior*	3000
Maize Gluten 60	*KZN*	3000
Fish Meal		
Fish Meal hi pro	*Cape*	6200
Fish Meal hi pro	*Interior*	6200
Fish Meal hi pro	*KZN*	6200
Fish Meal lo pro	*Cape*	6200
Fish Meal lo pro	*Interior*	6200
Fish Meal lo pro	*KZN*	6200
Full-fat		
Full-fat Canola	*Cape*	2900
Full-fat Canola	*Interior*	Unlimited
Full-fat Canola	*KZN*	Unlimited
Full-fat Cotton	*Cape*	Unlimited
Full-fat Cotton	*Interior*	1800
Full-fat Cotton	*KZN*	1800
Full-fat Soya	*Cape*	2275
Full-fat Soya	*Interior*	2275
Full-fat Soya	*KZN*	2275
Grain		
Barley	*Cape*	1650
Barley	*Interior*	1650
Barley	*KZN*	1650
Maize White	*Cape*	Unlimited
Maize White	*Interior*	1289
Maize White	*KZN*	1289
Maize Yellow	*Cape*	Unlimited

Maize yellow	*Interior*	1260.97
Maize Yellow	*KZN*	1260.97
Oats	*Cape*	1400
Oats	*Interior*	1400
Oats	*KZN*	1400
Sorghum	*Cape*	Unlimited
Sorghum	*Interior*	1000
Sorghum	*KZN*	1350
Tritcale	*Cape*	Unlimited
Tritcale	*Interior*	Unlimited
Tritcale	*KZN*	Unlimited
Wheat	*Cape*	Unlimited
Wheat	*Interior*	Unlimited
Wheat	*KZN*	Unlimited
Lupins		
Lupins	*Cape*	1500
Lupins	*Interior*	Unlimited
Lupins	*KZN*	Unlimited
Oilcake		
Canola Oilcake	*Cape*	1340
Canola Oilcake	*Interior*	Unlimited
Canola Oilcake	*KZN*	Unlimited
Cotton Oilcake	*Cape*	1600
Cotton Oilcake	*Interior*	1600
Cotton Oilcake	*KZN*	1600
Groundnut	*Cape*	Unlimited
Groundnut	*Interior*	Unlimited
Groundnut	*KZN*	Unlimited
Soya hi pro Oilcake	*Cape*	Unlimited
Soya hi pro Oilcake	*Interior*	2080
Soya hi pro Oilcake	*KZN*	Unlimited
Soya lo pro	*Cape*	Unlimited
Soya lo pro	*Interior*	Unlimited
Soya lo pro	*KZN*	Unlimited
Soya med pro	*Cape*	Unlimited
Soya med pro	*Interior*	Unlimited
Soya med pro	*KZN*	Unlimited
Sunflower hi pro Oilcake	*Cape*	Unlimited
Sunflower hi pro Oilcake	*Interior*	1350
Sunflower hi pro Oilcake	*KZN*	1350
Sunflower lo pro Oilcake	*Cape*	Unlimited
Sunflower lo pro Oilcake	*Interior*	Unlimited
Sunflower lo pro Oilcake	*KZN*	Unlimited
Sunflower med pro Oilcake	*Cape*	Unlimited
Sunflower med pro Oilcake	*Interior*	Unlimited

Sunflower med pro Oilcake	*KZN*	Unlimited
Other		
Lucerne	*Cape*	1500
Lucerne	*Interior*	1500
Lucerne	*KZN*	1500
Milk Replacers	*Cape*	6000
Milk Replacers	*Interior*	6000
Milk Replacers	*KZN*	6000
Roughage	*Cape*	2000
Roughage	*Interior*	2000
Roughage	*KZN*	2000
Rendering		
Blood meal	*Cape*	3000
Blood meal	*Interior*	3000
Blood meal	*KZN*	3000
Feather meal	*Cape*	3000
Feather meal	*Interior*	3000
Feather meal	*KZN*	3000
Meat-bone meal	*Cape*	2400
Meat-bone meal	*Interior*	2400
Meat-bone meal	*KZN*	2400
Poultry Byprod	*Cape*	3200
Poultry Byprod	*Interior*	3200
Poultry Byprod	*KZN*	3200
RM Price Factors	***Factor***	**Actual**
Full-fat		
Soya	*Soybean Price (R/Ton)*	1200
Soya	*Storage Fee*	20
Soya	*Handling Fee*	10
Soya	*Processing Fee*	140
Soya	*% Loss*	6
Grain		
Maize White	*SAFEX*	880
Maize White	*Transport allowance (Randfontein)*	45
Maize Yellow	*SAFEX*	820
Maize Yellow	*Transport allowance (Randfontein)*	45
Oilcake		
Soya hi pro	*Soybean Price*	1200
Soya hi pro	*Storage Fee*	30
Soya hi pro	*Interest %*	18
Soya hi pro	*Interest Period (months)*	6
Soya hi pro	*Oil Price*	3500
Soya hi pro	*% Oil produced*	18

Soya hi pro	*Crushing Margin*	150
Soya hi pro	*% Loss*	2
Soya hi pro	*Meal Price % of Oilcake price*	82
Soya hi pro	*% of Hi pro Cost*	100
Soya lo pro	*Soybean Price*	1200
Soya lo pro	*Storage Fee*	30
Soya lo pro	*Interest %*	18
Soya lo pro	*Interest Period (months)*	6
Soya lo pro	*Oil Price*	3500
Soya lo pro	*% Oil produced*	18
Soya lo pro	*Crushing Margin*	150
Soya lo pro	*% Loss*	2
Soya lo pro	*Meal Price % of Oilcake price*	82
Soya lo pro	*% of Hi pro Cost*	0
Soya med pro	*Soybean Price*	1200
Soya med pro	*Storage Fee*	30
Soya med pro	*Interest %*	18
Soya med pro	*Interest Period (months)*	6
Soya med pro	*Oil Price*	3500
Soya med pro	*% Oil produced*	18
Soya med pro	*Crushing Margin*	150
Soya med pro	*% Loss*	2
Soya med pro	*Meal Price % of Oilcake price*	82
Soya med pro	*% of Hi pro Cost*	0
Sunflower hi pro	*Soybean Price*	1300
Sunflower hi pro	*Storage Fee*	30
Sunflower hi pro	*Interest %*	18
Sunflower hi pro	*Interest Period (months)*	6
Sunflower hi pro	*Oil Price*	3500
Sunflower hi pro	*% Oil produced*	41
Sunflower hi pro	*Crushing Margin*	150
Sunflower hi pro	*% Loss*	17
Sunflower hi pro	*Meal Price % of Oilcake price*	82
Sunflower hi pro	*% of Hi pro Cost*	100
Sunflower lo pro	*Soybean Price*	1300
Sunflower lo pro	*Storage Fee*	30
Sunflower lo pro	*Interest %*	18
Sunflower lo pro	*Interest Period (months)*	6
Sunflower lo pro	*Oil Price*	3500
Sunflower lo pro	*% Oil produced*	41
Sunflower lo pro	*Crushing Margin*	150
Sunflower lo pro	*% Loss*	17
Sunflower lo pro	*Meal Price % of Oilcake price*	82
Sunflower lo pro	*% of Hi pro Cost*	76
Sunflower med pro	*Soybean Price*	1300
Sunflower med pro	*Storage Fee*	30

