Triticale as an Alternative to Milling Wheat: The Case of the Western Cape Province, South Africa

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In the

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DECLARATION

I, Frederik Terblanche, declare that the Master's Degree research dissertation or interrelated, publishable manuscripts/published articles, or coursework Master's Degree mini-dissertation that I herewith submit for the Master's Degree qualification, Master of Agriculture Majoring in Agricultural Economics, at the University of the Free State is my independent work, and that I have not previously submitted it for a qualification at another institution of higher education.

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ABSTRACT

Triticale as an Alternative to Milling Wheat: The Case of the Western Cape Province, South Africa

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Abstract

The decline in the profitability of milling wheat is amongst the challenges faced by wheat producers in South Africa. The decline in profitability is hampering the ability of wheat producers to remain financially viable, and as a result, many producers have shifted their production focus to alternatives, which are believed to be more profitable. Producers in the Western Cape Province are, however, not that fortunate with the resource endowments that limit their options. Additionally, no attention has been given to the financial viability of alternatives for wheat production in the Western Cape Province. Therefore, this study examined triticale as an alternative crop. The financial viability of triticale, as compared with milling wheat, was determined by using the Agricultural Products Requirements Optimising (APR_OPT) model, coupled with a budget analysis. Results from the APR_OPT model in the form of demand and successive prices were used as inputs in the budget analysis to determine the financial viability of triticale, compared with milling wheat. Although triticale reported a positive gross margin for the period under review, its financial viability compared with milling wheat will largely depend on the prices of maize and milling wheat, respectively.

SAMEVATTING

Korog as ʼn Alternatief vir Meulkoring: Die geval van die Wes-Kaap Provinsie, Suid-Afrika

deur

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Samevatting

Die afname in die winsgewendheid van meulkoring is een van die uitdagings wat Suid-Afrikaanse koringprodusente in die gesig staar. Die afname in winsgewendheid onderdruk die vermoë van koringprodusente om finansieel lewensvatbaar te wees en het veroorsaak dat vele produsente hul produksiefokus verskuif het na alternatiewe wat meer winsgewend geag word. Produsente in die Wes-Kaap Provinsie is egter nie so gelukkig om, gegewe die beskikbare hulpbronne wat beperkende effekte het, ook sodanige skuiwe te oorweeg nie. Verder is daar nog geen aandag geskenk aan die finansiële lewensvatbaarheid van alternatiewe vir koringproduksie in die Wes-Kaap Provinsie nie. Hierdie studie ondersoek daarom die finansiële lewensvatbaarheid van korog as ʼn alternatiewe gewas teenoor meulkoring, met gebruik van die “Agricultural Products Requirements Optimising” (APR_OPT) model, saam met ʼn begrotingsanalise. Resultate vanaf die APR_OPT model in die vorm van vraag en toepaslike pryse, is gebruik as insette in die begrotingsanalise om die finansiële lewensvatbaarheid van korog in vergelyking met koring te bepaal. Alhoewel korog gedurende die betrokke tydperk ʼn positiewe bruto marge getoon het, sal die finansiële lewensvatbaarheid daarvan teenoor meulkoring, grootliks afhang van die pryse van mielies en meulkoring onderskeidelik.

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LIST OF ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
AFMA	Animal Feed Manufacturers Association
APR	Agricultural Products Requirements
APR_OPT	Agricultural Products Requirements Optimising
BFAP	Bureau for Food and Agricultural Policy
CWANA	Central and West Asia and North Africa
DDG	Distillers dried grains
DDGS	Distillers dried grains with solubles
EU	European Union
EA	Evolutionary Algorithm
FAPRI	Food and Agricultural Policy Research Institute
FCR	Feed Conversion Ration
FSP	Free State Province
GAMS	General Algebraic Modelling System
GDP	Gross Domestic Product
IFPRI	International Food Policy Research Institute
JSE	Johannesburg Stock Exchange
IMPACT	International Model for Policy Analysis of Agricultural Commodities
LP	Linear Programming
MCA	Multi-objective Constrained Algorithm
NCP	Northern Cape Province
NIAB	National Institute of Agricultural Botany
NSGAII	Non-dominated Sorting Genetic Algorithm
R&D	Research and development
SADC	Southern African Development Community

SAFEX	South African Futures Exchange
SAGL	South African Grain Laboratory
TMR	Total Mixed Rations
WCP	Western Cape Province
WSM	Weighted Sum Method
USA	United States of America
USGS	United States Geological Survey
US HRW	United States Hard Red Winter Wheat No.2

Chapter 1 – Introduction

1.1 Background and Motivation

Due to a decline in the profitability of wheat, it is necessary to identify an alternative crop that will be suited for production in the traditional wheat-producing areas of the Western Cape Province (WCP). In this study, reference is often made to either wheat or milling wheat, depending on the context in which it is used. When referred to as 'wheat', the discussion is focused towards it as a crop or commodity, whereas 'milling wheat' refers to a specific class (B-class) of wheat. The latter is mainly of importance in terms of the financial comparison between milling wheat (B-class wheat) and potential alternatives.

The decrease in performance (decline in profitability) of the wheat industry is evident from the constant decline in the number of hectares dedicated to wheat production in South Africa. Since 1997, local production has declined, while imports have been on the rise (Van der Merwe, 2015). This study therefore seeks to provide producers with a financially viable alternative to traditional milling wheat for the specific region. The focus will be on the production of triticale as a financially viable alternative to milling wheat. From a marketing perspective, triticale will be evaluated according to its potential as an alternative energy feed source. Triticale is a winter crop and is thus chosen as an alternative, because it is suitable for the WCP's crop producing conditions. It is a hardened crop, which has higher resistance to pests and diseases than other crops, and tolerates overly wet and dry conditions (Botes, 2017). Myer and Lozano del Rio (2004) considered the energy content of triticale to be similar to that of yellow maize, and even surpasses yellow maize on protein and mineral content levels. Triticale production can therefore be considered as a preferred alternative to wheat production.

Wheat production fills an important part in the WCP farming sector, and additionally, wheat grain is regarded as one of the most important grains globally, as it is used for human consumption as well as for animal feed (Heuzé et al., 2015b). Similarly, wheat grain is the second most important grain crop in South Africa (DAFF, 2015b). During the 2016/2017 production season, the WCP was responsible for 56.8% of all wheat produced in South Africa (Grain SA, 2017a), which is estimated to attain a gross value of approximately R4 billion (DAFF, 2017). Considering that wheat is the largest commercially produced field crop in the WCP (DAFF, 2017; Grain SA, 2017a), the declining trend in terms of the number of hectares planted can certainly be regarded as a matter of concern.

In elaborating on the factors influencing the wheat industry's performance, it can be seen that the deregulation of the marketing boards and the opening of the South African borders contributed towards increased levels of competition, both locally and internationally. As a result, the increase in supply from outside the South African borders has contributed towards the decline in prices, and subsequently in profitability (Van Schalkwyk & Van Deventer, 2005; NAMC, 2006; Sosland, 2011; Stanwix, 2012; Van der Merwe, 2015). This situation is not unique to South Africa: globalisation and increased competitiveness have also resulted in lower levels of production in countries such as Argentina, Australia and even the USA (USDA, 2017b).

From a South African perspective, consider the Free State Province (FSP), a region that has transformed from being the leading wheat producer during 2006/07 with 780 000 tonnes, to producing only 40% of that amount (308 500 tonnes) during 2016/17 (Grain SA, 2017a). Although the focus of this study is directed towards the WCP, the significance of the FSP's decline as a result of changing conditions and the pursuit of profitability (thus sustainability) is worth noting. The FSP has reported the most significant decline in wheat production, which is mainly the result of a lesser number of hectares that has been dedicated to wheat production. Producers on dryland conditions can, in most instances, only produce one crop per year. Unlike those farmers who produce wheat under irrigation, the ability of dryland producers to produce more than one crop per year is limited by factors such as rainfall patterns, soil moisture levels, and production seasons. The same accounts for dryland producers in the WCP, where many are limited to a crop that can be produced during the winter months. As a result, this crop should then optimise farm income for that year, or the longer term.

As the FSP field crop areas mostly comprise of dryland, the producers in the FSP have switched, in an effort to be more profitable, from the production of wheat to maize to a large degree (Grain SA, 2017a, b). In other words, many producers have switched from producing a winter crop to a summer crop. Since 2005, a decline of approximately 71% has been recorded in terms the number of hectares dedicated towards wheat production in the FSP (Grain SA, 2017a). This is a clear indication that once producers have the option to choose between crops, it enables them to react to price movements, which will promote profitability. As a result, producers tend to shift to the most profitable crop and understandably so, given that the latter directly impacts on the financial viability of their operations. This also increases a farmer's ability to be more competitive.

Fowler et al. (2015) identified three competing objectives that are considered when stakeholders (farmers, among others) face planting decisions, namely profitability, meeting demand targets, and water conservation. The declining trend of wheat production, as referred to earlier, provides an illustration of how FSP producers considered profitability as a factor in crop planning. A similar situation will apply in terms of triticale versus milling wheat in the WCP. Triticale and wheat have similar agronomic traits and resource demands (Botes, 2017; Strauss, 2017), the choice of whether to produce the one or the other will therefore mainly boil down to profitability.

Objectives such as water conservation as referred to by Fowler et al. (2015) also relate to resource or factor endowments that, similar to competing objectives, have an influence on production choices or possibilities. The Business Dictionary (2017) defines the term 'factor endowment' as being an "amount of labour, land, money and entrepreneurship that could be exploited for manufacturing within a country." The same principle can be applied to farming or the production of agricultural produce. However, the factor endowments for agricultural produce will most arguably be broader than the competing objectives mentioned by Fowler et al. (2015), so as to include aspects such as climate, precipitation, biomes, etc. To a large extent, these factor endowments determine the success with which any specific crop or animal can be produced. Similarly, a factor endowment such as land, from an agricultural perspective, is much broader than just the number of hectares available. It includes aspects such as soil type, water holding or drainage capacity, topography, etc.; all of which have an influence on the suitability of, and production ability for, different crops. The same principle applies to other agricultural-related factor (resource) endowments such as climate and precipitation levels.

The factor endowments for FSP and WCP differ notably. This is evident from the fact that a particular crop can be produced successfully in one of the provinces, while failing dismally in the other provinces, despite having the same number of hectares, capital outlay, labour and skills. This again highlights the importance of other factor endowments such as climate, biomes, etc., when it comes to agriculture. As a result, the same change in practice will not have the same effect in another province and thus be as rewarding in different provinces. The WCP producers face entirely different circumstances, as compared with their FSP counterparts.

Many producers in the WCP have introduced a crop rotation system in an attempt to improve productivity and consequently their sustainability as far as wheat production is concerned. Crop rotation systems in the province have proven to comprise an effective method of naturally improving land quality, such as by increasing nitrogen levels in the soil, and reducing pest control requirements (Western Cape Government, 2015). The main crops considered in a wheat-based crop rotation system include canola and legumes such as alfalfa and medics. Such crops are produced in a particular sequence to improve the productivity of wheat and consequently the sustainability of wheat farmers in the WCP. The crop rotation not only contributes towards lower levels of production costs, but also to higher wheat yields (Grain SA, 2010). As many as 98.8% of the wheat farmers in the province employ a crop rotations system in an attempt to improve productivity, profitability and as a result, sustainability (Western Cape Government, 2015).

Wheat can be considered as being the driver of the economy for a region such as the Swartland (an essential wheat-producing region in the WCP), and with increasing risks in wheat production such as persistent drought conditions and market uncertainty, there is some reason for concern which has caused a search for alternative crops and new cropping systems (Western Cape Government, 2015). Increasing risks place farmers under financial pressure and have the potential to not only influence the financial viability of their operations, but also to have a negative impact on the agriculture sector in the province. An investigation into alternatives is therefore of utmost importance to ensure, or to contribute towards, the financial viability of traditional wheat producers in the WCP.

Apart from factor endowments, the price of a specific product is another important factor that needs to be considered, provided that it has a direct influence on profitability. Additionally, the price of a product is greatly influenced by the demand, supply and the price of substitute products. As a result, the demand for a product can be considered just as important as the factor endowments when it comes to the successful production and the consequent sustainability of the product in a specific region.

Milling wheat consumption in the WCP ranges between 500 and 600 tonnes per annum (Willemse, 2017), which constituted approximately 0.05% of the total harvest in the province during the 2015/16 season (Grain SA, 2017a). The majority of the milling wheat produced in the WCP is consumed in other parts (provinces) of South Africa (Karaan, Kassier, Vink & Cherry, 2004). To account for transport costs experienced on the derivative markets, location differentials are calculated based on the SAFEX price, and an area's proximity to Randfontein as the reference point. Since the WCP is far from Randfontein, the location differential for an area such as Malmesbury in the Swartland amounts to approximately R550 per tonne (JSE, 2017b). The price or farm-gate price for milling wheat is thus discounted by as much as R550 per tonne, resulting in farmers realising a price notably lower than that of the SAFEX-based price. Many questions in terms of the location differential have been raised in the past. The research question in this study does not necessarily relate to the correctness/impartiality of the location differential, although it does have an impact on the profitability and consequently the viability of milling wheat producers in the WCP. The question in this study specifically relates to the financial viability of alternatives. Therefore, can triticale provide primary producers with a financially viable alternative, while at the same time improving the effectiveness of the entire grain value chain? Although questions around the effectiveness of the grain value chain and the possible impact of triticale falls outside the scope of this study, it still remains an important aspect in terms of ensuring a net gain for the entire industry and the country.

It is therefore necessary to identify well-established industries in the area, with the prospect of certain needs in that market being satisfied in the process of supplying triticale. A potential market opportunity might be the animal feed industry. The WCP has a large share in the production of various livestock, including beef cattle, sheep, pigs and poultry (DAFF, 2015a-e). Many of these livestock types are produced in intensive operations, and notably, a large part of their rations consist of grains as a source of energy (yellow maize), and oilseeds as a source of protein (soybeans), with added roughage (NSW Government, 2004). Although yellow maize is the most valuable energy source among grains (Heuzé & Tran, 2016), the WCP only produces around 7.6% of the yellow maize it requires to satisfy the demand for both agricultural and industrial purposes (DAFF, 2016a; Swarts, 2016). In order to supply the other 92.4%, the WCP has to ‘import’ most of its energy feed sources from other provinces in South Africa. As a result of the import of its energy feed, as well as the export of most of the WCP wheat crop to other provinces, the WCP amasses high transport costs and loses revenue from a discounted milling wheat price by the location differential.

1.2 The Problem Statement

Wheat producers have experienced enormous pressure from the cost–price squeeze over the past couple of years, which has had a negative effect on the profitability and sustainability of South African wheat producers (Jooste, 2012, as cited by Van der Merwe, 2015). Unlike wheat producers in the FSP, resource endowments limit the alternatives available for producers in the WCP. Summer crops such as maize, sunflower and soybeans are not suitable for production in the main wheat or crop producing regions in the WCP.

In addition to resource endowments which limit the alternatives that are available to producers, questions can also be raised in terms of the cost effectiveness of the supply chain, especially considering the input demands for industries such as the animal feed manufacturing industry in the WCP. To adhere to the demand from the animal feed manufacturing industry in the WCP, inputs such as maize are largely being imported from elsewhere, considering that with a yellow maize crop of 34 200 tonnes during 2015/16, the province's total deficit of yellow maize, processed and used in the province, was 378 872 tonnes (SAGIS, 2016). Maize production in the WCP is mainly confined to a few irrigation areas (Erasmus, 2012) that are not nearly sufficient to satisfy local demand, especially in terms of the demand coming from the animal feed industry.

Research is also limited, both in terms of studies investigating the potential of producing crops that could contribute towards a more cost effective supply chain, given the demands from industries such as the animal feed industry, and in terms of alternatives for wheat producers in the WCP. It should, however, be noted that the focus of this study is not on determining the cost effectiveness of the supply chain of the animal feed industry in the WCP, but rather on the viability of triticale as an alternative for wheat. The potential does exist, however, that should triticale be a viable alternative, it could present the animal feed industry the opportunity to develop a more cost-effective supply chain. Although the latter is outside the scope of the study, it is still worth mentioning, given that it provides a broader perspective and possibly additional motivation for investigating alternative crops that not only provide wheat producers with alternatives, but which might also contribute to the sustainability of related industries, and at the end of the day, yield a net positive gain for South Africa as a whole.

With this being said, most of the studies conducted in the past have focused on the comparison of the profitability of different crops in combination or rotation production systems, or the comparison of profitability in terms of different production methods. For example, Mahlanza, Mendes and Vink (2003) conducted a study regarding the comparative advantage of organic wheat as opposed to conventional wheat, in an effort to provide a niche product. This product would cater to the rising demand following from consumers' increasing awareness of healthy eating. Even though it was done more than a decade ago, it is still relevant, considering the persisting problem, i.e. the declining profitability of conventional wheat. No attention, however, has been given to the financial viability of alternatives for wheat production in the WCP. It is therefore necessary to determine whether there are potential financially viable alternatives for wheat producers in the WCP.

1.3 Objectives of this study

The main objective of this study is to determine whether triticale provides a financially viable alternative to milling wheat in the WCP of South Africa. To achieve the main objective, the following sub-objectives need to be achieved:

1. To conduct a thorough literature review of previous studies that have dealt with similar research questions to determine an effective method of establishing whether triticale can be considered financially viable;
2. To provide insight into the importance of wheat as a field crop in the WCP, and to reflect on the usefulness of triticale as an alternative;

3. To determine the appropriate methodological approaches for assessing the financial viability of triticale as an alternative for milling wheat in the main wheat producing areas in the WCP;
4. To draw conclusions and make recommendations based on the findings.

1.4 Methodology and Data

This study will mainly use quantitive approaches to reach the set objective. Firstly, the Agricultural Products Requirements Optimising (APR_OPT) model will be used to determine the potential demand for triticale. The APR_OPT model is a linear programming (LP) model that determines national raw material demand. It determines the national raw material demand by considering that various animals' minimum nutrient requirements are met with a least-cost approach (De Jager, 2016). The methodological approach forms the basis for determining the potential demand and consequently the price for triticale. A constraint in the form of a minimum level of triticale uptake (consumption) was introduced. Since the market should first be scanned before considering production, a minimum uptake was included as a demand requirement. The minimum uptake was based on the advisement of Robertson (2017), a specialist in the trade of raw materials in the WCP, who argued that for feed manufacturers to adjust formulations to include the use of a partial substitute for yellow maize, a supply of at least 20 000 tonnes should be available before the feed manufacturers would incorporate and use the raw material. Only then will a raw material be considered as a viable alternative from a production perspective.

In addition to the APR_OPT model, the study will also make use of partial budget analyses to determine whether triticale could be regarded as a financially viable alternative for milling wheat. Results obtained from the APR_OPT model will form part of the input data used to calculate the potential gross income for triticale in the WCP. The study will also make use of secondary data in the form of production data for various grains, oilseeds and by-products from grains and oilseeds used in the animal feed industry, financial information such as output prices or feed prices for the various raw materials, input prices for milling wheat and triticale, and the nutritive values of the various raw materials. The data was sourced from Overberg Agri for wheat and triticale production information, from Grain South Africa for grain prices, and existing data from the APR_OPT model which include animal feed requirements, raw material costs, and human consumption and population figures. Much of the APR_OPT model's data is sourced from the Bureau for Food and Agricultural Policy's (BFAP) sector model.

1.5 Chapter Layout

Chapter 1: Introduction

This chapter provides background as to why there is a need to identify an alternative for milling wheat. In addition, a framework is presented that effectively portrays the objectives and expected outcomes, followed by the methodological approach and layout of the dissertation.

Chapter 2: Literature Review

The literature review discusses how the chosen methods were selected from methods used in similar studies. Several methods of crop selection were reviewed, from which the most suitable were selected, based on the objectives and focus of this study.

Chapter 3: Industry Overview

This chapter provides background regarding the global and local wheat industries, the value of wheat, and the decline in domestic competitiveness. The final part of the chapter focuses on triticale, providing some background in terms of its energy content, the various uses of triticale, and its usefulness in feed rations.

Chapter 4: Methodology

Chapter 4 focuses on the methodological approach, i.e. the functioning of the methods and the data used.

Chapter 5: Results

Chapter 5 focuses on the results obtained from the respective analyses. The APR_OPT model was used to generate the demand for triticale at different price levels. The prices obtained from the APR_OPT model serve as part of the input data required to do conduct the budget analysis and thereafter the comparison between triticale and wheat.

Chapter 6: Summary and Conclusion

Chapter 6 revisits the necessity for the research done in this study, the objectives that were set, and provides a summary of key points discussed in each chapter. It ends with conclusions and recommendations for going forward for future research.

Chapter 2 – Literature Review

2.1 Introduction

To address the problem that was raised in the previous chapter, it is necessary to reflect on how other studies have approached similar problems. However, this chapter will start with a more detailed discussion in terms of viability and the basis for viability as it relates to this study. This will be followed by a discussion in terms of identifying methods that will measure the viability of triticale, as well as approaches from additional methods that could be supplementary in reaching this chapter's objective of determining triticale's viability.

2.2 The concept of feasibility and viability

Conducting a feasibility and viability analysis is synonymous with the process of establishing a new venture or enterprise. Nieman and Nieuwenhuizen (2009) clearly state that, before embarking on a new venture or introducing a new enterprise, it first needs to be evaluated to determine whether it is feasible and viable. It is clear from the statement that a difference exists between the concepts of feasibility and viability. According to Nieman and Nieuwenhuizen (2009), 'feasibility' refers to the availability of resources to ensure the successful implementation of the new venture or enterprise. In the previous chapter, it was noted that the Western Cape Province (WCP) has the required resource endowments for the production of a crop such as triticale. As a result, based on the guidelines provided by Nieman and Nieuwenhuizen (2009), it can therefore be considered as a feasible alternative.

The principle of viability, or farm viability, can be understood in terms of the principle of assessing whether on-farm activities can sustain a farming household and increase net worth. Salant, Smale and Saupe (1986) stated that to be viable, a farm (or in this case, the enterprise) must generate sufficient net income to meet financial obligations which include household expenses and operating costs of the farming enterprise, i.e. production costs, interest payments, capital replacement, and debt payments. Farming, in general, has evolved dramatically from being a subsistence vocation to becoming a business undertaking in the mass manufacturing of goods. The principle remains, nonetheless, that it is a means to sustain the household, which is why the viability of the enterprise remains important.

Salant et al. (1986) measured viability through dividing the sum of the income generated by the sum of said payments. A positive viability would be equal to or higher than 1, with a ratio below 1 indicating the degree of changes required in the farming business to increase viability.

Elsewhere, the definition of viability, or more specifically financial viability, is stated as “the ability of an entity (or venture) to continue to achieve its operating objectives and fulfil its mission over the long term” (Venture Line, 2017). In this case, one can consider triticale production as being an enterprise for consideration as a new venture, with the goal of increasing farm profitability. To achieve this, it will be necessary for triticale to be more profitable than milling wheat per hectare. Financial or economic viability is a very important determinant in the implementation/continuing of a new venture. Previous studies have used it as a measure to gauge whether or not a venture would be viable for a producer to invest in for further development; whether it is viable to validate governmental support (Makombe & Sampath, 1999; Somda et al., 2005); or to verify whether or not it is better to remain producing rather than selling off a current commodity, for example dairy cattle. Other studies have also used it to determine the scale of production that has the highest viability (Hanyani-Mlambo et al., 1998).

These studies have used a similar approach to that of Salant et al. (1986) in calculating a ratio that portrays financial viability. However, in addition to the income and sum of payments ratio, Hanyani-Mlambo et al. (1998) also measured the relationship between gross margin and scale of production. The same accounts in terms of the study by Somda et al. (2005), who used the relationship between gross margin and operating costs as a viability indicator, along with other indicators such as capital turnover and the relationship between net cash received for every unit variable cost spent. It is thus clear from the above that, although the principle remains the same, the approach or indicator for financial viability will largely depend on the objective of the study, i.e. scale, efficiency, returns, etc. The objective of this study is to determine whether triticale can be considered as an alternative to milling wheat with the main goal to realise higher profits for the producer. With this being said, financial viability in the context of this study will therefore be determined in terms of profitability, with it being determined based on the gross margin above allocated cost. In other words, if triticale is more profitable, as compared with milling wheat, it will be considered as a financially viable alternative.

2.3 Methods for crop selection

Dury et al. (2012) studied different models that focused on decisions regarding cropping plans and crop rotations. The authors reviewed more than 120 studies that focused on different cropping decisions and concepts and concluded that crop selection can be done based on both mono and multi-attribute objective selection. The authors also made mention of cropping plans versus rotation, with a cropping plan that refers to the area (hectares) that is occupied by the different crops in a specific year, whereas crop rotation refers to the management practice of growing different crops on the same land during a fixed period in a particular sequence (Dury et al., 2012).

In the context of this study, the focus will be on cropping rather than on rotation planning. In other words, on the hectarage that producers will allocate to either wheat or triticale, rather than on rotating the two crops on the same piece of land. Because of the similarity of the crops, it will not serve any use to alternate these crops in a crop rotation system. A crop rotation system is mainly implemented to potentially break weed and disease cycles, amongst other things (Bullock, 1992). In such crop rotations, cropping plan models follow a multi-attributive objectives approach.

The fundamental reasoning of such methods is provided by Akplogan et al. (2011), who argue that cropping-plan decision-making is dependent on various factors that interact at the different spatial (area allocation) and temporal (periodic planning) scales of farm management. From a spatial perspective, it is important to consider, with reference to the land that is being produced on, the accessibility to resources (irrigation) and the biophysical properties (soil type and topography) of that land. The sequence in which crops are produced on a specific area of land becomes important over time, especially where the production frequency of a specific crop might result in lower levels of soil fertility, increase in weeds and/or disease occurrence.

There are certain key issues, such as profit, equipment, labour, irrigation, energy, nutrient, pesticide and soil, that dictate the objectives to be set in multi-attribute cropping plans (Dury et al., 2012). Foltz et al. (1995) and Dogliotti et al. (2005) argue that decision-making should not be based on one particular objective such as profit, but rather on a combination of objectives that account for factors such as soil erosion, lower pesticide usage, and nutrient losses. Examples of multi-attribute objectives selection methods include the MODFLOW-FMP2 (Fowler et al., 2015), and the Multi-objective Constrained Algorithm (MCA) for solving multi-objective crop planning model (Sarker and Ray, 2009).

The MODFLOW-FMP2 is a simulation tool that was developed by the United States Geological Survey (USGS) to model groundwater flow. Fowler et al. (2015) developed it as a means to determine trade-offs in crop selection. The simulation tool was utilised in a decision-making framework with the use of optimising algorithms to seek optimal strategies for water management. The decision-making framework considered three competing objectives when facing planting decisions, namely profitability, meeting demand targets, and water conservation.

The study of Sarker and Ray (2009) compared various multi-objective solutions, some of which used an evolutionary algorithm (EA), i.e. the MCA and the Non-dominated Sorting Genetic Algorithm (NSGAII); and others have used conventional multi-objective methods, i.e. the Weighted Sum Method (WSM) and the ε-constrained method. The authors introduced the MCA, which is a bi-objective linear crop-planning model, which was then reformulated as a non-linear program in order to integrate reality aspects. To perform the comparison, Sarker and Ray (2009) followed three steps, namely: solving a simple multi-objective test problem, using the four mentioned methods; extending the comparison to crop-planning problems to observe the behaviour in realistic problems; and lastly, solving two instances of the crop-planning model. The research of Sarker and Ray (2009) was focused towards determining an annual crop production schedule for the required hectarage for different crops, considering limitations such as demand, land, capital and regional factors (e.g. topography and average rainfall). This model is developed to assist in formulations for double/triple-cropped land combinations, and can be considered to be a model that is very useful in solving highly complex, multi-objective trade-off problems.

It is very important that in the formulation of crop rotations over several sequences, the key issues mentioned (profit, equipment, labour, irrigation, energy, nutrient, pesticide and soil) be taken into account. This is due to the differences that exist between crops such as wheat and legumes, in the sense of the levels of different nutrients required, equipment and labour required, the profit generated, and also natural benefits, such as legumes increasing soil fertility through nitrogen fixation (Knott, 2015). In formulating the sequence over several stages, one can then consider the nitrogen fixation ability of legumes, and thus produce it prior to wheat in order to obtain higher yields, since wheat has a high nitrogen requirement (Knott, 2015).

If one were to focus on one sequence of such a plan, however, in which similar crops are considered (medics vs. alfalfa or wheat vs. triticale), a mono-attributive objective approach (i.e. crop selection being based on a primary objective) would be permitted, as the differences of the other key issues would be marginal. The primary objective will depend on the function of the crop within the sequence. With medics and alfalfa being legumes, its function could be attributed to its nitrogen fixation ability or its amount of biomass for grazing. With a region such as the Swartland, with its economy being based on wheat production (Western Cape Government, 2015), an alternative to wheat should also fulfil this function of being able to drive the economy. The comparison between milling wheat and triticale will, therefore, be based on profitability.

The decision to use mono- or multi-attributive objective selection models will, in essence, largely depend on the aim of the research. Mono-attributive objectives can be regarded as acceptable, considering decisions pertaining to crops with similar resource requirements and attributes. The latter is of specific reference to this study, with triticale being a hybrid of wheat. Moreover, although the focus of this study is mainly aimed at the financial viability of triticale as an alternative to milling wheat, the assumption is that most, if not all, of the environmental-related aspects, such as required pest control and provision for nutrients losses, if any, will indirectly be reflected through the methodological approach in terms of the budget analysis. This justifies the use of a mono-attributive objective approach in this study. The following sub-section will provide a more in-depth discussion in terms of mono-attribute objectives selection.

2.3.1 Mono-attribute objective selection

Adisa and Sofoluwe (2013) followed a mono-attributive approach in analysing the economic factors that are responsible for the productivity of different food crops (cassava, maize and yam) in the Osun State of Nigeria. The authors used different methods to address factors such as socio-economic characteristics (age, educational level and farm size that influence the ability to be productive and innovative), problems militating against production (inefficient capital; occurrence of drought, pests and theft; and high labour costs) of the different crops, and lastly, how these factors have influenced the level of financial returns. To assist in measuring the factors influencing returns, the authors used a budget analysis.

Alimi and Manyong (2000, as cited by Adisa and Sofoluwe, 2013) defined a budget as a quantitive expression of a total farm plan by giving a representation of income, costs and profit. This technique calculated the levels of profitability of the enterprises with regard to their revenues, gross margins and net farm incomes. The approach allowed the authors to compare the profitability of cassava, maize and yam.

Much like the budgetary technique, Nelson and Meikle (2001) developed the National Institute of Agricultural Botany (NIAB) Gross Margin Model, by using the NIAB's Recommended Lists of Cereal Varieties. These lists provide independent assessments of agronomic and quality attributes of available varieties in the United Kingdom (UK). The model extracts data for wheat, winter barley and spring barley, evaluates the data in monetary terms, and calculates the gross margin for each variety by deducting the variable costs from output. In a certain sense, this approach can also be regarded as a multi-objective solution, given its consideration of numerous aspects of each variety. In essence, the selection is, however, based on a primary objective, namely profitability.

From yield, agronomic, and quality data, as well as price information, such as premium prices and quality price differentials obtained through confidential surveys with grain traders and other trade sources, Nelson and Meikle (2001) were able to assign values to important traits such as yield level, drought resistance and protein content. The gross margin was determined in standard fashion, by deducting total variable costs of production from the product of yield and price plus area payments (Nelson & Meikle, 2001).

In the context of Nelson and Meikle's (2001) study area, yield has generally been the major factor considered in assessing varieties of a specific crop. Nelson and Meikle (2001) noted that the gross margin will, however, indicate the importance of other factors as well, as the price linked to grain quality, and the costs spent on pesticides, fertilisers and seed are also well reflected in the gross margin. The model therefore considered what the implications of variations in such factors might be in the gross margin. A variety could, for example, obtain higher yields amid dry conditions or pests than another might, but could be lacking in quality. The model will then estimate how the variety that requires less expenditure on pesticide, has a higher yield, but obtains a lower price will compare with a variety that has a lower yield, but receives a premium price for quality.

This model compares specific varietal differences within different types of crops, as the quality level of a certain crop could be valued differently from other crops. It is relatable to this study nonetheless, as triticale and milling wheat may have a similar give-and-take relationship as in the example provided. Considering the possibility of triticale obtaining a lower price than milling wheat, its higher tolerance for dry conditions (Botes, 2017) could compensate for it through a higher yield. In certain years though, in ideal conditions relating to rainfall and price, milling wheat could be much more profitable.

Lu et al. (2003) studied the effects that management intensity has on profitability in watermelon production. Three cultivars were analysed in this study by Lu et al. (2003), with each cultivar receiving low-, medium- and high-intensity management. The differing profitability within each cultivar was then compared by means of a partial budget analysis. The authors regarded the partial budget analysis as useful to determine the effect of management changes on the profitability through aspects such as yield, market price, and production cost. Lu et al. (2003) also noted the effectiveness of this method that was highlighted in its ability to evaluate the effect that changes in management practices have on profitability, considering how certain adjustments to current practice only have a partial effect on the total budget.

Although this study does not entail a mere management change, but rather a change in enterprise, the framework of this partial budget analysis still applies to what the study attempts to accomplish, i.e. to identify the effect a change of enterprise will have on a farming business's profitability, and whether the effect will be positive or negative. Provided how the market environments of 2016 and 2017 differed, a sensitivity analysis was also carried out in the form of analysing results for both 2016 and 2017 to illustrate how the outcome of the partial budget is affected by changing factors such as price, yield and costs, and thus how sensitive the results will be to changes in external factors; meaning, will the outcome remain positive/negative amid changes in prices, yield or costs, and to what degree will it change?

2.4 Models suitable for demand determination

To conduct a budget analysis, data in the form of price, yield and allocatable costs for both milling wheat and triticale will be required. At this point in time, triticale in South Africa is mostly produced as a source of forage, which makes it difficult to obtain a specific market price (Botes, 2017). The price for triticale is derived from either the price of barley or yellow maize (Robertson, 2017). The current price is therefore not a reflection of the demand for triticale; in actual fact, it can be considered as a reflection of the price of substitute products. However, Robertson (2017) clearly states that a crop such as barley serves a wholly different market, while the factors affecting the price of yellow maize may be entirely different, compared with that of triticale. Therefore, to be able to make an objective comparison, a price that is a function of the commodity's own demand needs to be determined. In other words, the potential demand and consequent price for triticale in the WCP needs to be determined in order to objectively compare triticale with milling wheat.

As mentioned above, the animal feed manufacturing industry is the most likely market for triticale in the WCP. As a result, the animal feed manufacturing industry will be used as the basis for modelling the potential demand and consequent price for triticale in the WCP. Aneja (1997) noted that in determining the viability of a new product/enterprise, it is necessary to perform cost and demand analyses. While the previous section focused on the cost analysis, the remainder of the chapter will be dedicated towards considering different approaches suitable for modelling the potential demand of triticale, and by doing so, determine a theoretical price that will allow for an objective financial comparison between the alternatives.

According to Msangi et al. (2014), "the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) has been widely applied to global projections on agricultural supply, demand and trade as well as for ex-ante assessments of the long run impacts of changes in drivers of agricultural production such as technological and climate change". It was developed at the International Food Policy Research Institute (IFPRI), and is regarded as a basis for research that examines the linkage between the production of essential food commodities, food demand, and food security at the national level (all within the context of different scenarios of future change). The IMPACT model in essence acts as the solution to a lack of long-term vision and agreement among policy-makers and researchers, experienced during the early 1990s, concerning steps necessary to maintain feeding the world, reducing poverty, and to protect the natural resource base (Rosegrant et al., 2012:1)

Within the IMPACT model, provision is made for food as a sub-module that provides a method of analysing baseline and alternative scenarios for international food demand, supply, trade, revenue and population. It includes 115 geopolitical regions and 126 hydrological basins, which creates 281 food production units. With 44 agricultural commodities being modelled in the IMPACT model, it enables the determination of each region's supply, demand and prices for these commodities. The supply and demand functions consider inelasticities to estimate underlying production and demand (Rosegrant et al., 2012:4).

Several improvements have been incorporated into the IMPACT, which has increased its usefulness over time, such as improving the accounting of livestock numbers, tracking previous years' stocks, and animals that are removed for slaughter. This has improved the ability to estimate feed demand and assess the potential of livestock production expansion under feed-constrained conditions (Msangi et al., 2014). The model now generates results regarding total production of various livestock categories, as well as an amount for feed demanded. It does not, however, focus on the raw materials used in different animals' feed rations, as formulated to meet nutritional requirements (De Jager, 2016).