Sunflower med pro	*Interest %*	18
Sunflower med pro	*Interest Period (months)*	6
Sunflower med pro	*Oil Price*	3500
Sunflower med pro	*% Oil produced*	41
Sunflower med pro	*Crushing Margin*	150
Sunflower med pro	*% Loss*	17
Sunflower med pro	*Meal Price % of Oilcake price*	82
Sunflower med pro	*% of Hi pro Cost*	88
RM Availability	***Region***	**Ton**
Byprod Industry		
Acid oil	*Cape*	Unlimited
Acid oil	*Interior*	Unlimited
Acid oil	*KZN*	Unlimited
CMS Molasses	*Cape*	0
CMS Molasses	*Interior*	8500
CMS Molasses	*KZN*	8500
Molasses	*Cape*	0
Molasses	*Interior*	Unlimited
Molasses	*KZN*	258400
Byprod Milling		
Maize Germ	*Cape*	22890
Maize Germ	*Interior*	610400
Maize Germ	*KZN*	129710
Wheat Middlings	*Cape*	Unlimited
Wheat Middlings	*Interior*	Unlimited
Wheat Middlings	*KZN*	Unlimited
Byprod Wet Mill		
Maize FF	*Cape*	0
Maize FF	*Interior*	0
Maize FF	*KZN*	0
Maize Gluten 20	*Cape*	11935
Maize Gluten 20	*Interior*	96565
Maize Gluten 20	*KZN*	0
Maize Gluten 60	*Cape*	2864.4
Maize Gluten 60	*Interior*	23175.6
Maize Gluten 60	*KZN*	0
Fish Meal		
Fish Meal hi pro	*Cape*	50000
Fish Meal hi pro	*Interior*	0
Fish Meal hi pro	*KZN*	0
Fish Meal lo pro	*Cape*	0
Fish Meal lo pro	*Interior*	0
Fish Meal lo pro	*KZN*	0

Full-fat		
Full-fat Canola	*Cape*	2000
Full-fat Canola	*Interior*	0
Full-fat Canola	*KZN*	0
Full-fat Cotton	*Cape*	0
Full-fat Cotton	*Interior*	35000
Full-fat Cotton	*KZN*	115000
Full-fat Soya	*Cape*	-1
Full-fat Soya	*Interior*	160000
Full-fat Soya	*KZN*	90000
Grain		
Barley	*Cape*	15200
Barley	*Interior*	0
Barley	*KZN*	0
Maize White	*Cape*	Unlimited
Maize White	*Interior*	Unlimited
Maize White	*KZN*	Unlimited
Maize Yellow	*Cape*	Unlimited
Maize yellow	*Interior*	Unlimited
Maize Yellow	*KZN*	Unlimited
Oats	*Cape*	8000
Oats	*Interior*	0
Oats	*KZN*	0
Sorghum	*Cape*	0
Sorghum	*Interior*	7000
Sorghum	*KZN*	0
Tritcale	*Cape*	7000
Tritcale	*Interior*	0
Tritcale	*KZN*	0
Wheat	*Cape*	0
Wheat	*Interior*	0
Wheat	*KZN*	0
Lupins		
Lupins	*Cape*	14400
Lupins	*Interior*	0
Lupins	*KZN*	0
Oilcake		
Canola Oilcake	*Cape*	19000
Canola Oilcake	*Interior*	0
Canola Oilcake	*KZN*	0
Cotton Oilcake	*Cape*	10000
Cotton Oilcake	*Interior*	32500
Cotton Oilcake	*KZN*	90000
Groundnut	*Cape*	0
Groundnut	*Interior*	0

Groundnut	*KZN*	0
Soya hi pro Oilcake	*Cape*	0
Soya hi pro Oilcake	*Interior*	155000
Soya hi pro Oilcake	*KZN*	0
Soya lo pro	*Cape*	0
Soya lo pro	*Interior*	0
Soya lo pro	*KZN*	0
Soya med pro	*Cape*	0
Soya med pro	*Interior*	0
Soya med pro	*KZN*	0
Sunflower hi pro Oilcake	*Cape*	0
Sunflower hi pro Oilcake	*Interior*	170000
Sunflower hi pro Oilcake	*KZN*	30000
Sunflower lo pro Oilcake	*Cape*	0
Sunflower lo pro Oilcake	*Interior*	0
Sunflower lo pro Oilcake	*KZN*	0
Sunflower med pro Oilcake	*Cape*	0
Sunflower med pro Oilcake	*Interior*	0
Sunflower med pro Oilcake	*KZN*	0
Other		
Lucerne	*Cape*	400000
Lucerne	*Interior*	0
Lucerne	*KZN*	0
Milk Replacers	*Cape*	Unlimited
Milk Replacers	*Interior*	Unlimited
Milk Replacers	*KZN*	Unlimited
Roughage	*Cape*	Unlimited
Roughage	*Interior*	Unlimited
Roughage	*KZN*	Unlimited
Rendering		
Blood meal	*Cape*	1301
Blood meal	*Interior*	2156
Blood meal	*KZN*	610
Feather meal	*Cape*	7550
Feather meal	*Interior*	12505
Feather meal	*KZN*	3539.2
Meat-bone meal	*Cape*	5207
Meat-bone meal	*Interior*	714
Meat-bone meal	*KZN*	2440
Poultry Byprod	*Cape*	30200
Poultry Byprod	*Interior*	50020
Poultry Byprod	*KZN*	14156