Hafi and Andrews (1997) developed the Australian Bureau of Agricultural and Resource Economics (ABARE) model to serve as a regional feed demand and allocation model. This mathematically programmed model combines feed formulation and market components in order to calculate the regional usage of raw materials used in feeds and its prices and amount traded in the region, and the imports and exports from several countries. With consideration being given specifically to Australia's established infrastructure and livestock and grain handling facilities to accommodate exports, this model has been designed for the Australian set-up.

To determine the amount of feed demanded by the animals, a total of 43 feed ingredients are included in the model, which then calculates a feed mix for 12 livestock categories at a minimum cost (Hafi & Andrew, 1997). These 12 livestock categories are divided into 6 groups (i.e. poultry (broilers); poultry (layers); pigs; dairy; feedlot cattle; and other (live sheep exports, grazing ruminant supplement and miscellaneous)). Each of these livestock categories' nutritional requirements are taken into account, and the model seeks to meet these requirements at a minimum cost. The allocation of feed ingredients is done simultaneously to ensure that the total feed costs are minimised (Brennan et al., 2002).

Brennan et al. (2002) evaluated the economic potential for improving the nutritional characteristics of feed grains. Due to a growing availability of potential new feed grains in Australia, it was necessary to provide information regarding the economic merit of the new grains to enable the prioritisation of the order to which funds should be allocated for further research and development. To ascertain the results from which this information could be derived, Brennan et al. (2002) determined the amount of cost that could be reduced as a result of the improved grains, and then executed an economic welfare analysis to estimate the size and distribution of the benefits obtained from the research. This was done with the assumption that grain producers would only produce feed if it provides at least as much return as the feed it replaces does.

The reduced costs were determined by an LP model with the objective of generating least-cost feed rations for several livestock categories. Brennan et al. (2002) noted that a cost reduction in livestock production causes a downward adjustment of the supply curve of animal products. The size of the adjustments will of course depend on the amount of the new feeds that are incorporated into the rations, and the total output of animal products. This model uses the same structure as the ABARE model, with the exemption that it is an aggregate (national-level) feed demand model, and is not disaggregated into regions.

With this model being derived from the ABARE model, which seeks to formulate feeds meeting nutritional requirements at a minimum cost, the model measures the effects the inclusion of a new feed, that provides better nutrition, has on some animals in terms of the composition of raw materials in feed formulations, and the total formulation cost. This is done by including the new feed into the model at an arbitrary quantity, which creates a hypothetical raw material supply and enables the model to evaluate the added feed grain's nutritional characteristics and estimate demand levels at different prices. A total of 25 improved feed grains were considered, such as high oil lupines, low arabinoxylan wheat, hull-less barley, high seed coat digestibility barley, and high protein feed wheat. These options are developed to be improvements on the standard feed grain to be either more valuable in the form of nutrient content or digestibility, or to reduce inefficiencies in digesting. The improvements can be classified as feeds involving (Brennan et al., 2002):

- a change in protein content;
- change in amino acid profile;

- improvement in feed digestibility and efficiency; or
- reduction in anti-nutritional factors.

From this model, the authors were then able to recommend which new feed grains provide sufficient benefits when added to feed rations that can be considered as worthy to allocate funds to for further research and development.

The international methods can be considered to be proper and useful for various purposes, bearing in mind the models' ability to make estimations and assist in policy issues and decision-making. However, none of these models is specifically able to determine the raw material demand for feed in the WCP, and therefore cannot determine the value of triticale in this region's raw material formulations. The IMPACT model does not account for nutrient composition of feed rations, the ABARE model is specifically compiled exclusively for an Australian setting (given its infrastructure, market set-up and grain handling facilities), and the model by Brennan et al. (2002), also compiled for Australian conditions, is not disaggregated into regions. It is deemed necessary that a local method should be identified that can specifically address the WCP situation.

With this being said, Meyer and Westhoff (2003), as cited by Meyer and Kirsten (2005) and Meyer, Strauss and Funke (2008), originally developed a South African grain, livestock and dairy model. This model was further developed by Meyer et al. (2008) to provide what is now known as the Bureau for Food and Agricultural Policy (BFAP) model, and is a model that can be considered to be "a dynamic system of econometric equations, which has the ability to model cross-commodity linkages". This large-scale, multi-sector commodity level simulation model includes 52 commodities, which are categorised into five groups, namely: grains, oilseeds, livestock and dairy, horticulture and viticulture, and other (De Jager, 2016). It can be considered as dynamic, as it is directly linked to the global Food and Agricultural Policy Research Institute (FAPRI) models. Meyers et al. (2010), as cited by De Jager (2016), stated that "the model generates results that consider the production, consumption, and prices of various commodities." Essential commodities' (such as maize) prices are obtained from a global equilibrium, thus where supply equals demand.

Meyer and Kirsten (2005) used the BFAP model to make baseline projections concerning the supply and consumption of milling wheat domestically, as well as to analyse potential impacts that various policies might have on the milling wheat sector from 2004 to 2008. With the use of the model, the authors managed to forecast changes in the number of hectares dedicated towards the production of wheat in both summer and winter regions. In another application, focus was placed on forecasting milling wheat consumption and the role of imports.

Meyer et al. (2008) also used the model to determine the economic feasibility of biofuel production in South Africa. The purpose of the BFAP model in the study by Meyer et al. (2008) was to simulate the impact that the inclusion of dried distillers grain (DDG) would have on feed cost. DDG is a by-product obtained from bioethanol production using maize. Meyer et al. (2008) were able to conclude that the economic viability of the local biofuels industry will largely depend on government involvement, in the form of providing fuel levy tax exemptions, and implementing import tariffs on both bioethanol and biodiesel. Scenarios projected in the study indicated local ethanol production being benefited by the implementation of import tariffs and the policy of a fuel levy tax exemption. De Jager (2016) noted that the BFAP model is able to simulate the effects of external shocks on commodities, and models cross-commodity linkages in South Africa, and can be considered to be a general equilibrium model. Its data is very useful to incorporate into other methods.

Considering another method, McGuigan and Nieuwoudt (2001) compiled a spreadsheet model to enable the projection of future supply and demand for protein feed, through a scenario analysis. Growth parameters that were incorporated into the model are income growth, population growth, and income elasticity of demand. The estimated price elasticities of supply and demand facilitated the projection of equilibrium consumption and price 20 years in advance.

The compilation of this model came from the need to have projections, mainly in terms of future oilcake supplies, to assist in decision-making relating to local production. The study therefore set out to estimate the international price and consumption of protein feed 20 years in advance, under different scenarios. The base year was set as 1999, with parameters being set for per capita income growth; population growth; income elasticities; demand and supply elasticity; and supply projection. Within each parameter, data from sources such as FAPRI and the World Bank were used as constants for base scenario assumptions. The base scenario and parameters were then altered to provide consideration of various "what if" possible scenarios that might occur (McGuigan & Nieuwoudt, 2001). According to McGuigan and Nieuwoudt (2001), per capita income and population growth rates assist in determining future demand, and real Gross Domestic Product (GDP) per capita growth was used to estimate per capita income growth.

The authors estimated oilcake supply shifts with the use of past production trends. The period of 1990–2000 was selected to ensure that the effects of the markets' structural changes (during 1997) on supply were also accounted for. To measure oilcake demand shifts, protein meal consumption was determined by means of estimating demand for animal products, from where the expected income and population growth rates assisted to determine future demand for the animal products, and ultimately for protein meal. These demand projections were made for 12 countries, as well as the European Union (EU) countries. Concerning the final parameter, income elasticities of demand for protein feed were accepted here to be derived from the income elasticity for livestock products (McGuigan & Nieuwoudt, 2001). Since income elasticities for specific foods tend to decline as a result of increasing incomes (Tomek & Robinson, 1990, as cited by McGuigan & Nieuwoudt, 2001), it is fitting that income elasticities should be adjusted in the process of making long-term projections (USDA, 1997, as cited by McGuigan & Nieuwoudt, 2001). For emerging economies with high GDP growth rates, declining elasticities were used, whereas with developed economies, the income elasticities were left stable. The McGuigan and Nieuwoudt model has an advantage as it can take consideration of a great number of alternatives, and could be useful in making long-term projections of protein feed demand and supply, considering its focus on protein feed demand among animals, and the parameters incorporated.

Lastly, De Jager (2016) conducted a study to forecast estimates of protein for animals in South Africa. Among other methods, the APR_OPT model was used in this study to quantify and model the protein interactions between human, animal and protein plant sources. This model is an optimisation of the Agricultural Products Requirements (APR) model, which was developed by Briedenhann (2001). To provide an illustration of the functioning of this model, Strydom (2009) studied the economic impact that maize-based ethanol production could potentially have on the South African animal feed industry with the use of the APR model. These are impacts such as replacement of raw materials in animal feed, the price sensitivity of raw material prices, the changes in feed expenses, and the consumption of distiller's dried grains with solubles (DDGS) by different animal species.

According to Strydom (2009), the APR model calculates the animal feed consumption in South Africa at the least total amount of costs. This, of course, while taking into consideration the availability of raw materials with their relevant prices. The APR_OPT is an optimisation of the APR, with the difference being that the APR_OPT measures animal feed consumption as well, but specifically within every animal category. The model uses linear programming with a focus on animal feed demand, raw material availability and prices to determine raw material requirements. LP minimises the cost per unit of feed, emphasising the attainment of minimum nutrient requirements and any other constraints.

Considering that the success of triticale as an enterprise will depend on its demand in the feed market, it is fitting that the APR_OPT model be used in this study. This model will conceive the nutrients that triticale offers at a certain price level and, based on that, will determine its substitutability over other raw materials. This will set a price at which there is a reasonable quantity that can be substituted into the formulation, and then one can determine whether that price is profitable through budget analyses.

2.5 Conclusions

The chapter started by discussing the concepts of feasibility as compared with viability. From literature, it was clear that feasibility refers to the ability to produce, given the nature and availability of resources, while viability refers to the ability of an enterprise to sustain the farming household and to increase the net worth of the farming business. With this being said, triticale was considered as a feasible option in the WCP. The financial viability of triticale will therefore be determined, based on its profitability compared with milling wheat.

It was resolved that if triticale is more profitable compared with milling wheat, it will be considered as being a financially viable alternative The availability of crop selection methods was then considered with regard to which methods would enable the study to select between milling wheat and triticale, based on profitability. Considering that there are mono- and multi-attribute objectives selection methods to choose from, it was noted that the similarity of triticale and wheat as crops permits one to look past the minor differences of resource use and environmental impact, and focus solely on profitability, thus justifying the use of a mono-attribute objective method. Studies from Adisa and Sofoluwe (2013), Nelson and Meikle (2001) and Lu et al. (2003) provided valuable insights into the approach to comparing gross margins; thus performing a budget analyses, specifically with regard to the circumstances that could greatly affect the outcome.

The items of data required for a budget analysis, including yield, price and production costs, were revealed. Although such data can be obtained directly, it is necessary to use a method to project a price for triticale that is not derived from another commodity's value. Methods that could assist in estimating demand and price for triticale, based on its value as a raw material, were then discussed. Of these, the APR_OPT model can be considered to be the best suited, as it can determine the demand for animal products for the WCP, with the use of data from the BFAP model, from which one can then determine raw material demand at the raw materials' respective costs.

Apart from the APR_OPT model, there are important principles from the other studies to consider with the use of the chosen method, which will assist in determining demand and price. Of these principles, one from Brennan et al. (2002) is specifically important, and this entails including an arbitrary quantity into the model, creating a hypothetical raw material supply, which the model will use to evaluate the added feed grain's nutritional characteristics and estimate demand levels at different prices. In addition, one can adopt the assumption that grain producers will only produce feed (triticale) if it provides at least as much return as the feed grain (in this case the grain, milling wheat) it replaces does.

In Chapter 4, the functioning of the methods will be further discussed to fully comprehend the principles on which the results will be based. The following chapter, Chapter 3, provides an overview of the wheat industry, the WCP feed industry, and the usefulness of triticale as an alternative feed.

Chapter 3 – Industry Overview

3.1 Introduction

The focus of this chapter will be to provide a broad industry overview of both wheat and triticale, and of the animal feed manufacturing sector in the Western Cape Province (WCP) as a potential market for triticale. The aim is to provide the reader the opportunity to gain a better understanding of the industries in question, and by doing so, provide the necessary context for the interpretation of the results to follow in the subsequent chapters.

The first part of the chapter will be dedicated towards an international overview, providing information in terms of the main role players and trends as far as production, consumption, prices and trade are concerned. This will be followed by an overview of the local industry, the animal feed manufacturing sector and finally, the potential for triticale.

3.2 Global wheat industry

3.2.1 Production and consumption

Overall, global wheat production has continuously increased since 1990, reaching an estimated 751.2 million tonnes at the end of the 2017/18 marketing season. Although generally on the up, (see Figure 3.1) cyclical movements are clearly visible. Moreover, the increase in production also led to an overall positive trend in terms of world stocks, which reached a historic high in the 2017/18 marketing season. Periods that show declining world stocks can, according to Van der Merwe (2015), be attributed to higher producer prices, resulting from supply and demand factors.

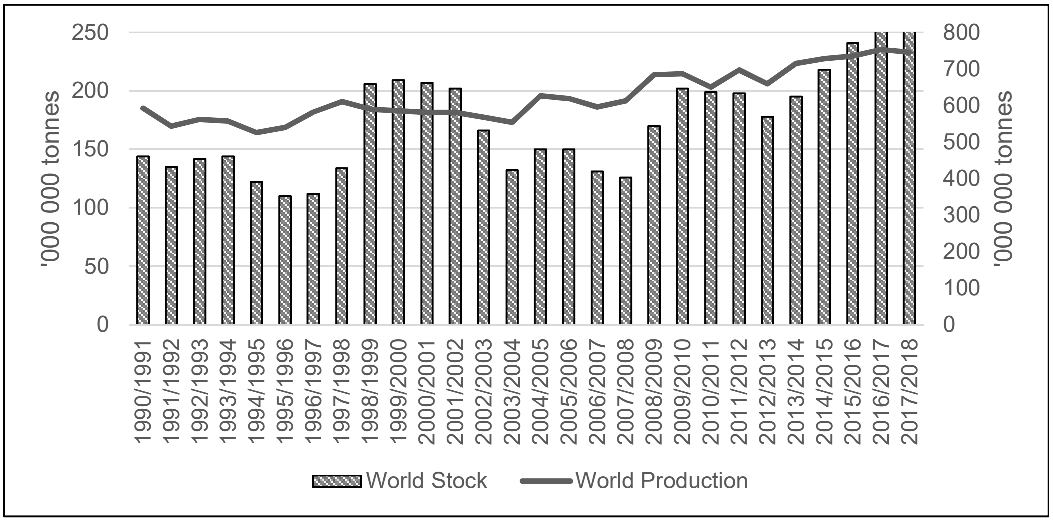

Figure 3.1: World wheat stock and production (1990/91 to 2017/18)

Source: SAGIS (2017b)

Figure 3.2 provides an overview of the wheat producers during 2017/18, indicating their shares in total tonnes produced. The European Union (EU), China, India, Russia and the United States of America (USA) are the largest producers, accounting, on average, for two-thirds of global wheat production over the past decade. France, Germany, the United Kingdom and Poland are amongst the main wheat producers in the EU. France and Germany account for an estimated 42% of wheat production in the EU (FAO, 2017).

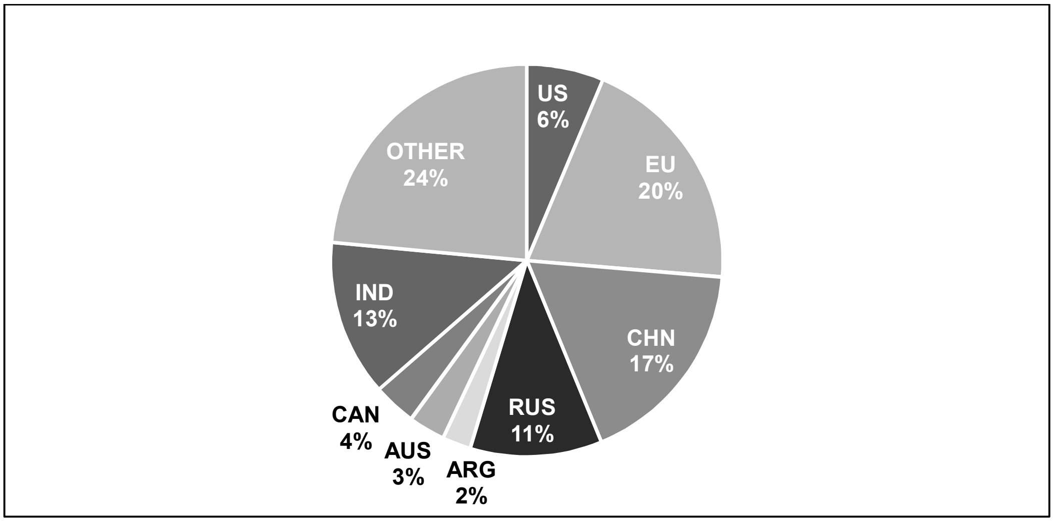

Figure 3.2: Global wheat production for 2017/18

Source: USDA (2017b)

While Figure 3.2 indicates the share of wheat production, Figure 3.3 provides a broader perspective in terms of the tonnage and the production growth rates of the different countries. Russia and Ukraine are amongst the countries with the highest growth rate in terms of production, expanding by 57% and 62%, respectively, since 2000/01. On the contrary, the United States and South Africa reported declines in production of 28% and 37%, respectively, over the same period in time. The period of 2007/08 carries significant relevance, as certain regions (EU, USA, Canada and Australia) depict lower production figures compared with 2000/01, which relates to the hike in wheat prices during that time.