RM Availability Factors	*Factor*	Actual
Byprod Industry		
Acid oil	*Total Oil Refined per Annum*	500000
Acid oil	*% Recovered as Acid Oil*	2
Acid oil	*Amount Used by Other Industries*	1500
Acid oil	*Fatty Acids from Other Industries*	28500
CMS Molasses	*Molasses to Alchohol Industry*	340000
CMS Molasses	*% Recovered as CMS*	5
Molasses	*Total Sugar Refined per Annum*	2200000
Molasses	*% Recovered as Molasses*	34
Molasses	*Molasses Exports*	15000
Molasses	*Molasses to Various Industries*	70000
Molasses	*Molasses to Alchohol Industry*	340000
Byprod Milling		
Maize Germ	*Maize Milled*	3632000
Maize Germ	*% Germ Byproduct*	20
Wheat Middlings	*Wheat Milled*	2472200
Wheat Middlings	*% Middlings Byproduct*	20
Byprod Wet Mill		
Maize FF	*Wet Maize Milled*	620000
Maize FF	*% FF Byproduct*	6
Maize Gluten 20	*Wet Maize Milled*	620000
Maize Gluten 20	*% Gluten 20 Byproduct*	17.5
Maize Gluten 60	*Wet Maize Milled*	620000
Maize Gluten 60	*% Gluten 60 Byproduct*	4.2
Fish Meal		
Fish Meal hi pro	*Predicted Catches per Annum*	400000
Fish Meal hi pro	*% Converted to Fish meal*	20
Fish Meal lo pro	*Predicted Catches per Annum*	0
Fish Meal lo pro	*% Converted to Fish meal*	20
Full-fat		
Full-fat Canola	*Full-fat Amount*	19000
Full-fat Canola	*% Yield*	100
Full-fat Cotton	*Full-fat Amount*	10000
Full-fat Cotton	*% Yield*	90
Full-fat Soya	*Full-fat Amount*	60000
Full-fat Soya	*% Yield*	94
Grain		
Barley	*Hectares Planted*	215100
Barley	*Yield per Hectare*	2
Barley	*Export*	0
Barley	*Carry In*	0
Barley	*Carry Out*	0
Barley	*Malting*	500000
Maize White	*Hectares Planted*	1772200

Maize White	*Yield per Hectare*	2.4
Maize White	*Export*	300269
Maize White	*Carry In*	76108
Maize White	*Carry Out*	76108
Maize White	*Milling*	3632000
Maize Yellow	*Hectares Planted*	1039000
Maize Yellow	*Yield per Hectare*	2.2
Maize Yellow	*Export*	300000
Maize Yellow	*Carry In*	1500000
Maize Yellow	*Carry Out*	250000
Maize Yellow	*Milling*	0
Oats	*Hectares Planted*	30000
Oats	*Yield per Hectare*	1
Oats	*Export*	0
Oats	*Carry In*	0
Oats	*Carry Out*	0
Oats	*Human Consumption*	0
Sorghum	*Hectares Planted*	37200
Sorghum	*Yield per Hectare*	2
Sorghum	*Export*	0
Sorghum	*Carry In*	0
Sorghum	*Carry Out*	0
Sorghum	*Human Consumption*	20000
Sorghum	*Milling or Malting*	20000
Tritcale	*Hectares Planted*	56000
Tritcale	*Yield per Hectare*	2
Tritcale	*Export*	0
Tritcale	*Carry In*	0
Tritcale	*Carry Out*	0
Wheat	*Hectares Planted*	2283500
Wheat	*Yield per Hectare*	1
Wheat	*Export*	0
Wheat	*Carry In*	0
Wheat	*Carry Out*	0
Wheat	*Milling*	2283500
Lupins		
Lupins	*Hectares Planted*	31000
Lupins	*Yield per Hectare*	1.2
Lupins	*Export*	0
Lupins	*Carry In*	0
Lupins	*Carry Out*	0
Lupins	*% Yield*	100
Oilcake		
Canola Oilcake	*Hectares Planted*	31000
Canola Oilcake	*Yield per Hectare*	1.2
Canola Oilcake	*Import (for Local Crushing)*	0

Canola Oilcake	*Export*	0
Canola Oilcake	*Carry In*	0
Canola Oilcake	*Carry Out*	0
Canola Oilcake	*Full-fat Amount*	19000
Canola Oilcake	*% Oilcake Yield*	53.5
Cotton Oilcake	*Hectares Planted*	59000
Cotton Oilcake	*Yield per Hectare*	1.2
Cotton Oilcake	*Import (for Local Crushing)*	0
Cotton Oilcake	*Export*	0
Cotton Oilcake	*Carry In*	0
Cotton Oilcake	*Carry Out*	0
Cotton Oilcake	*Full-fat Amount*	10000
Cotton Oilcake	*% Oilcake Yield*	53.5
Groundnut	*Hectares Planted*	65000
Groundnut	*Yield per Hectare*	1.4
Groundnut	*Import (for Local Crushing)*	0
Groundnut	*Export*	0
Groundnut	*Carry In*	0
Groundnut	*Carry Out*	0
Groundnut	*Full-fat Amount*	91000
Groundnut	*% Oilcake Yield*	53.5
Soya hi pro Oilcake	*Hectares Planted*	0
Soya hi pro Oilcake	*Yield per Hectare*	1.4
Soya hi pro Oilcake	*Import (for Local Crushing)*	0
Soya hi pro Oilcake	*Export*	0
Soya hi pro Oilcake	*Carry In*	0
Soya hi pro Oilcake	*Carry Out*	0
Soya hi pro Oilcake	*Human Consumption*	0
Soya hi pro Oilcake	*Ful-fFat*	0
Soya hi pro Oilcake	*% Oilcake Yield*	80
Soya lo pro	*Hectares Planted*	132000
Soya lo pro	*Yield per Hectare*	1.4
Soya lo pro	*Import (for Local Crushing)*	0
Soya lo pro	*Export*	10000
Soya lo pro	*Carry In*	0
Soya lo pro	*Carry Out*	0
Soya lo pro	*Human Consumption*	20000
Soya lo pro	*Full-fat*	60000
Soya lo pro	*% Oilcake Yield*	80
Soya med pro	*Hectares Planted*	132000
Soya med pro	*Yield per Hectare*	1.4
Soya med pro	*Import (for Local Crushing)*	0
Soya med pro	*Export*	0
Soya med pro	*Carry In*	0
Soya med pro	*Carry Out*	0
Soya med pro	*Human Consumption*	0

Soya med pro	*Full-fat*	0
Soya med pro	*% Oilcake Yield*	80
Sunflower hi pro Oilcake	*Hectares Planted*	754000
Sunflower hi pro Oilcake	*Yield per Hectare*	1.1
Sunflower hi pro Oilcake	*Import (for Local Crushing)*	0
Sunflower hi pro Oilcake	*Export*	0
Sunflower hi pro Oilcake	*Carry In*	0
Sunflower hi pro Oilcake	*Carry Out*	0
Sunflower hi pro Oilcake	*% Oilcake Yield*	42
Sunflower lo pro Oilcake	*Hectares Planted*	0
Sunflower lo pro Oilcake	*Yield per Hectare*	1.1
Sunflower lo pro Oilcake	*Import (for Local Crushing)*	0
Sunflower lo pro Oilcake	*Export*	0
Sunflower lo pro Oilcake	*Carry In*	0
Sunflower lo pro Oilcake	*Carry Out*	0
Sunflower lo pro Oilcake	*% Oilcake Yield*	42
Sunflower med pro Oilcake	*Hectares Planted*	0
Sunflower med pro Oilcake	*Yield per Hectare*	1.1
Sunflower med pro Oilcake	*Import (for Local Crushing)*	0
Sunflower med pro Oilcake	*Export*	0
Sunflower med pro Oilcake	*Carry In*	0
Sunflower med pro Oilcake	*Carry Out*	0
Sunflower med pro Oilcake	*% Oilcake Yield*	42
Rendering		
Blood meal	*Animals Slaughtered*	3000000
Blood meal	*Average Weight (kgs)*	60
Blood meal	*% Blood Meal Yield*	2
Feather meal	*Poultry Slaughtered*	30000000
Feather meal	*Average Weight (kgs)*	1.8
Feather meal	*% Feather Meal Yield*	2
Meat-bone meal	*Animals Slaughtered*	3000000
Meat-bone meal	*Average Weight (kgs)*	60
Meat-bone meal	*% Meat-Bone Meal Yield*	8
Poultry Byprod	*Poultry Slaughtered*	30000000
Poultry Byprod	*Average Weight (kgs)*	1.8
Poultry Byprod	*% Byproduct Yield*	8
Imported RM prices	***Country***	**R/ton**
Fish meal		
Hi pro	*Chile*	Unlimited
Hi pro	*Peru*	Unlimited
Lo pro	*Chile*	Unlimited
Lo pro	*Peru*	Unlimited
Grain		
Maize White	*USA*	Unlimited
Maize Yellow	*Argentina*	1338

Maize Yellow	*USA*	Unlimited
Oilcake		
Soya hi pro	*Argentina*	1948
Soya hi pro	*Brazil*	Unlimited
Soya hi pro	*USA*	Unlimited
Soya lo pro	*Argentina*	Unlimited
Soya med pro	*Argentina*	Unlimited
Sunflower hi pro	*Argentina*	1450
Sunflower lo pro	*Argentina*	Unlimited
Sunflower med pro	*Argentina*	Unlimited
Imported RM Price Factors	***Country***	Actual
Fish meal		
Hi pro	*Chile* ***(CIF Hamburg (US$/Ton))***	600
Hi pro	*Chile* ***(Less Freight to Hamburg (US$)***	40
Hi pro	*Chile* ***(Bagging Cost (US$))***	20
Hi pro	*Chile* ***(Premiums Hamburg (US$))***	-10
Hi pro	*Chile* ***(Freight (US$))***	58
Hi pro	*Chile* ***(Wharfage Fee %)***	1.78
Hi pro	*Chile* ***(Landing (R))***	53.33
Hi pro	*Chile* ***(Import Duty %)***	0
Hi pro	*Chile* ***(Insurance/Margin/Financing (R))***	30
Hi pro	*Chile* ***(Handling Cost (R))***	35
Hi pro	*Chile* ***(Storage Cost (R))***	0
Hi pro	*Peru* ***(CIF Hamburg (US$/Ton))***	600
Hi pro	*Peru* ***(Less Freight to Hamburg (US$)***	40
Hi pro	*Peru* ***(Bagging Cost (US$))***	20
Hi pro	*Peru* ***(Premiums Hamburg (US$))***	-10
Hi pro	*Peru* ***(Freight (US$))***	58
Hi pro	*Peru* ***(Wharfage Fee %)***	1.78
Hi pro	*Peru* ***(Landing (R))***	53.33
Hi pro	*Peru* ***(Import Duty %)***	0
Hi pro	*Peru* ***(Insurance/Margin/Financing (R))***	30
Hi pro	*Peru* ***(Handling Cost (R))***	35
Hi pro	*Peru* ***(Storage Cost (R))***	0
Lo pro	*Chile* ***(CIF Hamburg (US$/Ton))***	600
Lo pro	*Chile* ***(Less Freight to Hamburg (US$)***	40
Lo pro	*Chile* ***(Bagging Cost (US$))***	20
Lo pro	*Chile* ***(Premiums Hamburg (US$))***	-10
Lo pro	*Chile* ***(Freight (US$))***	58
Lo pro	*Chile* ***(Wharfage Fee %)***	1.78
Lo pro	*Chile* ***(Landing (R))***	53.33
Lo pro	*Chile* ***(Import Duty %)***	0
Lo pro	*Chile* ***(Insurance/Margin/Financing (R))***	30
Lo pro	*Chile* ***(Handling Cost (R))***	35
Lo pro	*Chile* ***(Storage Cost (R))***	0