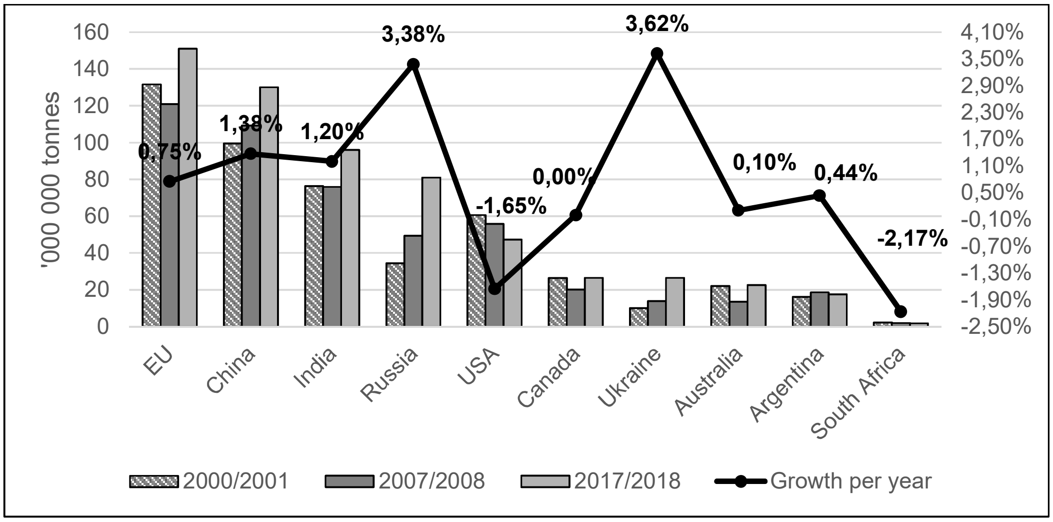

Figure 3.3: Wheat production per country and annual growth rate (2000/01 to 2017/18)

Sources: USDA (2017b) & SAGIS (2017a)

One will notice in Figure 3.4 that India and Russia are the countries with the highest amounts of hectares dedicated to wheat production. Unfortunately, recent data concerning the wheat area and yields of India are not available, but nonetheless, one can see modest growth for the period of 2000/01 to 2007/08. However, since 2000/01, there has been a considerable number of countries that have reduced their areas of wheat production, of which South Africa had the highest decrease per year (-5.29%), followed by the USA (-2.42%), Canada (-1.31%), Argentina (-0.84) and China (-0.61%). Interestingly Canada, Argentina and China have, despite lower areas harvested, maintained or even increased their levels of wheat production, indicating increased productivity.

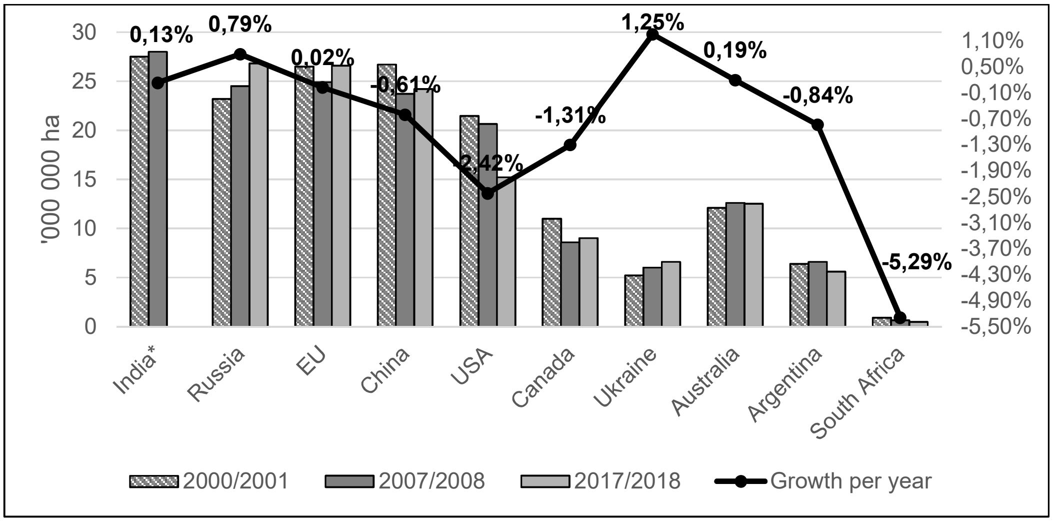

Figure 3.4: Wheat harvested area per country and annual growth rate (2000/01 to 2017/18

Sources: USDA (2017b) & SAGIS (2017a)

Having perceived the amounts of wheat produced by these countries, it is interesting to note the differences in efficiency of these countries, with some producing on much larger areas, while others produce more on less land due to higher yields. Figure 3.5 also provides an illustration of which countries manage to increase yields through research and development (R&D). Of these, Russia and Ukraine have shown the most growth, with the total growth in yields since 2000/01 being 52% and 50%, respectively. Considering these countries' growths, both in area of production and in yields, they might soon surpass other major role-players in the global wheat industry.

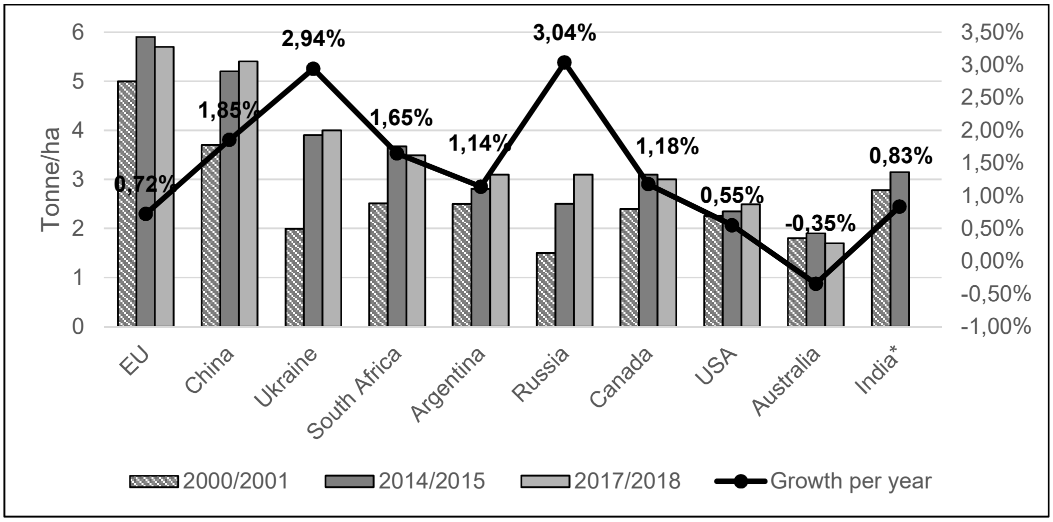

Figure 3.5: Wheat yields of countries and annual growth rate (2000/01 to 2017/18)

Source: USDA (2017b) & SAGIS (2017a)

When considering the amount of wheat that is produced globally, the amount seems impressively large, but it is worthwhile to mention that the growth rate in global wheat production has declined in recent years. It is concerning that the growth of total wheat production has declined from 2.1% per year (1961–1990), to only 0.17% per year (1990–2017), with the rate of decline in the area of wheat production being 0.28% per year since 1990 (USDA, 2017a). Additionally, during 2017 as much as 18% less wheat kilograms were produced per capita than was the case during 1990 (Pardey, 2011). The decline is not a trend among all crops, as none of the major crops (maize, rice and soybeans) recorded declines in per capita production since 1990, and interestingly, wheat consumption has increased at a faster rate than all other cereals (Kearney, 2010). The global declining trend in wheat productivity can be attributed to the reduced growth of expenditure on agricultural research and development (R&D) in several countries, as well as a trend moving away from farm-productivity-oriented R&D (Pardey, 2011).

The declining wheat productivity is a matter of concern, considering that in several regions of the world, wheat fulfils a very important role as a source of nutrition, as is especially the case in the countries of the Central and West Asian and North African (CWANA) region. In the CWANA region, the average wheat consumption is approximately 200 kg/capita/year (Tadesse et al., 2016), and provides up to 45% of the calorie intake of people in the region. In general, wheat contributes 20% of the world's total dietary calorie and protein intake (Shiferaw et al., 2013).

Figure 3.6 provides the growth in global wheat consumption and trade from 1990/91 to 2017/18. Since 1990/91, global wheat consumption has increased from 569 million tonnes, with a 23% increase being projected (at 738 million tonnes) in 2017/18. Periodic developments and a rising global population, which is currently estimated at 7.55 billion for 2017 (FAO, 2017), have ignited globalisation and created the need for ease of trade in foodstuffs. Globalisation and ease of trade have contributed to an increase in global wheat trade of 49% since 1990/91 (SAGIS, 2016), which increases the availability of wheat globally and supplements global consumption.

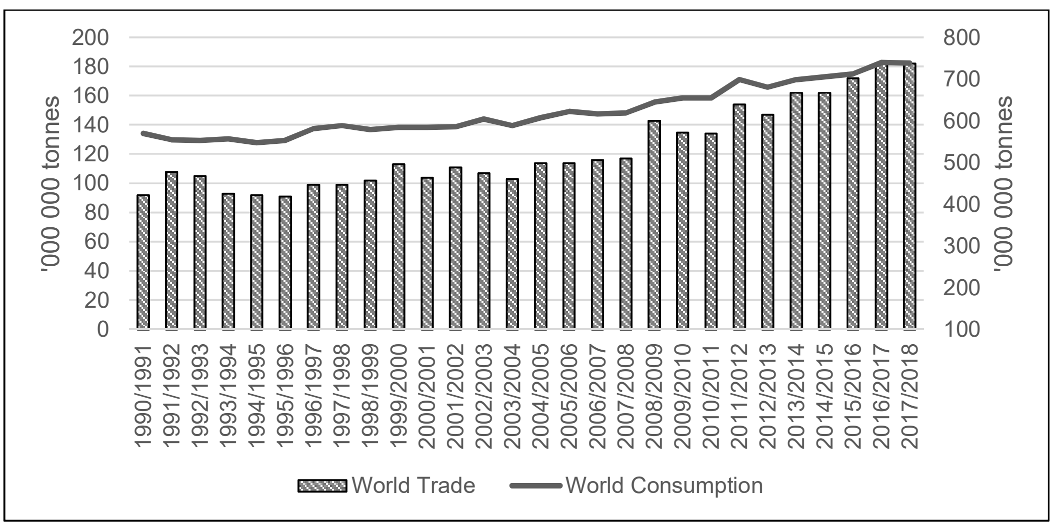

Figure 3.6: World wheat trade and consumption (1990/91 to 2017/18)

Source: SAGIS (2017b)

3.2.2 International wheat prices

From 1999 towards 2006, a gradual increase in wheat prices was recorded, followed by a dramatic spike during 2007 and 2008, being the exact period during which the previous global recession took place. Analysing the food and financial crises during 2008 and their implications for agriculture and the poor, Von Braun (2008) noted the sharp price increases of various food types, with wheat and maize prices being three times higher than at the beginning of 2003, and the rice price being as much as five times higher. Headey and Fan (2008) also assessed the causes and consequences of this dramatic event, and attributed much of the increase in food commodity prices to the historic high oil prices, considering the unprecedented Brent crude oil price of $145.16 per barrel during July 2008 (Grain SA, 2017c). This resulted in the rising costs of fuel and fertilisers, accounting for 20% of wheat price increases (Headey & Fan, 2008). Additionally, weather shocks negatively affected wheat production, as can be seen in the decreases in production among regions such as the EU (10.9 million tonnes, relating to a 7% decrease), Australia (8.5 million tonnes, relating to 38%), and Canada (6.4 million tonnes, relating to 24%).

Figure 3.7 gives a representation of US Hard Red Winter Wheat No.2 (US HRW) price movements, since it is used by policy-makers in South Africa as the reference price for international milling wheat. As this a representation of USA wheat prices specifically, it is worth mentioning that the then depreciating US Dollar had an effect on the increased prices of the country's commodities (Headey & Fan, 2008). Subsequent to 2008, the wheat prices have moved towards more modest levels, and have in fact undergone a declining trend since then.

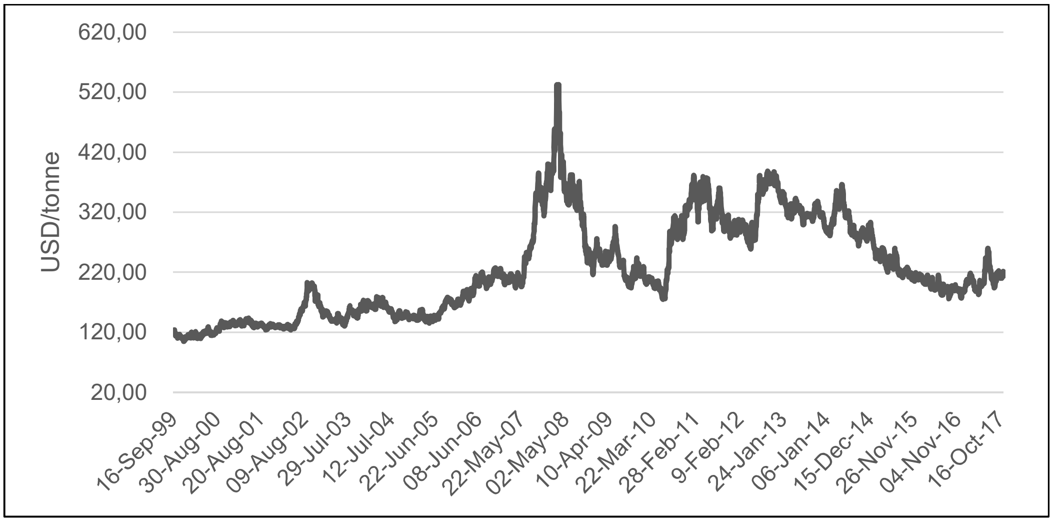

Figure 3.7: US HRW price since 1999

Source: Grain SA (2017c)

Figure 3.8 below provides a closer view of the price movements of US HRW and Argentinian milling wheat since January 2007 to illustrate movements in international milling wheat prices in reaction to production levels. It is evident how wheat prices in the USA and in Argentina, as a representation of the international market, have gradually decreased, and the cyclical pattern of the milling wheat prices for the past couple of years is also worth noting. One should be aware that all markets move in cyclical patterns (Nistor & Radu, 2011), and are always likely to have turning points after long periods of increases or decreases.

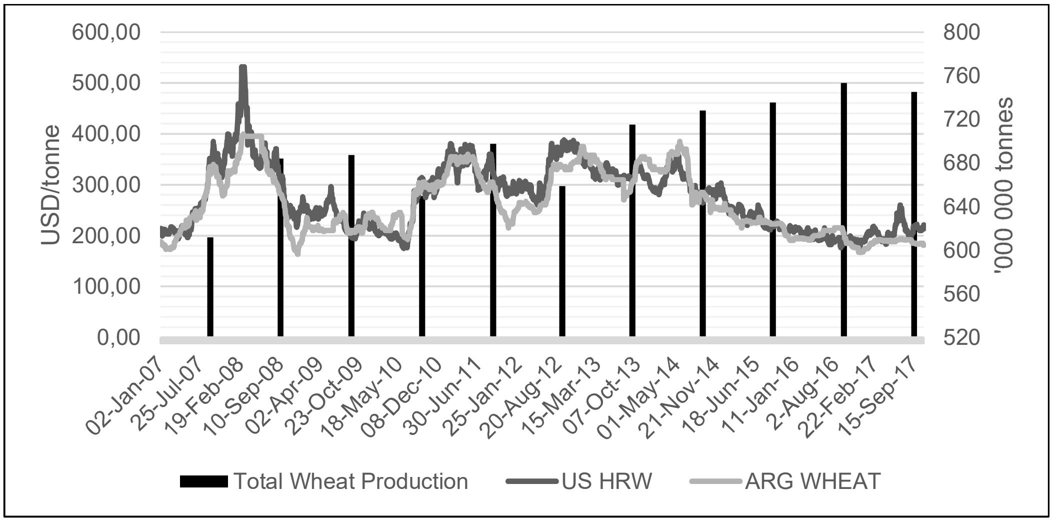

Figure 3.8: International Milling Wheat Prices and Production

Source: Grain SA (2017c) & USDA (2017a)

A possible explanation for the declining trend subsequent to 2008 could be the increased efficiency in wheat production in recent years, which might have caused milling wheat prices to decline. Although it was noted earlier that there has been slower growth in R&D expenditure, a closer examination of more recent years reveals how several countries have managed to increase productivity by improving the quality of seed produced and with the use of improved genetics and genomics (Morgounov et al., 2005), as one can observe a 16% increase in average wheat yields in the USA over the past ten years. Improved efficiency has a negative effect on prices, which could act as a disincentive for wheat production (Widmar, 2016).

The hindrance of a lower price is smaller when it can be compensated by increased productivity or with subsidies, as seen in the EU, where Rizov, Pokrivcak and Ciaian (2013) made mention of €50 billion annual expenditure by the EU on its Common Agricultural Policy, which is mainly aimed towards supporting farmers' income and to improve the environmental impact of agricultural production. Considering that there are no subsidies allocated to commercial farmers in South Africa, and the increasing volatility of global food commodity prices (FAO, 2009, as cited by Rizov et al., 2013), the competitiveness of South African wheat production in the international market is placed under severe pressure.

3.2.3 Trade

Although China and India together account for 30% of global wheat production, as well as 37% of the global population (FAO, 2017), these countries are interestingly not at the forefront of global wheat trade. The majority of these countries' crops are consumed locally, and can with the addition of rice production (among others) prove to be sufficient. During certain years, however, these countries have undergone fluctuations in wheat imports, which for China can be accredited to shifts in governmental policy over the past two decades (Sekhar, 2010, as cited by Van der Merwe, 2015), or in India's case, occur to refill depleted wheat stocks (Bhosale, 2017). The largest participants in the global wheat market are described in Figure 3.9 and Figure 3.10, indicating the average export and import amounts of the leading participants for 2016/17. Figure 3.9 illustrates the leaders in wheat, flour and wheat product exports. Of these participants, Russia (15.6%) has the highest contribution of the 2016/17 global amount of 179.6 million tonnes of wheat exported, closely followed by the USA (15.5%), the EU (14.8%) and Australia (12.8%). Of the EU countries, France (21%) and Germany (17%) have the highest contributions of the EU crop (FAO, 2017).