Lo pro	*Chile* ***(% of HiPro Cost)***	94
Lo pro	*Chile* ***(CIF Hamburg (US$/Ton))***	600
Lo pro	*Chile* ***(Less Freight to Hamburg (US$)***	40
Lo pro	*Chile* ***(Bagging Cost (US$))***	20
Lo pro	*Chile* ***(Premiums Hamburg (US$))***	-10
Lo pro	*Chile* ***(Freight (US$))***	58
Lo pro	*Chile* ***(Wharfage Fee %)***	1.78
Lo pro	*Chile* ***(Landing (R))***	53.33
Lo pro	*Chile* ***(Import Duty %)***	0
Lo pro	*Chile* ***(Insurance/Margin/Financing (R))***	30
Lo pro	*Chile* ***(Handling Cost (R))***	35
Lo pro	*Chile* ***(Storage Cost (R))***	0
Lo pro	*Chile* ***(% of Hi Pro Cost)***	94
Grain		
Maize White	*USA* ***(CBOT (US cents/bushel))***	2.27
Maize White	*USA* ***(Bushel to Tons Conversion Factor)***	29.37
Maize White	*USA* ***(Cost to Gulf (US$))***	9
Maize White	*USA* ***(Freight (US$))***	23
Maize White	*USA* ***(Wharfage Fee %)***	1.78
Maize White	*USA* ***(Landing (R))***	48.66
Maize White	*USA* ***(Import Duty (R/Ton))***	84
Maize White	*USA* ***(Insurance/Margin/Financing (R))***	20
Maize White	*USA* ***(Handling Cost (R))***	30
Maize White	*USA* ***(Storage Cost (R))***	10
Maize Yellow	*Argentina* ***(CBOT (US cents/bushel))***	2.27
Maize Yellow	*Argentina* ***(Bushel to Tons Conversion Factor)***	39.37
Maize Yellow	*Argentina* ***(Cost to Gulf (US$))***	9
Maize Yellow	*Argentina* ***(Freight (US$))***	17
Maize Yellow	*Argentina* ***(Wharfage Fee %)***	1.78
Maize Yellow	*Argentina* ***(Landing (R))***	48.66
Maize Yellow	*Argentina* ***(Import Duty (R/Ton))***	84
Maize Yellow	*Argentina* ***(Insurance/Margin/Financing (R))***	20
Maize Yellow	*Argentina* ***(Handling Cost (R))***	30
Maize Yellow	*Argentina* ***(Storage Cost (R))***	10
Maize Yellow	*USA* ***(CBOT (US cents/bushel))***	2.27
Maize Yellow	*USA* ***(Bushel to Tons Conversion Factor)***	39.37
Maize Yellow	*USA* ***(Cost to Gulf (US$))***	9
Maize Yellow	*USA* ***(Freight (US$))***	23
Maize Yellow	*USA* ***(Wharfage Fee %)***	1.78
Maize Yellow	*USA* ***(Landing (R))***	48.66
Maize Yellow	*USA* ***(Import Duty (R/Ton))***	84
Maize Yellow	*USA* ***(Insurance/Margin/Financing (R))***	20
Maize Yellow	*USA* ***(Handling Cost (R))***	30
Maize Yellow	*USA* ***(Storage Cost (R))***	10

Oilcake		
Soya hi pro	*Argentina* ***(CBOT)***	130
Soya hi pro	*Argentina* ***(Tons Conversion Factor)***	1.1
Soya hi pro	*Argentina* ***(Premiums Argentina (US$))***	-10
Soya hi pro	*Argentina* ***(Freight (US$)***	23
Soya hi pro	*Argentina* ***(Wharfage Fee %)***	1.78
Soya hi pro	*Argentina* ***(Landing (R))***	48.66
Soya hi pro	*Argentina* ***(Import Duty %)***	6.6
Soya hi pro	*Argentina* ***(Insurance/Margin/Financing (R))***	120
Soya hi pro	*Argentina* ***(Handling Cost (R))***	0
Soya hi pro	*Argentina* ***(Storage Cost (R))***	0
Soya hi pro	*Brazil* ***(CBOT)***	130
Soya hi pro	*Brazil* ***(Tons Conversion Factor)***	1.1
Soya hi pro	*Brazil* ***(Premiums Argentina (US$))***	-10
Soya hi pro	*Brazil* ***(Freight (US$)***	23
Soya hi pro	*Brazil* ***(Wharfage Fee %)***	1.78
Soya hi pro	*Brazil* ***(Landing (R))***	48.66
Soya hi pro	*Brazil* ***(Import Duty %)***	6.6
Soya hi pro	*Brazil* ***(Insurance/Margin/Financing (R))***	120
Soya hi pro	*Brazil* ***(Handling Cost (R))***	0
Soya hi pro	*Brazil* ***(Storage Cost (R))***	0
Soya hi pro	*USA* ***(CBOT)***	130
Soya hi pro	*USA* ***(Tons Conversion Factor)***	1.1
Soya hi pro	*USA* ***(Premiums Argentina (US$))***	-10
Soya hi pro	*USA* ***(Freight (US$)***	23
Soya hi pro	*USA* ***(Wharfage Fee %)***	1.78
Soya hi pro	*USA* ***(Landing (R))***	48.66
Soya hi pro	*USA* ***(Import Duty %)***	6.6
Soya hi pro	*USA* ***(Insurance/Margin/Financing (R))***	120
Soya hi pro	*USA* ***(Handling Cost (R))***	0
Soya hi pro	*USA* ***(Storage Cost (R))***	0
Soya lo pro	*Argentina* ***(CBOT)***	130
Soya lo pro	*Argentina* ***(Tons Conversion Factor)***	1.1
Soya lo pro	*Argentina* ***(Premiums Argentina (US$))***	-10
Soya lo pro	*Argentina* ***(Freight (US$)***	23
Soya lo pro	*Argentina* ***(Wharfage Fee %)***	1.78
Soya lo pro	*Argentina* ***(Landing (R))***	48.66
Soya lo pro	*Argentina* ***(Import Duty %)***	6.6
Soya lo pro	*Argentina* ***(Insurance/Margin/Financing (R))***	120
Soya lo pro	*Argentina* ***(Handling Cost (R))***	0
Soya lo pro	*Argentina* ***(Storage Cost (R))***	0
Soya med pro	*Argentina* ***(CBOT)***	130
Soya med pro	*Argentina* ***(Tons Conversion Factor)***	1.1
Soya med pro	*Argentina* ***(Premiums Argentina (US$))***	-10
Soya med pro	*Argentina* ***(Freight (US$)***	23

Soya med pro	*Argentina **(Wharfage Fee %)***	1.78
Soya med pro	*Argentina **(Landing (R))***	48.66
Soya med pro	*Argentina **(Import Duty %)***	6.6
Soya med pro	*Argentina **(Insurance/Margin/Financing (R))***	120
Soya med pro	*Argentina **(Handling Cost (R))***	0
Soya med pro	*Argentina **(Storage Cost (R))***	0
Sunflower hi pro	*Argentina **(FOB)***	80
Sunflower hi pro	*Argentina **(Freight (US$))***	23
Sunflower hi pro	*Argentina **(Wharfage Fee %)***	1.78
Sunflower hi pro	*Argentina **(Landing (R))***	48.66
Sunflower hi pro	*Argentina (**Import Duty %)***	6.6
Sunflower hi pro	*Argentina **(Insurance/Margin/Financing (R))***	120
Sunflower hi pro	*Argentina **(Handling Cost (R))***	0
Sunflower hi pro	*Argentina **(Storage Cost (R))***	0
Sunflower low pro	*Argentina **(FOB)***	80
Sunflower low pro	*Argentina **(Freight (US$))***	23
Sunflower low pro	*Argentina **(Wharfage Fee %)***	1.78
Sunflower low pro	*Argentina **(Landing (R))***	48.66
Sunflower low pro	*Argentina (**Import Duty %)***	6.6
Sunflower low pro	*Argentina **(Insurance/Margin/Financing (R))***	120
Sunflower low pro	*Argentina **(Handling Cost (R))***	0
Sunflower low pro	*Argentina **(Storage Cost (R))***	0
Soya med pro	*Argentina **(FOB)***	80
Soya med pro	*Argentina **(Freight (US$))***	23
Soya med pro	*Argentina **(Wharfage Fee %)***	1.78
Soya med pro	*Argentina **(Landing (R))***	48.66
Soya med pro	*Argentina (**Import Duty %)***	6.6
Soya med pro	*Argentina **(Insurance/Margin/Financing (R))***	120
Soya med pro	*Argentina **(Handling Cost (R))***	0
Soya med pro	*Argentina **(Storage Cost (R))***	0
Imported RM Availability	***Country***	**Ton**
Fish meal		
Hi pro	*Chile*	Unlimited
Hi pro	*Peru*	Unlimited
Lo pro	*Chile*	Unlimited
Lo pro	*Peru*	Unlimited
Grain		
Maize White	*USA*	Unlimited
Maize Yellow	*Argentina*	930000
Maize Yellow	*USA*	Unlimited
Oilcake		
Soya hi pro	*Argentina*	Unlimited

Soya hi pro	*Brazil*	Unlimited
Soya hi pro	*USA*	Unlimited
Soya lo pro	*Argentina*	0
Soya med pro	*Argentina*	0
Sunflower hi pro	*Argentina*	68000
Sunflower lo pro	*Argentina*	0
Sunflower med pro	*Argentina*	0
Basic RM prices		Price
Additives		
Carophyll R		85000
Carophyll Y		45000
Coccidiostats		20000
Marigold 20%		30000
Pronutrients		20000
Viamins/Minerals		30000
Amino acids		
Lysine		11000
Methionine		20000
Threonine		40000
Minerals		
Dicalcuim P		2900
Limestone		550
Monocalcium P		2750
Salt		400
NPN		
Ammonium CI		3000
Urea		2600
Basic RM availability		**Ton**
Additives		
Carophyll R		Unlimited
Carophyll Y		Unlimited
Coccidiostats		Unlimited
Marigold 20%		Unlimited
Pronutrients		Unlimited
Viamins/Minerals		Unlimited
Amino acids		
Lysine		Unlimited
Methionine		Unlimited
Threonine		Unlimited
Minerals		
Dicalcuim P		Unlimited
Limestone		Unlimited
Monocalcium P		Unlimited

Salt		Unlimited
NPN		
Ammonium CI		Unlimited
Urea		Unlimited
RM Transport cost	*Destination*	**R/ton**
Cape	*Cape*	160
Cape	*Interior*	610
Cape	*KZN*	775
Interior	*Cape*	610
Interior	*Interior*	160
Interior	*KZN*	310
KZN	*Cape*	775
KZN	*Interior*	310
KZN	*KZN*	160

Sources: AFMA (2007) and Briedenhann (2007)

Annexure C

Table C1: Niewoudt/Mc Guigan base data for different income groups

Income Elasticity in Base Year		0-12500	12501-50000	50001-100000	100001-300000	300001-500000	500001-750000	750 001+
Beef		1.08	0.27	0.96	0.42	0.24	0.08	0.45
Poultry		0.92	0.36	0.45	0.18	0.09	0.15	0.11
Pork		0.18	0.10	0.81	0.62	0.98	0.38	0.15
Mutton/Goat		1.28	0.02	1.26	0.93	0.59	0.03	0.44
Eggs		0.96	0.20	0.80	0.64	0.47	0.32	-0.06
Milk		0.57	0.40	0.48	0.16	0.09	0.05	0.30
Milk Powder		0.56	0.83	0.35	-0.02	0.03	0.27	0.58
Cheese		1.27	-0.20	3.70	1.79	0.91	0.46	0.30
Income Growth		*Annual growth %*						
Low		-0.8%	-0.8%	-0.6%	-0.4%	-0.2%	0%	0%
High		1.8%	1.9%	1.9%	1.8%	1.7%	2%	2%
Aids		-2%	-2%	-2%	-2%	-2%	-2%	-2%
Population Growth		*Total growth %*						
Year	**Source**							
2015	**BER 2003**	0.70%	0.72%	0.60%	0.36%	0.17%	0.09%	0.03%
Populasuion Actual Data								
2007		33650764	7105288	2980949	3024844	664769	275436	215503
Annual Per Capita Meat Expenditure in 2003		R/person/year						
Beef		16.36	700	1,763	2,535	4,583	7,023	9,157
Poultry		17.70	903	1,663	1,903	2,807	4,290	4,264
Pork		2.60	62	167	369	1,082	1,981	2,296
Mutton		7.60	189	602	1,260	2,535	4,130	5,233
Eggs		4.38	235	447	503	737	1,066	1,232
Milk		7.39	352	765	1,153	2,280	3,788	3,431
Import tarrifs								*Everyone*
Beef								40%
Poultry								27%
Pork								15%
Mutton								40%

Table C2: Niewoudt/Mc Guigan base data for different racial groups

Income Elasticity in Base Year	*Asian*	*Urban Black*	*Rural Black*	*Coloured*	*White*
Beef	0.65	1.04	1.33	0.7	0.34
Poultry	1.09	0.66	1.33	0.65	0.32
Pork	0.4	0	0.25	0.6	0.32
Mutton/Goat	1.65	1.3	1.52	0.65	0.23
Eggs	0.53	0.74	1.42	0.53	0.15
Milk	0.74	0.5	0.6	1.07	0.21
Milk Powder	0	0.88	0.4	0.57	-0.23
Cheese	0.65	2.03	0.65	1.38	0.46
Income Growth	***Annual growth %***				
Low	1.0%	0.0%	-2.0%	0.0%	0.0%
High	2.8%	2.8%	0.8%	2.8%	1.5%
Aids	-2%	-2%	-2%	-2%	-2%
Population Growth	***Total growth %***				
Year / **Source**					
2015 / **BER 2003**	0.30%	0.80%	0.86%	0.58%	-0.02%
Population					
2007	1168570	22274794	15221109	4068543	5184539
Per Capita Meat Expenditure in 2007	**R/person**				
Beef	300.63	299	69	315.58	952.35
Poultry	794.21	390	221	486.08	671.22
Pork	60.88	35	5	77.06	370.32
Mutton	1,068.72	102	21	456.49	722.61
Eggs	159.59	115	10	125.46	216.94
Milk	581.68	183	26	275.00	736.94
Import tarrifs					***Everyone***
Beef					40%
Poultry					27%
Pork					15%
Mutton					40%