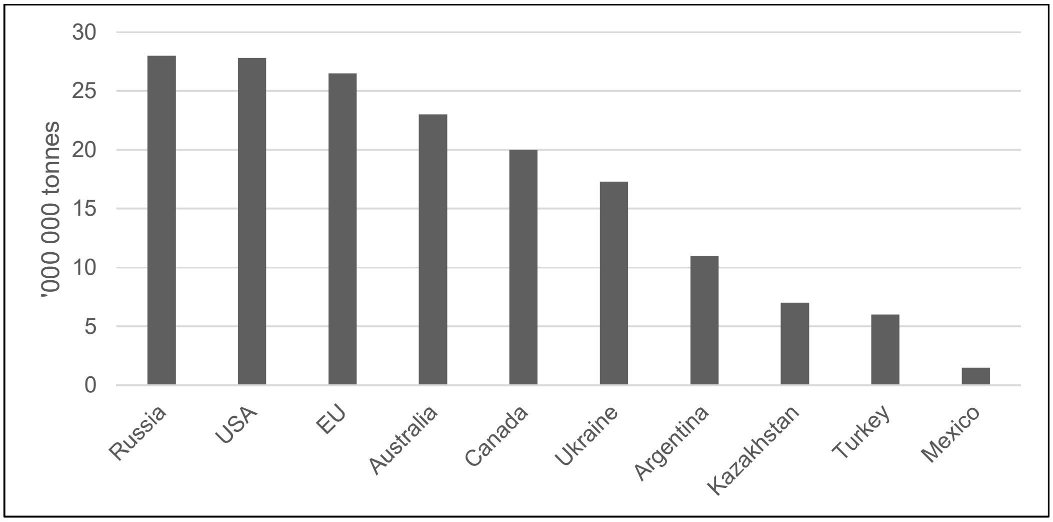

Figure 3.9: 2016/17 global wheat exports

Source: USDA (2017b)

Figure 3.10 provides an overview of the main wheat importing countries. Based on the 2016/17 amount, Egypt is the leading importer, accounting for 6.4% of global imports of wheat, flour and wheat products. This is followed by Indonesia (5%), Algeria (4.6%) and Brazil (4.1%).

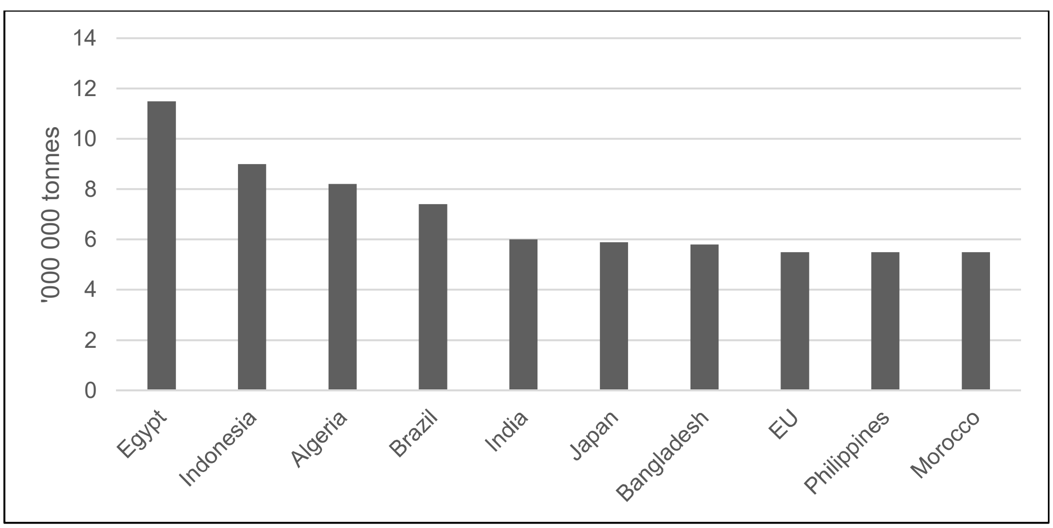

Figure 3.10: 2016/17 global wheat imports

Source: USDA (2017b)

3.3 Local wheat industry

3.3.1 Production

For the 2016/17 season, South Africa produced 1.9 million tonnes of wheat, on an area of 508 365 ha, which is, on average, 10.3% of the total cultivated area for field crops in the country (SAGIS, 2017a). Figure 3.11 indicates that among all of the provinces, the WCP is the largest producer of wheat in South Africa, contributing 58% to total wheat production. This is followed by the Free State Province (FSP) and the Northern Cape Province (NCP) with 16% and 14%, respectively (Grain SA, 2017a).

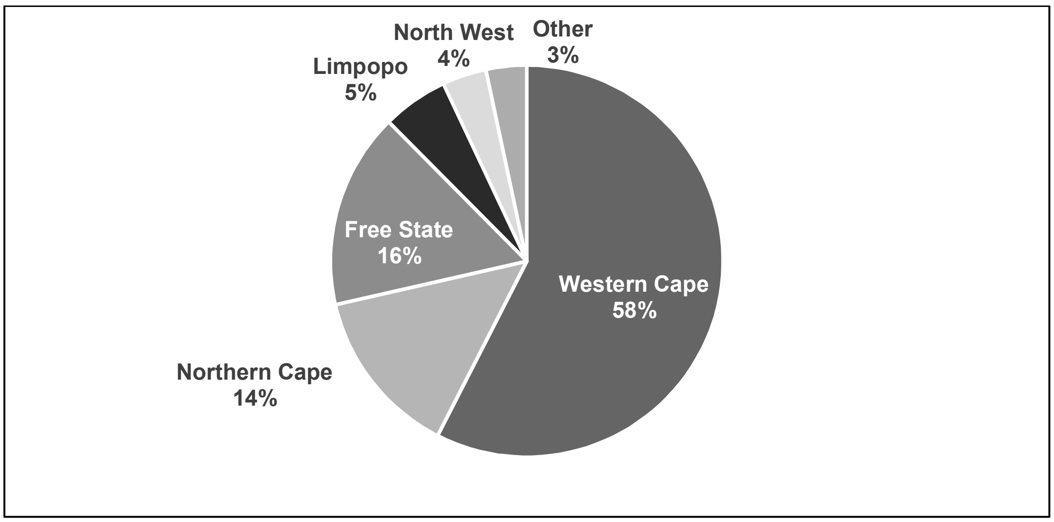

Figure 3.11: 2016/17 wheat production per province
Source: Grain SA (2017a)

3.3.2 Western Cape

Figure 3.12 illustrates the production, area and yield of wheat in the WCP, from 1997/98 to 2017/18. Despite 24% fewer hectares in the WCP being dedicated to wheat production, a 56% yield increase (from 1.51 tonnes per ha to 3.4 tonnes per ha) has seen the province, producing a record amount of 1.1 million tonnes in 2016/17, 45% more than in 1997/98. Apart from occasional dry seasons, the WCP amount of wheat produced has gradually increased over the past two decades. There are different regions in the WCP in which wheat is produced, with the Swartland and the Southern Cape being the most essential wheat-producing regions.

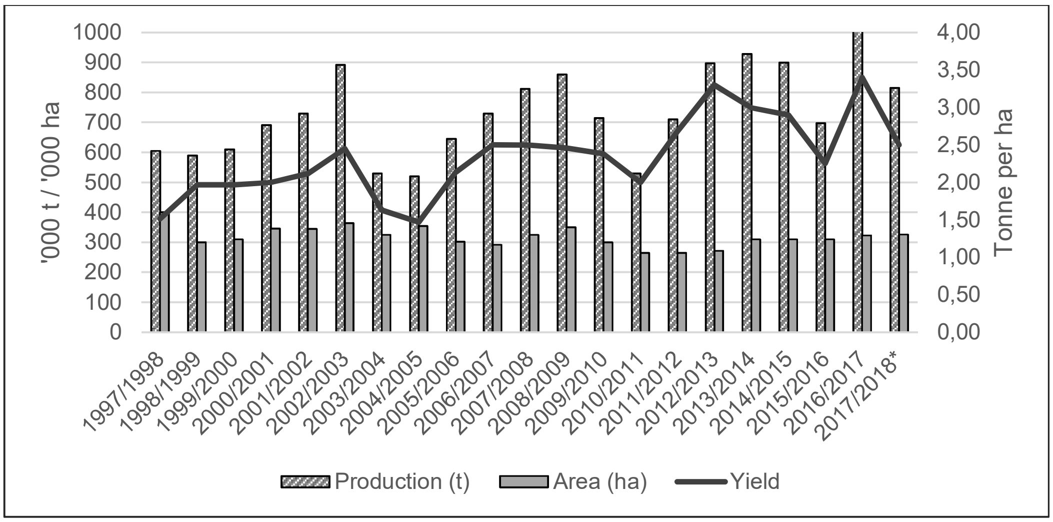

Figure 3.12: Western Cape wheat production, area and yield (1997/98 to 2017/18)

Source: Grain SA (2017a)

Figure 3.13 and Figure 3.14 reflect the actual production figures that were compiled by Grain South Africa. Wheat production in the Swartland region, as depicted by Figure 3.13, indicates varying profit levels in recent years, and even losses in certain years. These losses can be attributed partly to location differentials, without which WCP producers could have actually made profits, or at least marginalised the losses. The producer price for 2009 presents a good example, considering Swartland's price of R 1 603.15 per tonne, as opposed to R 2 115.00 per tonne in the eastern FSP (Grain SA, 2017d). Low yield levels also attributed to losses, as one can derive from Figure 3.12 that 2004 had the lowest yield level.

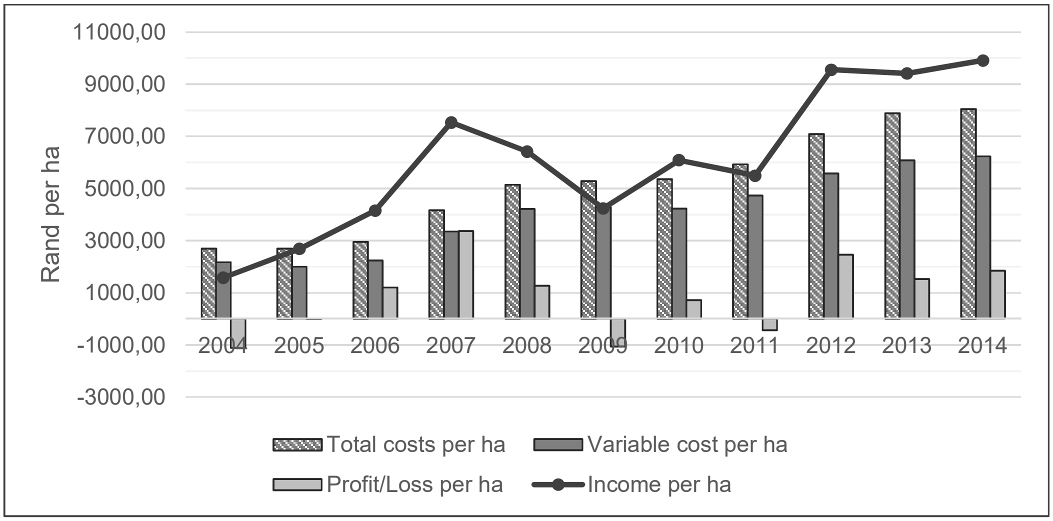

Figure 3.13: Production cost per ha, income per ha and profits/losses from wheat production in the Swartland from 2004 to 2014

Source: Grain SA (2017d)

The Southern Cape (in which the Overberg region is included) also indicates fluctuations in profit margins obtained by producers (Figure 3.14). Variable costs, rising from R 2 253.54 per hectare in 2004 to R 7 050.79 per hectare in 2014, have called for much improved efficiency in terms of South African Rands (R) spent per tonne harvested. Much like the Swartland, the Southern Cape is also severely affected by location differentials, considering that this region obtained an even lower producer price during 2009, at R 1 576.48 per tonne.

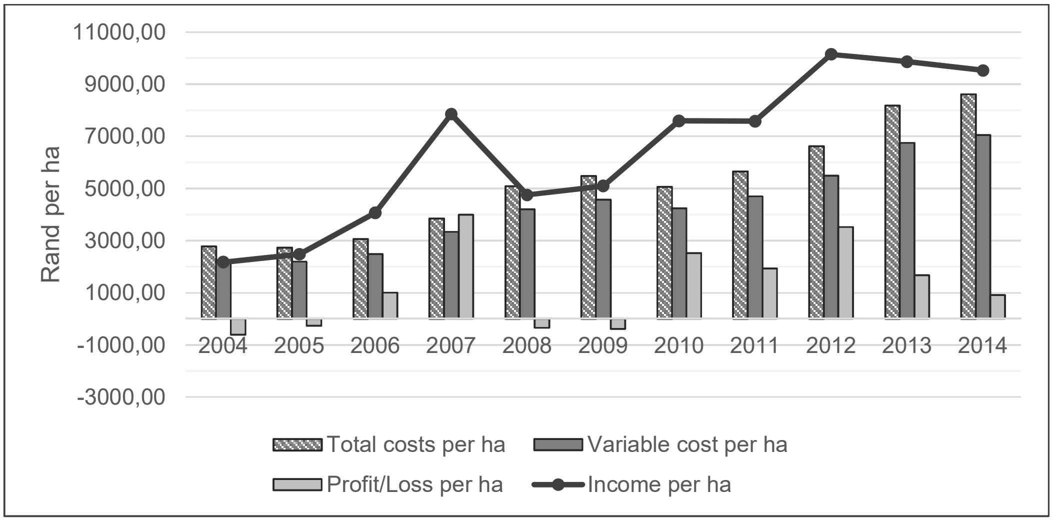

Figure 3.14: Production cost per ha, income per ha and profits/losses from wheat production in the Southern Cape from 2004 to 2014

Source: Grain SA (2017d)

3.3.3 Free State and Northern Cape

Although the focus of this study falls upon the region of the WCP, it is important to mention other key areas of wheat production as well, as this provides more background of South African production, and also provides context to the problem of the WCP not being suitable for summer crop production.

In the sphere of domestic wheat production, the NCP is a region worth noting. Wheat production in the NCP is done under irrigation, which enables the province to produce at yield levels way higher than other provinces. Despite a 71% decrease in the area of production, the amount produced has only declined by 3% (Figure 3.15).

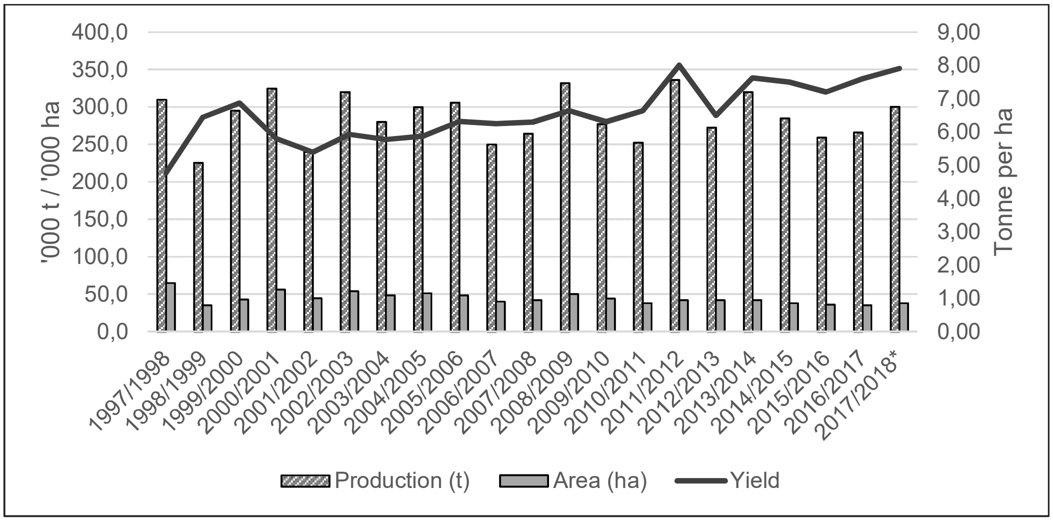

Figure 3.15: Northern Cape wheat production, area and yield (1997/98 to 2017/18)

Source: Grain SA (2017a)

Earlier, when discussing the international wheat industry, it was mentioned that the global area of wheat production has declined. It is the case for the NCP, as seen above, and this is especially the case in the FSP, where an immense decrease in the area of wheat planted in South Africa has been recorded (Grain SA, 2017a), with its current area of production being almost ten times lower than two decades ago. For many years, the FSP was the leading wheat producer in South Africa, producing in some years almost double the amount of its WCP counterpart. Figure 3.16 clearly indicates the dramatic decrease in FSP wheat production.

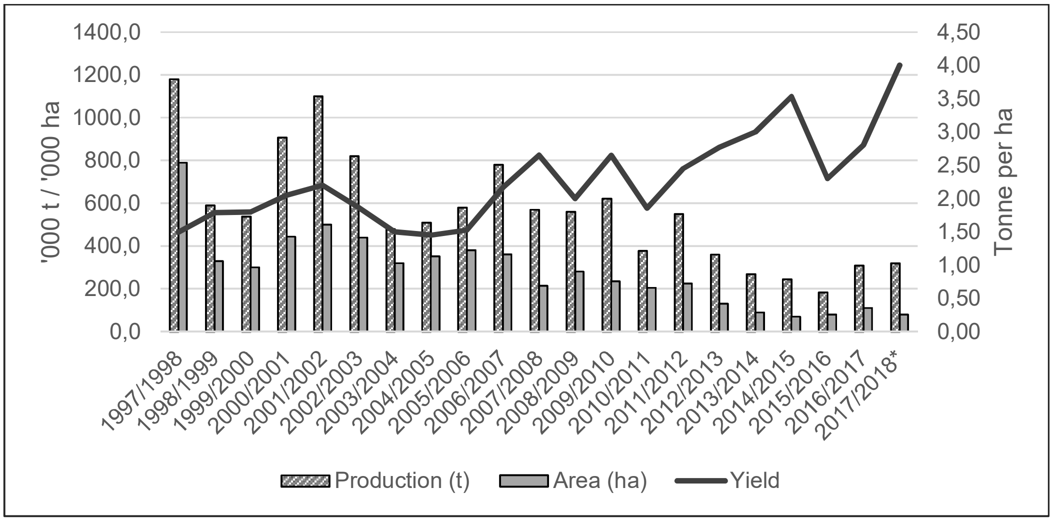

Figure 3.16: Free State wheat production, area and yield (1997/98 to 2017/18)

Source: Grain SA (2017a)

Apart from the significant drop in the area of maize production during an extremely dry 2015/16 season, a strong increase in maize production is evident in Figure 3.17. To make way for maize production, the area of wheat produced in the FSP declined by 71% since 2005 (Grain SA, 2017a).The FSP provides a good example of what happens when farmers have the option of planting other crops that are more profitable. Unfortunately, the WCP farmers cannot make the same transition, since summer crops are not suited to the area. This leaves the WCP farmers with very few options.