Annexure D

Table D1: Raw material prices for different scenarios

RM Prices	1w	1wo	2w	1wo
	R/ton			
Byprod Industry				
Acid oil	9645	9649	11194	11196
CMS Molasses	815	814	1166	1169
Molasses	2508	2506	3588	3589
Byprod Milling				
Maize Germ	1352	1262	1934	1797
Wheat Middlings	2000	1980	2861	2760
Byprod Wet Mill				
DDGS	1609	0	1954	0
Maize Gluten 20	1162	1085	1662	1545
Maize Gluten 60	3960	3697	5665	5267
Fish Meal				
Fish Meal hi pro	6249	6249	8372	8372
Full-fat				
Full-fat Canola	3531	3533	5789	5791
Full-fat Cotton	1571	1571	1823	1970
Full-fat Soya	3254	2801	4984	4986
Grain				
Barley	2802	2802	4105	4105
Maize White	1707	1678	2390	2349
Maize Yellow	1690	1577	2417	2248
Oats	2174	2029	3109	2891
Sorghum	1489	1479	1912	1898
Wheat	3476	3476	4857	4857
Lupins				
Lupins	1980	1848	2832	2633
Oilcake				
Canola Oilcake	1874	1874	2175	2350
Cotton Oilcake	2237	2238	2596	2805
Soya hi pro Oilcake	3708	3708	4303	4650
Sunflower hi pro Oilcake	3056	3070	3346	3480
Other				
Lucerne	1980	1848	2832	2633
Milk Replacers	6000	5601	8583	7980
Roughage	2640	2464	3777	3511
Rendering				
Blood meal	4406	4408	5114	5123
Feather meal	4406	4408	5114	5123
Meat-bone meal	3355	3357	3894	3926
Poultry Byprod	4474	4476	5193	5264

Annexture E

PNS - BFAP – UFS

CONCEPT NOTES AND SCENARIO FROM MEETING HELD

Tuesday 10 July 2007 at 10:00
PNS Offices, Rivonia

Present:
Gerhard Scholtemeier - PNS
Munro Griessel - PNS
Deon Joubert - PNS
Erhard Briedenhann - PNS
Pieter Taljaard - UFS
Dirkie Strydom - UFS
PG Strauss - BFAP
Ferdi Meyer - BFAP

1. Objective

- To explore the possibilities of collaboration between PNS, BFAP and UFS with respect to the application of scenario planning and various modelling techniques.
- To development a "case study scenario" to analyse and illustrate SA's protein supply and requirements in the livestock industry over the next decade with the help of the BFAP and APR models.

2. General ideas

- The objective for the PNS is to understand and project what SA's protein supply and requirements in the livestock industry will be over the next 10 years and what will be the sources of protein at the various prices.
- The APR and BFAP modelling approaches are briefly explained by the modellers. The model used in this scenario is the Agricultural Products Requirement (APR) model developed by Briedenhann (2001). This model is a linear programming feed formulation model that minimises total cost of animal feed in South Africa given the availability of raw materials and

their corresponding prices. The demand for animal feeds is taken into account by the model, and the number of animals that need to be fed based on the nutrient requirements of those animals and their feed conversion ratios is determined. Imports and exports of raw materials are further determined by domestic availabilities of raw materials The BFAP model is dynamic econometric simulation model that takes changes in the macro economic environment into account and simulates for a dynamic equilibrium for a range of commodities over time.

- It is decided that the best way to compare the usefulness and shortcomings of the models is to develop a scenario that can be simulated within the models.
- The PNS also explains the demand projection model that was developed by Nieuwoudt, which has the capacity to project the demand for protein feed based on income, population and growth in per capita consumption of animal product. However, this model does not model the dynamic interaction between demand and supply and, therefore, does not simulate for an equilibrium price over time.

3. Way forward

- Based on the first meeting a *"Case Study Scenario"* will be developed by UFS and BFAP.
- PNS will review the critical drivers, uncertainties and scenario and will provide feedback to the modellers.
- The APR and BFAP models will be used to analyse and generate the scenario results.
- The modelling results will be compared to determine gaps and overlapping of the various approaches. The main goal of this exercise is to form a more complete picture and gain a better understanding of the possible future scenario taking both modelling results into consideration. UFS and BFAP do not intend for one model to replace the other, but rather to enrich the outcomes of the various approaches.
- UFS and BFAP will undertake this first exercise without any costs.
- PNS will review the usefulness of the results and decide on future collaboration.
- If the PNS finds this modelling and scenario planning exercise to add value to the industry, PNS will request UFS and BFAP to submit a proposed working plan and budget.
- It is envisaged by UFS and BFAP that if the PNS finds this exercise useful, a scenario planning session of this nature can be repeated on an annual base to review the protein market and update future scenarios.

4. Proposed time frame

- "Case study scenario" to be developed by UOVS and BFAP - middle of August.
- PNS reviews scenario, the critical drivers and uncertainties – end of August

- UFS and BFAP simulate case study scenario in the various models and compare results – end September
- First presentation of results to PNS – end of September

5. Case Study Scenario

The following drivers and uncertainties were listed by the meeting:

Drivers: A Driver is a factor or combination of factors of which the direction of change, magnitude of change, as well as the impact of change is quite predictable.

- Legislation
    - o The balance between government policies on job creation vs food inflation.
    - o DTI and NDA are the main government institutions that will determine government policy that affects agriculture.
    - o Import tariffs on all meats remain in place
    - o Land Reform will continue at a slow pace.
- Population
    - o The continuation of legal and illegal immigrants together with a small positive growth rate of the local population will cause population to grow constantly.
    - o The impact of HIV aids is smaller than anticipated due to the effective use of antiretroviral drugs.
- Urbanisation
    - o Urban areas are associated (expected) with a higher level of income and the maintaining of a better lifestyle due to an expected increase in level of disposable income. Disposable income plays an essential role in driving the food consumer to more value added goods
    - o The presents of urbanization is expected to be associated with the change in consumption from that of starchy staples to that of more value added goods especially with regards to animal goods.
    - o Urbanisation has a dampening effect on the growth of the population.
- Disposable income
    - o Slow pace of job creation will continue
    - o Expenditure patterns of black middle income vs “fat cats” can shift.
    - o New credit laws and higher interest rates will not negatively affect the consumption of basic food items, but rather luxury food items, the consumption of fast food and restaurants.
- Local profitability of the production of protein.