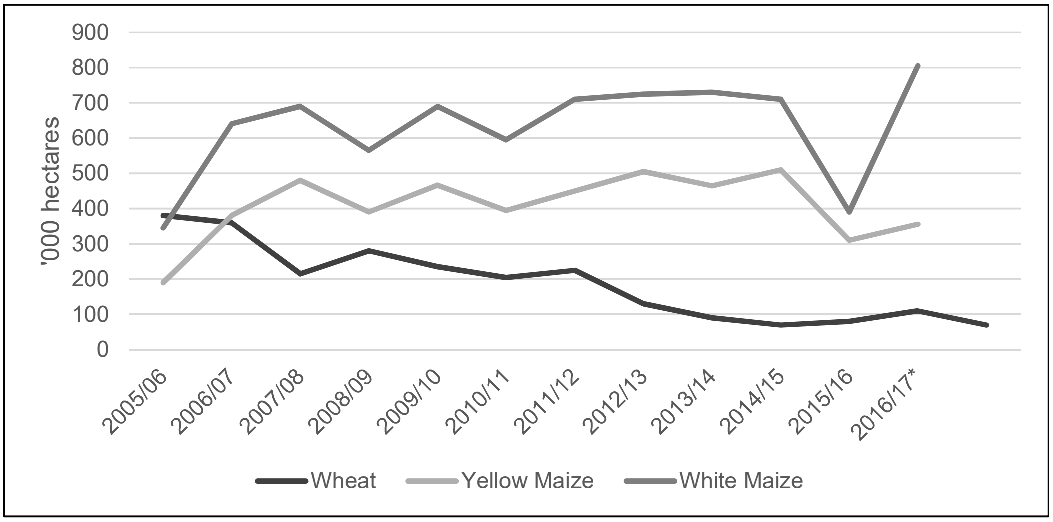

Figure 3.17: Area of production in the Free State Province

Source: Grain SA (2017a, b)

Several factors influenced the FSP's transition away from wheat production, such as the risk of weather patterns in the province. However, one should also note the changes made in the market structure during 1997, which have had a dramatic decreasing effect in the area of wheat production of South Africa subsequent to that. During the 1997/98 production season, South Africa still produced on 1 382 300 ha, but by 1999/2000, this area decreased to 718 000 ha, thus by 48% (Grain SA, 2017a). The area of wheat production for 2016/17 was only 508 365 ha. Before discussing the effects of the change in market structure, it is first important to provide background of the South African wheat value chain to understand the influence that concentrated buyers can exercise in such a value chain.

3.3.4 South African wheat value chain

Wheat grain is regarded as being one of the most important grains, globally, and is used for human consumption as well as the production of animal feed (Heuzé et al., 2015b). In South Africa, milling wheat is the second most important grain crop, accounting for 2.4% of total gross value of agricultural products (DAFF, 2017). The local wheat value chain consists of various role players, each making a notable contribution towards the effectiveness and efficiency of the wheat value chain. Figure 3.18 below provides an illustration of the various role players and stages of wheat, from farm to consumption.

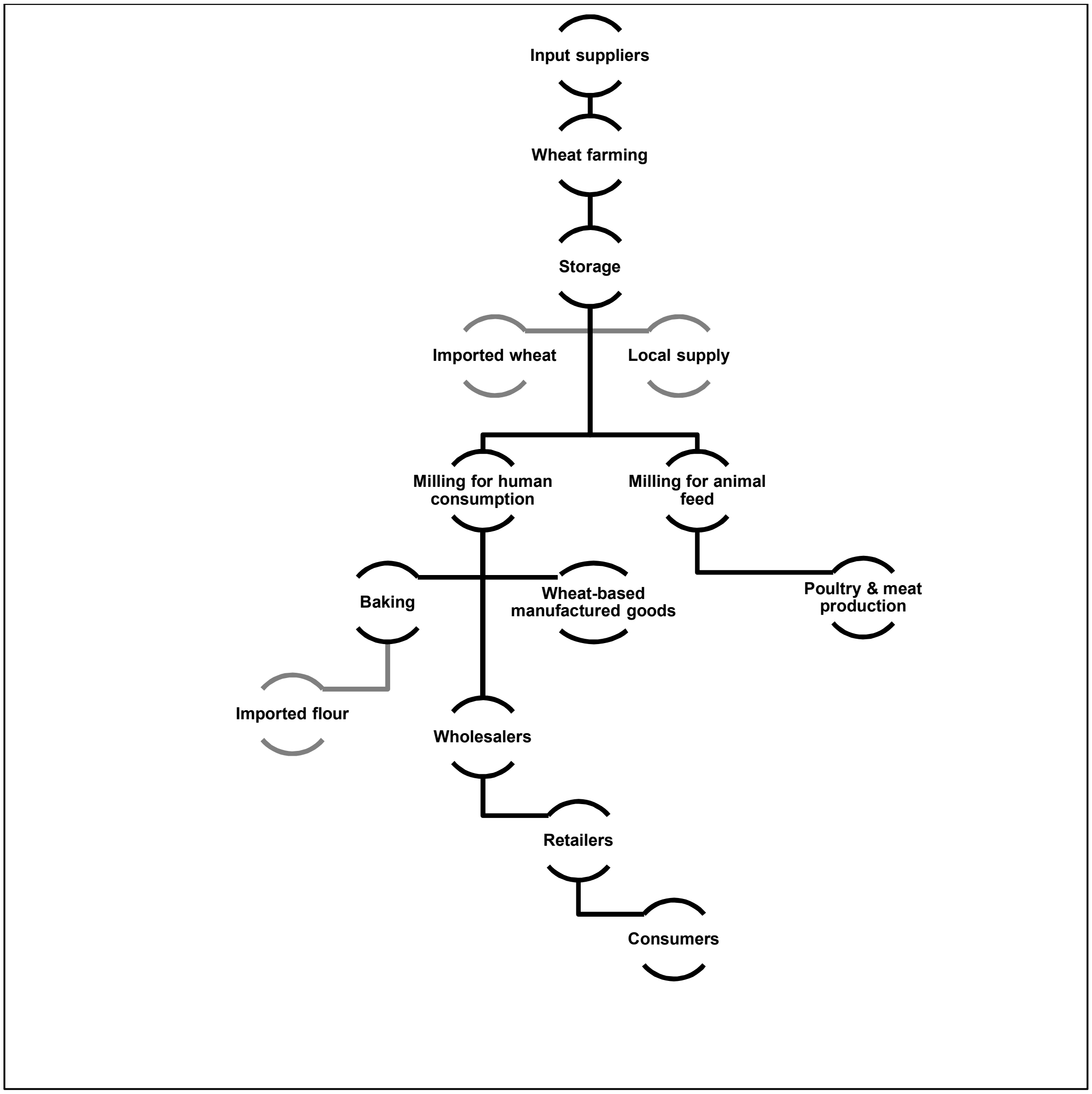

Figure 3.18: Wheat market value chain

Source: DAFF (2016b)

On the primary level, role players include input suppliers that provide resources, such as seed, fuel, fertiliser and equipment, to farmers. Wheat farmers grow the wheat, which is later harvested, from where it is transported to storage facilities, along with imported wheat. The milling companies process the wheat into different forms, namely flour, meal and bran. In these forms, wheat products can be sold for consumption, or continue through to the millers to be presented and sold as baked goods (DAFF, 2016b). Apart from human consumption goods, by-products result from the production of above-named goods, which can then be utilised in other forms, as can be seen in Figure 3.19.

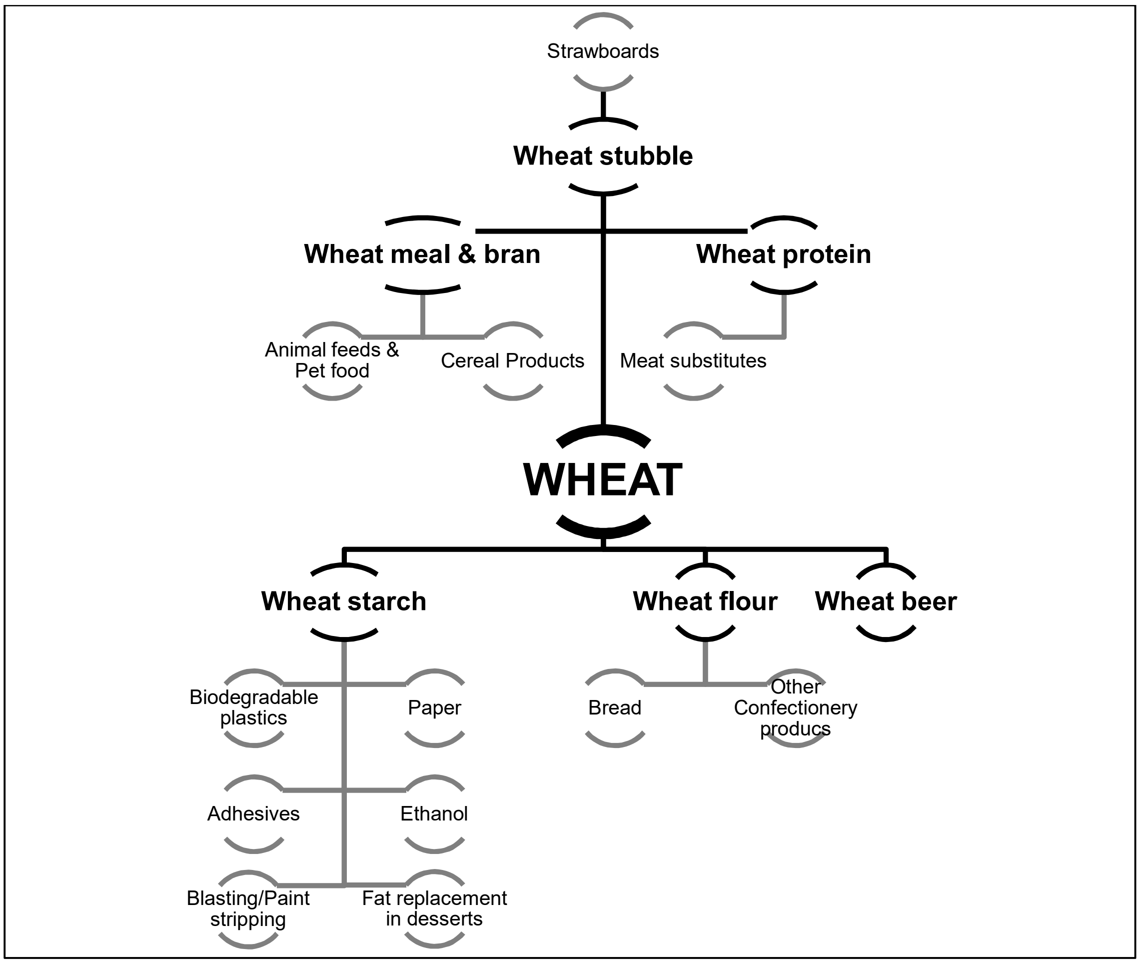

Figure 3.19: Wheat value chain tree

Source: DAFF (2016b)

Notably, there is a vast amount of products that can be obtained from wheat. For human consumption, wheat can be used for producing pasta, breakfast cereals, cookies, pastries, and bread – the main product. In addition to human consumption, wheat is also used in the production of animal feed, and from time to time is planted as pasture for animals to graze. As depicted in Figure 3.19, by-products of wheat can be processed for industrial uses, such as adhesives, paper, and strawboards for furniture (DAFF, 2016b).

To differentiate between the different types of wheat according to its different uses, wheat is classified into classes, and grades within each class. The classes include: class B (good bread baking quality) (referred to as milling wheat in this study); class C (good for cookies and biscuits) and class D (durum wheat for pasta). With regard to class B wheat, milling wheat is graded on a scale from 1 to 4, according to standards set by the Agricultural Product Standards Act, 1990 (Act No. 119 of 1990) (Government Gazette, 1998; ARC, 2017), which can be seen (with its requirements) in Table 3.1.

Table 3.1: Classes and grades of milling wheat

Grade	Minimum protein (12% moisture)	Minimum hectolitre mass (kg/hl)	Minimum falling number (seconds)
B1	12	77	220
B2	11	76	220
B3	10	74	220
B4	9	72	200
Utility	8	70	150
Class others	Do not comply to the above-mentioned or any other grading regulations		

Source: ARC (2017)

One can derive here, that for milling wheat to comply with the grading standards, it must be within the limits set by the Agricultural Product Standards Act, 1990 (Act No. 119 of 1990) (Government Gazette, 1998). When milling wheat deviates too far from the set standards (i.e., below utility grade), it can be downgraded to a feed grade, which will be used to feed animals (Robertson, 2017). The Research Technical

Committee (RTC) for milling wheat determines the standards (Van der Merwe, 2015), which are in general more favourable towards bakers and millers.

Furthermore, milling wheat is an internationally traded commodity, which leads to the local prices being subject to international price movements (DAFF, 2016b). Price determination is done by means of online trading on the JSE's (Johannesburg Stock Exchange) agricultural derivatives market, better known as SAFEX (South African Futures Exchange). Agricultural commodities, such as grains and oilseeds, are traded on the SAFEX market, and the prices are determined by buying and selling contracts according to the traders' needs in the market. The buying and selling of such contracts ultimately leads to present and future prices being established (JSE, 2016).

South Africa is a net importer of milling wheat, which means that the amount of milling wheat imported exceeds the amount of milling wheat exported. South Africa does not produce sufficient milling wheat to fulfil the domestic consumption. The countries from which South Africa imports milling wheat are mainly Argentina, Australia, Brazil, Germany, the Russian Federation, Uruguay and the United States of America (USA) (DAFF, 2016b).

Reflecting on what has been discussed regarding the quality standards and price determination of milling wheat, one can further examine the effects of the change in market structure. Prior to 1996, there was a system of control boards in place, under which several agricultural products were protected, especially in terms of prices, while these boards also controlled quality standards and both the demand and supply sides for products, such as milling wheat (NAMC, 2006). During 1996 to 1997, however, the Marketing of Agricultural Products Act of 1996 was implemented, which had the objectives to increase market access for all of the market participants and to promote efficiency in the marketing of agricultural products. Whereas the government was previously permitted to intervene on prices by fixing commodities' prices on foreign markets, and endeavoured to reduce the difference between producer and consumer prices, this is now forbidden by the Act in order to prevent unwanted intervention.

Although this succeeded in facilitating free trade for all market participants, it was not necessarily good for milling wheat producers. As Stanwix (2012) puts it: “The post-apartheid liberalisation, which was intended to generate a more competitive environment and break down these structures of power, served rather to cement monopoly control.” This statement refers to the domination of the milling wheat market by only a few major milling companies, comprising Tiger Brands, Pioneer Foods, Foodcorp and Premier Foods, which collectively control approximately 85% of the bread industry (Van der Merwe, 2015). This level of market concentration in the South African milling wheat industry (with regard to millers and milling wheat buyers) leads to a power imbalance occurring.

The power imbalance in this case causes the degree of the suppliers’ dependence towards the buyers to become relatively high (Wilson, 1995). The buyers then have the power to set strict quality standards, without rewarding the producers for good quality, since prices are determined by import parity, with South Africa being a net importer (DAFF, 2016b). This good quality is determined by factors such as protein content, hectolitre mass, and falling number (Karaman, Cetin, Oguzlar & Yagdi, 2009; Van der Merwe, 2015). A high protein content ensures that the bread quality adheres to consumer requirements; hectolitre mass provides an indication of the potential flour extraction of a grain sample; and the falling number indicates whether or not starch molecules have been broken down to sugars, causing it to be unsuitable for commercial baking and milling purposes (ARC, 2017). The RTC for milling wheat sets high standards, based on these factors, which determine the bread-making characteristics of wheat. These standards are applied to the process in which new milling wheat cultivars are released, and whether any of these might be listed as a cultivar for bakers and millers (Van der Merwe, 2015).

Fossati, Brabant and Kleijer (2011) noted that with wheat, there is a negative correlation between yield and protein content, with the latter being an essential component. Considering that wheat producers in South Africa are not rewarded for quality that exceeds the quality limits of class-B1 wheat, one could then pose the question: Is it likely that, in a pursuit for increased wheat quality, milling wheat could be bred with an exceptional quality to such an extent (beyond the necessary level) to where the yield level is too low for profitability at the given prices? Van der Merwe (2015), bearing in mind that far lower quality wheat is demanded by South African end consumers than what is required in the release criteria for wheat cultivars, questioned the similarity of the quality of price-determining wheat (i.e. wheat that determines import parity price) and the quality that is prescribed for South African cultivars. With reference to this, the remainder of this section will discuss consumption and trade of wheat in South Africa, as well as the pricing of wheat.

3.3.5 Consumption and trade

Before focusing on South African wheat trade and wheat quality, it is necessary to observe the growth in wheat consumption figures since 1990 (Figure 3.20). A gradual increasing trend in total wheat consumption can be discerned, although a decline in per capita consumption has occurred since 2009. Several factors could influence this decline, but most significantly, it could be caused by increased household incomes, which according to Halbrendt (1994), results in more expenditure being channelled to luxury foods such as meat.

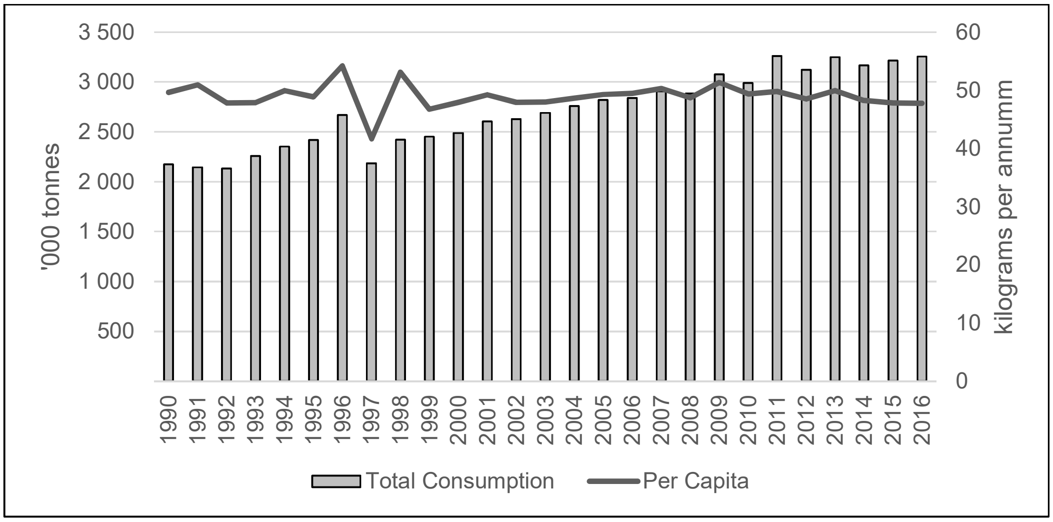

Figure 3.20: Total and per capita consumption of wheat in South Africa
Source: DAFF (2017)

To satisfy the demand for 3.25 million tonnes of wheat, considering a domestic wheat crop of 1.7 million tonnes, it is necessary to import wheat to account for the deficit. From Figure 3.21, one can see that Russia is currently the country supplying the largest amount of imports to South Africa, by a significant margin. Prior to 2011/12, no wheat was imported from Russia, at all (hence, the lower 10-year average), but imports in recent years have grown exponentially, to stand at 956 705 tonnes in 2015/16 (SAGL, 2017). The increasing imports from Russia have replaced other countries such as Germany and Argentina as key trade partners. In certain years, the Argentinian contribution to South African wheat imports have been as much as 38% (2010/11 and 2011/12) and 49% (2007/08). During 2009/10, imports sourced from Germany were as much as 63% of the total amount (SAGL, 2017), and between 2013/14 and 2015/16, imports from Russia ranged from 40% to 48%. This provides a good indication of countries that are crucial to the wheat supply of South Africa, and therefore of the importance of the conditions in these countries.

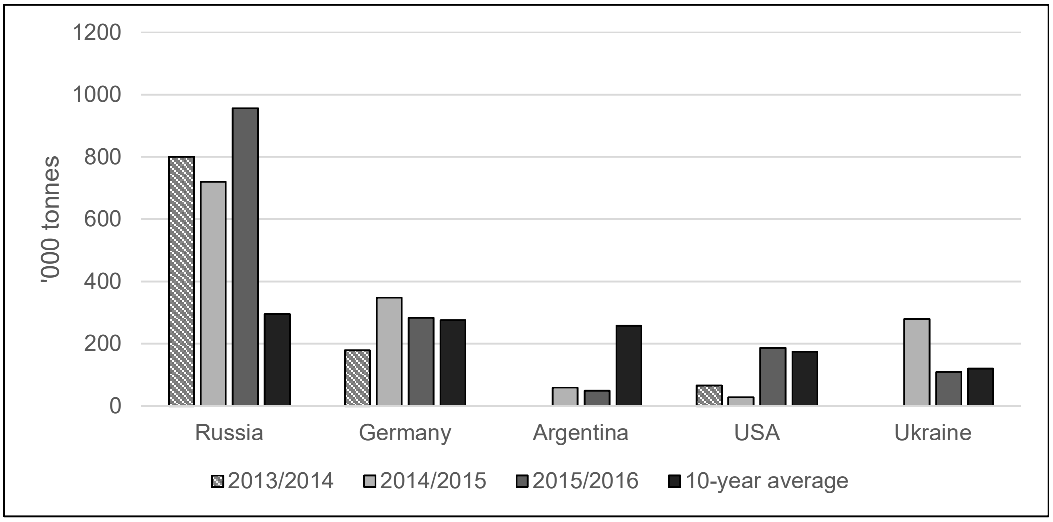

Figure 3.21: Main countries exporting to South Africa

Source: SAGL (2017)

Annually, the South African Grain Laboratory (SAGL) releases wheat reports that include a summary of the quality of wheat imported from countries with significant contributions. Figure 3.22 provides details of the average quality of wheat from these countries (Argentina, Australia, Canada, Germany, Latvia, Lithuania, Poland, Russia, Ukraine and the USA) compared with the average of the South African harvested wheat. The selected quality measures, which are used as grading criteria, are hectolitre mass (kilogram per hectolitre), falling number (seconds), and protein (percent). Considering that the standards for B1-class wheat are set at 77 kg hectolitre mass, a falling number of 220 seconds, and 12% protein content, it is seen that both domestic and foreign wheat exceed the falling number and hectolitre mass (ranging between 76–81 seconds) limits, with domestic wheat seeming to have better quality. From a protein content perspective, domestic wheat has significantly higher quality, considering 1.08 and 0.42% higher protein contents for 2014/15 and 2015/16, respectively.

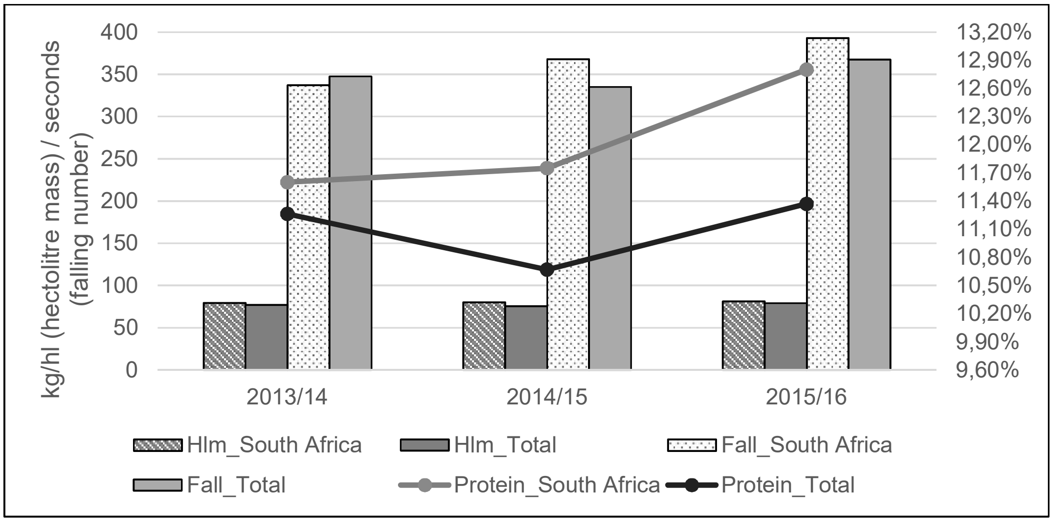

Figure 3.22: Quality of imported wheat

Source: SAGL (2017)

The results in Figure 3.22 indicate that South African wheat, regardless of a lower falling number in 2013/14, has a higher quality, in general, than the wheat that is imported from elsewhere has. This supports Van der Merwe's (2015) notion that the criteria set for domestically produced wheat might be higher than what is demanded, and therefore importers have leeway with regard to the quality of wheat imported. Considering that no distinction is made between domestic and imported wheat during processing, the pricing of domestic wheat is determined by the lower quality foreign wheat. Domestic price movements, in conjunction with foreign wheat prices, will be discussed. As a last point concerning domestic trade, it is worthwhile to mention the South African wheat exports to other countries.

The four countries listed in Figure 3.23 are all recognised neighbouring countries, and are all part of the Southern African Development Community (SADC), which is a constituted by a treaty between 15 countries with the aim, inter alia, of enhancing economic growth, alleviating poverty and enhancing the standard and quality of life of the peoples of Southern Africa (SADC, 2017). This treaty encourages free trade between these countries and, in the process of enhancing economic growth among these countries, serves to found the responsibility of each country to facilitate and assist in the trade of its SADC partners. Apart from this responsibility, the SADC group is also a well-established market for South African goods, as these countries, including Botswana, Lesotho, Namibia and Zimbabwe, do not produce sufficient food products for their own use. This is based on the fact that 80% of processed food products in those countries are imported from South Africa, as well as on the large numbers of small-scale farmers in those countries, with 80% of them being subsistence farmers (Emongor & Kirsten, 2009).

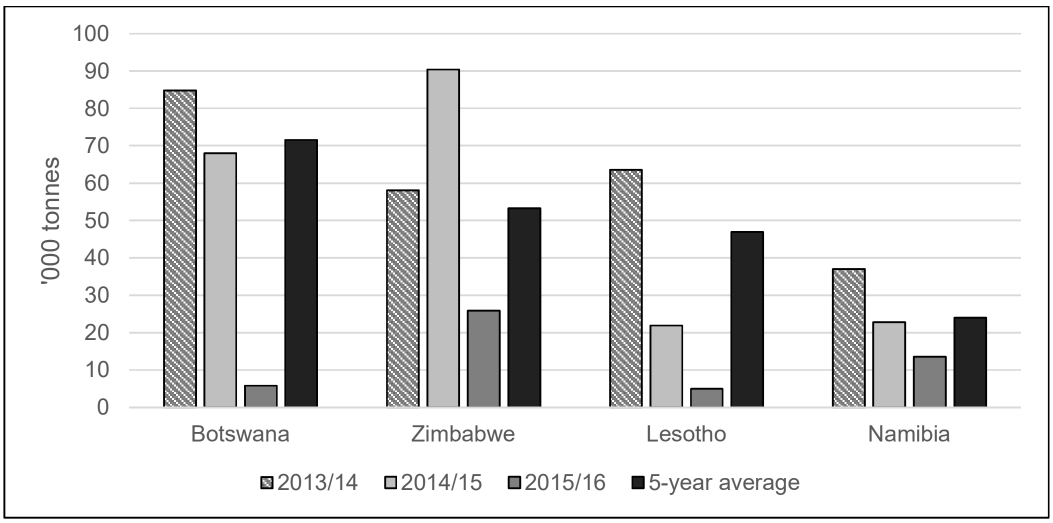

Figure 3.23: Main destinations of South African wheat exports
Source: SAGL (2017)

Neighbouring countries without coastlines, such as Botswana, Lesotho and Swaziland, are also dependant on South Africa to facilitate their global imports, seeing that South Africa exported 71 596, 46 927 and 53 300 tonnes of foreign wheat to those countries, respectively, during 2015/16 (SAGL, 2017).

3.3.6 Price

As the improving quality of South Africa's milling wheat has a negative effect on yield levels, and since the price is determinant on international milling wheat (bearing in mind other countries' superior efficiency and policy support), it has become necessary to set measures that will protect local farmers. An import tariff on milling wheat (which can be seen in Figure 3.24) has been implemented to protect local farmers from events where consumers would rather import cheaper milling wheat from elsewhere (Department of Agriculture, 2006). The formula with which import tariffs on milling wheat are determined includes the use of a reference price, which was set at $294 per tonne from 2013 (ITAC, 2013), and adjusted to $279 per tonne in June 2017 (SAGIS, 2017c). A reference price entails that whenever the price of US HRW moves below the set price, the import tariff adds on the difference. Figure 3.24 below provides an indication of the reference price in relation to the prices of US HRW, Argentinian wheat and German wheat prices.

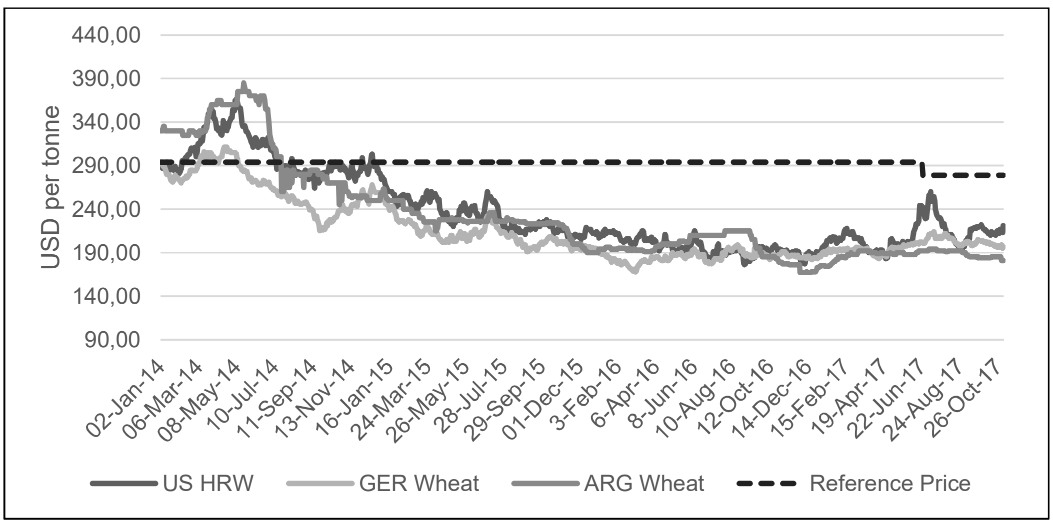

Figure 3.24: Import reference price in relation to international milling wheat prices

Source: Grain SA (2017c)

Figure 3.24 depicts international price movements to be very similar, although slight differences between US HRW and other foreign wheat prices can cause instances where imported wheat is still cheaper than domestic wheat is, regardless of import tariffs. To illustrate this point, Figure 3.25 indicates several instances where

Argentinian and German milling wheat delivered in Randfontein were cheaper than local wheat was. The international prices already include the import tariff.

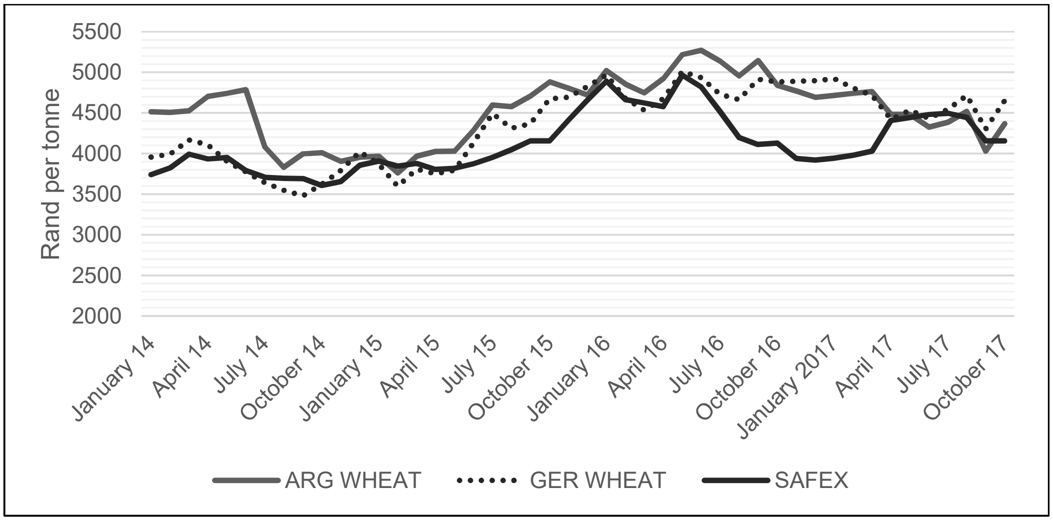

Figure 3.25: Average Milling Wheat Prices Delivered in Randfontein
Source: Grain SA (2017c)

To elaborate on the point of instances arising where imported wheat is cheaper than domestic wheat, one should consider that although the US HRW price is a good indication of international prices, differing circumstances (such as weather patterns, and differences in efficiency and exchange rates) in countries such as Argentina and Germany could cause inconsistencies. It is possible, for instance, that if the price of US HRW alone increases, the reference price could be adjusted, regardless of the price levels of Argentinian and German milling wheat; or that the import tariff amount, adding the difference between the reference price and the US HRW, could be insufficient with regard to other countries' prices. This could lead to other countries' milling wheat having a lower price at import parity than that of SAFEX wheat.

With the market environment not being as 'farmer-friendly', producers would ultimately consider producing other crops that are also suited to the area and that may be as profitable as milling wheat, or even more profitable. For a product to be profitable, though, there has to be a reasonable level of demand for it. This is why one needs to identify well-established industries in the area, with the prospect of certain needs in that market being satisfied in the process.

3.4 Evaluating a potential alternative

Since 2011/12 there has been an increase of 12.4% in feed sales among Animal Feed Manufacturers Association (AFMA) members, bringing the amount for 2015/16 to 6.9 million tonnes of feed sold. Some of the increase in feed sales can be attributed to the extreme drought conditions experienced in recent years, which generally causes producers (farming with livestock on natural pastures) to be more reliant on buying feed to sustain animals, or to finish for marketing (Agri Western Cape, 2015). Nevertheless, the increased sales points to a flourishing South African feed industry and, considering a growing population, there is much potential for further expansion. Of all the provinces, the WCP accounted for the largest share in terms of sales, at 19.64%. AFMA (2016) provides a list of the different raw materials used, of which maize had an inclusion rate of 48.42% in all animal feed sold.

Yellow maize makes up a vital part of most feed rations, being the primary source of carbohydrates. Yellow maize is produced throughout South Africa, especially in the central region. This enables a better distribution to consumers, since producers are often in the same area or close vicinity. This, however, is not the case for the WCP, with most of the maize that is consumed being imported from other provinces. In 2014/15, the total maize crop in the WCP amounted to just over 34 thousand tonnes, which was less than 10% of the total demand (SAGIS, 2016; Swarts, 2016). Considering the 2014/15 amount of yellow maize processed in the WCP for agricultural purposes, at approximately 410 000 tonnes (Swarts, 2016), one cannot help but think of the accumulating costs required to transport that amount to the WCP, especially with increasing fuel and tyre levies.

All of this points to a very expensive inconvenience. It cannot be avoided by producing yellow maize in the WCP itself, as the production in the province can only be sustainably produced under irrigation and not under dryland conditions, since the rainfall season is during the winter. Since there are not sufficient resources for yellow maize production (primarily irrigation), it is necessary to determine whether or not there are alternatives that could satisfy the same need.

Suitable alternatives to consider would be winter crops, which are suited to the WCP's conditions. Apart from wheat, winter crops include barley, oats, rye, and triticale. In this section, wheat is included as it can serve different purposes such as, in this case, feed. Feed wheat is therefore considered as an alternative, as other cultivars could potentially be viable. A suitable alternative should be a good source of energy in ruminant, pig and broiler rations. Figure 3.26 reflects a comparison of each grain's average metabolizable energy available, per kilogram of dry matter.