  - Maize and soya price ratio is critical.
  - Maize yields increase fast in contrast to soya bean yields, which remain fairly constant. Maize and soya bean yields will continue to following the trend over the past 5 years.
  - The oil fraction of soya beans remains constant.
  - The temporary rebate of the duty on soya beans for the extraction of soya bean oil to be used in the production of biodiesel will remain in place over the period of the scenario.
- Biofuels
  - Government commitment to meet Kyoto protocol
  - Biofuels are only “drop in the bucket” of global energy market, but have big impact on agricultural commodity markets
  - Biofuels in SA will not have the positive impact on the labour market, which government is hoping for.
  - Technical constraints of blending ethanol into petrol are not experienced when blending biodiesel into diesel.
- Oilseed market (Vegetable oils and cake)
  - World demand for oilseeds will continue to outstrip world supply for the next few years, drawing down on stocks and putting upward pressure on prices.
  - Structural shift in the local industry - the expansion of soya bean crushing facilities over the past few years will remain and as a consequence soya beans will trade closer to import parity levels than in the past.
- Crude oil market
  - Political instability in the middle east will keep on putting upward pressure on oil prices
  - Whereas the Chinese economy will grow, but at a decreasing rate, the Indian economy will grow at an increasing rate.
- Exchange rate (Macro economy)
  - Strong growth in local economy will support Rand and attract more foreign direct investment.
  - Gold prices remain high
  - US economy under pressure while Japan recovers,
  - EU economic recovery not as fast as hoped for.

Key Uncertainties: A key uncertainty is a factor or combination of factors of which the direction, magnitude and impact of change is totally unpredictable. Key uncertainties are factors or combinations of factors that can change the outcome of a process dramatically and significantly from what is generally expected or predicted.

- Biofuels
    - Government strategy on blending rates, tax incentives and subsidies, tariffs on imported biofuel and the price formulation of biofuel
    - SASOL plant of 600 000 tons soya beans to produce 400 000 tons of cake and 200 000 tons of oil.
    - Will all the feedstock for biofuels be sourced locally?
    - Will licensing for the production of biofuels be implemented?
- Legislation
    - Political instability of ANC vs SAKP/Cosatu
    - Social policies of a "Welfare State" – grants and food stamps that can increase the demand for protein
- Crude oil
    - The discovery of an alternative source for crude oil.

- Lack of electrical supply

- Macro economic shocks – USA, EU, China, Japan
    - Should a significant macro-economic shock occur in one of these countries such as a dramatic downturn in markets, world economic trends would change dramatically since world economy is already under pressure in light of current high energy prices and high interest rates. This could influence exchange rate, inflation and therefore interest rates in South Africa.

Scenario 1: (Period: 2007 – 2016)

Current general world economic trends continue over the next decade with the US and EU economies under pressure and India and China continuing to grow at a rapid pace, especially that of India. Oil prices remain high (approx. $80/barrel) due to refinery constraints, uncertainty surrounding the political situation in the Middle-East, supply problems with key oil suppliers like Iraq, Nigeria and Venezuela, as well as fuel shortages experienced in key fuel consumer countries like the USA due to fuel type changes. No significant alternative source of energy is discovered in the next decade and increases in oil prices fuel fears and uncertainty surrounding a possible downturn in the world economy due to expensive energy. This has an impact on the gold price in terms of investors buying gold due to the economic uncertainties. The increase in the gold price causes the Rand to be valued on average against the Dollar and the Euro around levels of R7/$ and R9.5/€ respectively. However, due to uncertainties in world markets with regards to energy prices and economic growth, the Rand remains highly volatile around the average exchange levels.

SA's economy continues to grow at a rate above 4% and inflation peak at 7.4 % in the first quarter of 2008. The election of the new president in 2009 cause no upset in the local economy and sound fiscal and monetary policies draw foreign direct investment. However, service delivery continues to be a problem putting more strain on the infrastructure. As a result, more electrical outages occur and transportation costs increase rapidly as rail and road fail to meet local demand for transport. The transformation of land into the hands of PDI farmers continue at a slow pace and the target set for 2014 is not met. However, there are small pockets of emerging farmers were sizeable farming units is transformed successfully to produce more high valued crops and animal products. Urbanization alleviates some pressure on rural economies and the land reform program. This phenomenon, however, affect food security and the changing habits of consumers that move to urban areas, further increase the demand for higher value goods such as oils & fats, dairy, meat and fish. The emphasize here is on higher "value goods". The rate of population growth also declines as a result of urbanization. The existing levels of import tariffs remain in place for all meats and SA remain a net importer of these products. The impact of high interest rates only have an impact on disposable income during 2008 and 2009, causing a dampening effect on high valued food items, but as the repo rate is adjusted downward with decreasing inflation levels, real disposable income again increase.

World demand for oilseeds continues to outstrip world supply until 2013, drawing down on stocks and putting upward pressure on prices. Higher world prices for oil and cake transmit to domestic prices securing positive crushing margins for soya bean crushing plant facilities. This implies that the structural shift that has occurred in the local crushing industry over the past few years with the expansion of local soya bean crushing facilities remain and as a consequence soya beans trade closer to import parity levels than in the past. The soya maize price ratio, therefore, increases favouring soya beans. As a result farmers shift maize fields into soya production over time. However, the growth in soya bean crushing facilities outpaces the increase in local production and as a result, beans and cake is still imported. Maize yields increase slightly faster than soya bean yields because of cultivar improvements, but due to the positive rotational effects of soya beans with other crops, farmers are inclined to continue with the increase in soya bean plantings.

After the severe drought in 2007, weather patterns return to normal in the 2008 production season. However, in 2014 the typical 9-year drought cycle repeat itself and the SA summer production region is severely affected. Although average temperatures increase globally, climate change does not affect yields drastically over the next decade because of cultivar improvements.

The strategy on biofuels is announced towards the end of 2007, and reports that government only require very low mandatory blending rates (B1 and E2) for the period 2009 – 2016. The reason being that government is careful of not causing an increase in food inflation, keeping to the Kyoto protocol commitment, but at the same time create employment opportunities where possible. Further more, no tariffs on imported biofuels is introduced but the production of biodiesel from soya beans is supported by the rebate of the duty on soya beans for the extraction of soya bean oil to be used in the production of biodiesel. Due to the lack of substantial support by government, SASOL does not build its biodiesel production facilities and biodiesel is produced on small scale by means of on-farm facilities. The E2 blending requirement is made up by maize-to-ethanol and a sugar-to-ethanol processing plant.