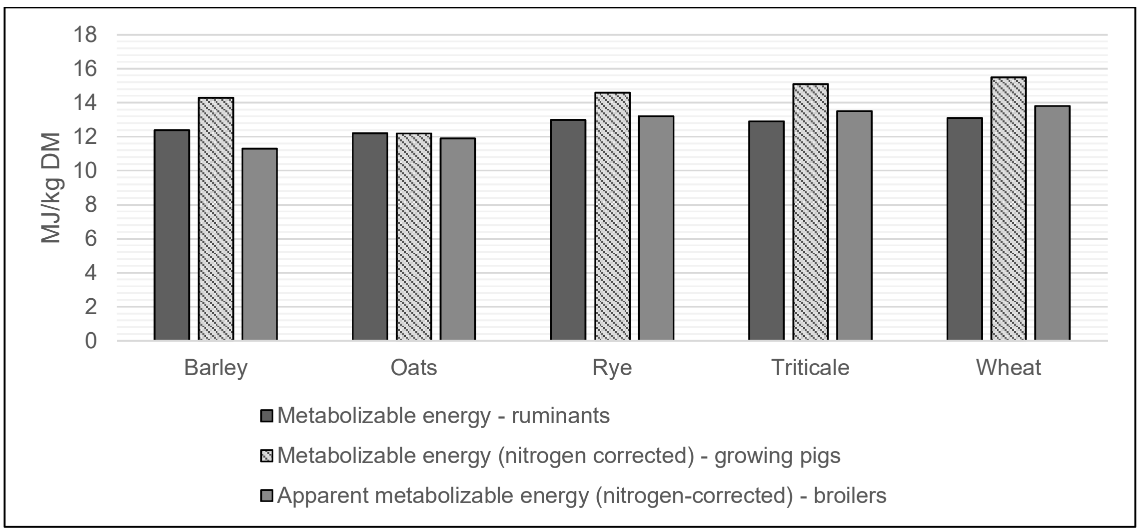

Figure 3.26: Metabolizable energy of winter crops

Source: Heuzé et al. (2015a, b) & Heuzé et al. (2016a, b)

Figure 3.26 indicates that triticale and wheat provide the most energy. Considering the lack of data available regarding feed grain wheat cultivars, and the familiarity of triticale as a feed crop, triticale is regarded as being the best alternative for the purposes of this study. Triticale was originally developed through crossing durum wheat (*Triticum sp.*) with rye (*Secale sp.*) (Ammar, Mergoum & Rajaram, 2004), to merge the attributes of wheat's usefulness in food products with rye's ability to grow in unfavourable soils and climates, as well as rye's lower input requirements (Oettler, 2005; Du Pisani, 2009). Locally, the awareness of triticale is relatively small in many circles, as it is a crop that is not commercially produced, i.e. produced to be sold in an established market, in South Africa. In Europe, however, it has been adopted by numerous producers as an animal feed, mostly for on-farm consumption (Oettler, 2005), as one can see in the most recent data available for triticale produced among the four leading countries (see Figure 3.27).

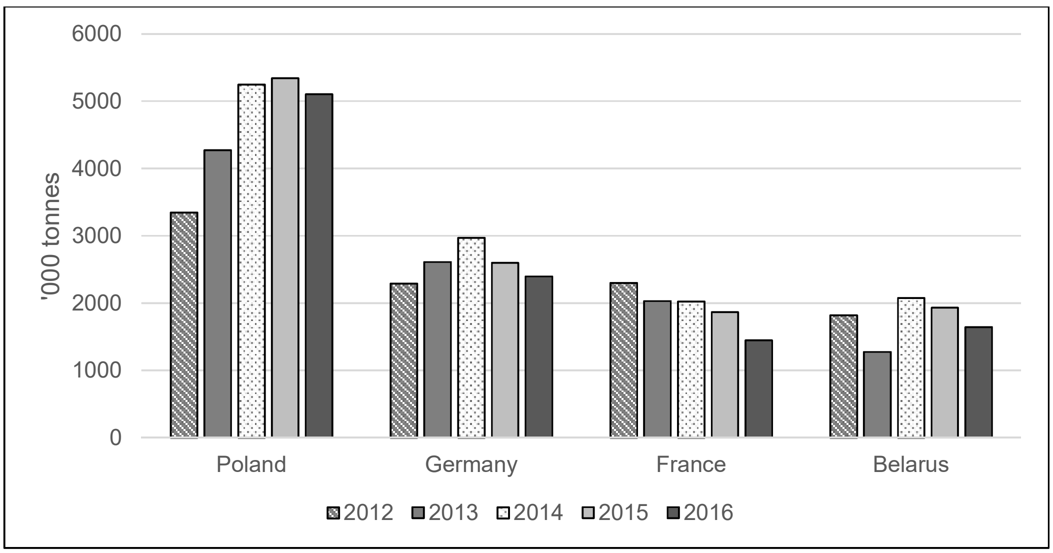

Figure 3.27: Leading triticale producers
Source: FAO (2017)

It is known, though, by several producers to be a versatile crop, as it can be grazed during early growth stages, after which it is harvested with an acceptable grain yield. Other uses in which triticale has proved useful include silage in dairy producing areas, serving as a cover crop in vineyards (Botes, 2017), and can also be used in food products and industrial uses such as bio-ethanol production (Du Pisani, 2009). The significance of the crop can also be attributed to its superiority over other cereals in terms of resistance to pests and diseases, contending well with weeds and tolerating overly wet and dry conditions (Botes, 2017).

While triticale in South Africa is not commercially produced (which is why exact domestic production figures are not available), it is commonly produced for on-farm use. If one were to consider marketing triticale, the price will, unfortunately, be subject to the price of other commodities such as yellow maize and barley. The rule of thumb for several years has been to market triticale at 80% of the price of barley or yellow maize delivered in the Western Cape (Robertson, 2017), but not accounting for any improvements made in triticale cultivars' nutritive value. Although the demand and supply for yellow maize has a large influence on its substitute, it cannot be considered to be an efficient market structure when a commodity itself and the unique nutritive composition it offers are not considered. Normally, as is the case in perfect price determination, the price should be determined where the demand for the commodity meets the supply. It is therefore necessary to determine how triticale can be marketed at a price that is not solely determined by other commodities, but that specifically reflects the demand for the value of triticale.

Since triticale is commonly considered to be only useful for on-farm use, many regard triticale as an inferior crop and not as an enterprise that could generate a revenue stream. It should, therefore, be cautioned that the current yield data is not necessarily a reflection of the potential, since many farmers tend to confine triticale production to marginal lands with low, if any, levels of fertilisation (Botes, 2017). Myer and Lozano del Rio (2004) discussed triticale as animal feed, and thus triticale's nutrient composition with regard to other grains, especially maize. It was proved that triticale provides about 95 to 100 percent of the energy that maize or wheat has in non-ruminant diets, and in ruminant diets, triticale was very comparable to maize, barley and wheat. Additionally, higher nutrient levels of digestible protein, amino acids, and minerals such as phosphorus are found in triticale. These are essential nutrients that will need less supplementation from other sources in diet formulations.

3.5 Summary

This chapter started with an overview of the global wheat industry, which shed light on the global environment and trends which have enormous effects on the local industry, such as other countries' increased efficiency which places competitors that are not as efficient under pressure. Production trends in South Africa were then discussed to illustrate that milling wheat production in South Africa is declining, and that producers in summer rainfall regions have resorted to alternatives that are not available for WCP producers to consider. The South African wheat value chain was discussed to indicate the importance of wheat as a commodity, and also to provide context of how the industry has developed to measure wheat quality, and to market it. Background of the milling wheat market and price trends then provided context of the pressures that are apparent in the wheat industry. For the welfare of the WCP producers, and therefore the province itself, a potential alternative was then identified and evaluated that could potentially serve as an alternative crop for producers, and also as an alternative raw material for feed.

Chapter 4 – Methodology

4.1 Introduction

This section will provide more detail in terms of the methodological approach used to determine the financial viability of triticale, as compared with milling wheat. As mentioned, financial viability will be measured according to the profitability of triticale compared with milling wheat. To enable an estimation of the profitability of triticale, the demand for triticale at various prices will be determined, provided that a minimum amount of at least 20 000 tonnes is being absorbed in the animal feed manufacturing industry. This will be done by means of the Agricultural Products Requirements Optimising (APR_OPT) model, after which the price results will be included into a budget analysis to determine and compare profitability. The following sub-sections will discuss the two complimentary approaches.

4.2 Methods

4.2.1 Budget analysis

By reflecting on definitions provided by Standard Bank (2013) and Kay, Edwards and Duffy (2016), a partial budget can be described as providing a method that is just and consistent in calculating the projected change in profit resulting from a change of enterprise. This will provide a clear representation of whether a move towards triticale will generate more profit on a certain hectarage than what would have been the case if the producer had remained with milling wheat. It is thus ideal to use when considering adding an additional enterprise, or when replacing an existing enterprise (partly or completely) with another in the farm business (Standard Bank, 2013).

Drawing up a partial budget requires data on expected yields and prices, as well as production costs (Standard Bank, 2013). These are often presented in an enterprise budget, which is organised in a way to present “an estimate of the potential revenue, expenses, and profit for a single enterprise” (Kay et al., 2016:177). Once these calculations are done, a comparison between triticale and milling wheat can be performed to compare profitability and subsequently the financial viability of triticale compared with milling wheat.

The data required for the compilation of the partial budgets (such as cost information) will be sourced budgeted production costs, which Overberg Agri releases prior to the winter crop production season each year. These values of the budgets are theoretical, and include average yield and producer price. This provides an estimated gross income and total allocatable costs, and thus the estimated gross margin. The output prices for milling wheat will be based on the producer prices in the Caledon region, whereas the price for triticale will be obtained from the APR_OPT model, subject to a threshold uptake of at least 20 000 tonnes. Table 4.1 provides an outline of a partial budget.

Table 4.1: Outline of a partial budget

Existing practice		Alternative	
(i) Lost income	a	(i) Additional income	c
(ii) Saved costs	b	(ii) Additional costs	d
Difference (sacrifice)	a - b	Difference (benefit)	c - d

Source: Standard Bank (2013)

Considering the existing practice, one will discern that its income will be lost, and the cost of producing it will be saved, but the alternative’s income will be acquired, and its production costs spent. The difference (gross margin) of the existing practice will be sacrificed, and that of the alternative be acquired. The question is whether or not the benefit outweighs the sacrifice. As mentioned, the prices to be used for triticale in the analyses are yet to be determined, and will be obtained from the following method.

4.2.2 Agricultural Products Requirements Optimising model

Briedenhann (2001) developed the Animal Products Requirements (APR) model to deal with the country's need for a method to predict raw material requirements for the animal feed industry. This need arises from effects such as population growth; extrinsic factors (such as imports of meat and dairy products); and the influence that international market prices have in the cost chain. Briedenhann's objective was to measure such effects and display it in a model, which De Jager (2016) subsequently optimised to enable it to formulate least-cost rations according to the nutrients required for each animal category, and also to measure raw material usage and allocation, thus providing the APR_OPT model. The model was originally developed by Briedenhann (2001) to assist farmers in estimating a relative value of their commodities, which would then assist in determining which crops to produce, and also in considering nutrient requirements of animals. This addresses the "how" of this study's objective. By considering animals' nutrient requirements, the model considers the nutrients that raw materials (in this case 'triticale') provides and determines the demand for it at a specific price.

The demand for animal products (meat, eggs, milk, etc.) is determined by human population figures, which then provide the amount of animals that need to be fed to satisfy the demand (Strydom, 2009). This brings in the first section of this model: calculating animal feed demand based on the per capita consumption of animal products, which is done using performance data (Briedenhann, 2001). Figure 4.1 illustrates how feed demand is calculated, taking into consideration several sub-categories. This includes determining animal product demand through population figures and consumption patterns, thereby addressing animal requirements to meet demand, from which the feed demanded per region is estimated to determine total feed demand.

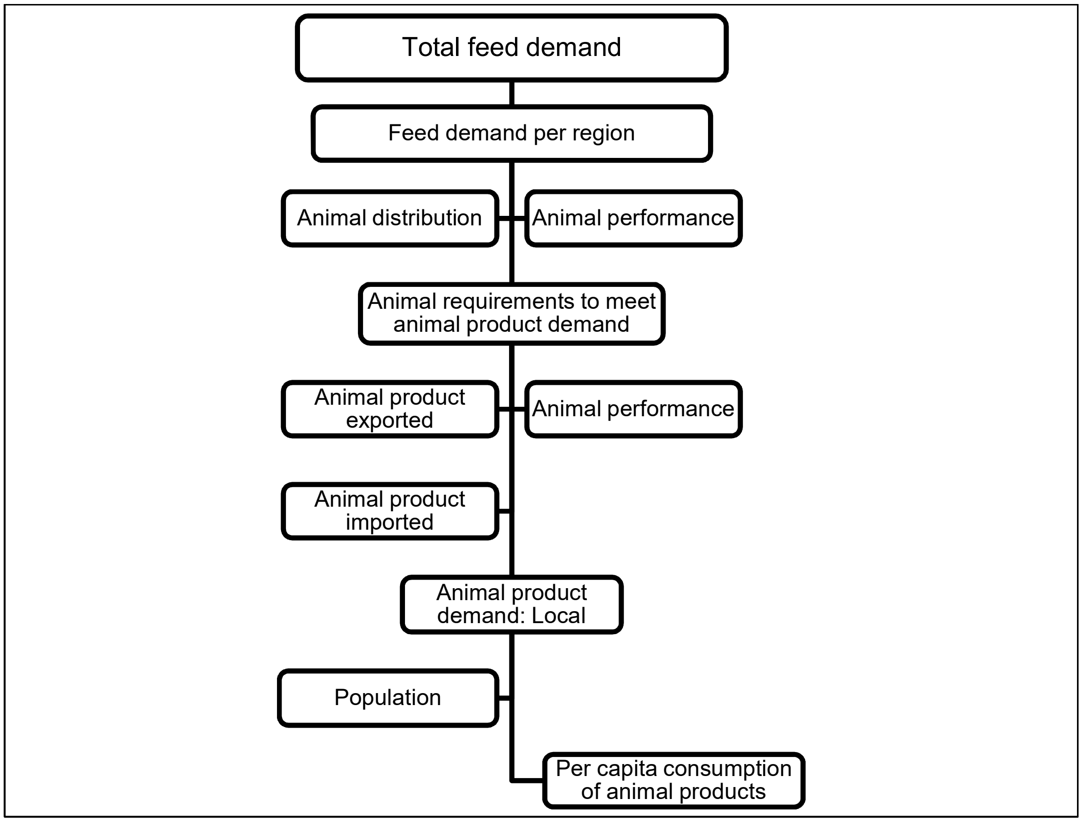

Figure 4.1: Representation of the model interrelationships for determining feed demand

Source: Briedenhann (2001)

In determining the demand for raw materials, it is necessary that all categories of the several animal types be considered. The second section contains the use of linear programming (LP), which formulates feed rations by using optimal quantities of raw materials in a least-cost ratio. The prices of available local and international raw materials are considered, with the quantity of imported raw materials being determined by the local availability thereof (Briedenhann, 2001). Figure 4.2 provides a clear layout of this section.

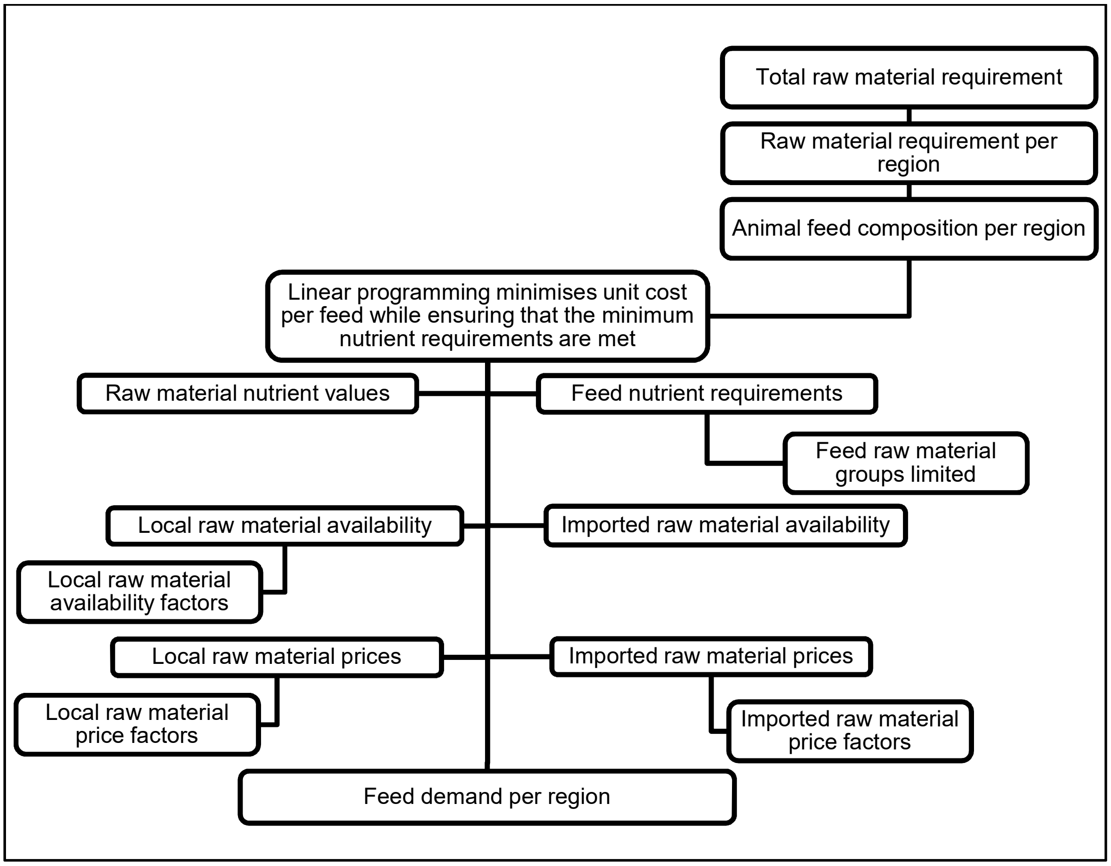

Figure 4.2: Representation of the model interrelationships for determining raw material demand

Source: Briedenhann (2001)

LP, which falls under mathematical programming, is a very powerful and commonly used problem-solving approach among quantitive methods (Kaiser & Messer, 2011). Briedenhann (2001), as well as Kaiser and Messer (2011, as cited by De Jager, 2016), refer to LP as a method to determine the optimum solution for a problem, in which optimum refers to either maximisation or minimisation of the objective function. This could be used to determine maximum profits or minimum expenditure. With the objective function, linear constraints (defining the limits of the problem) are set as parameters in which the objective function should remain.

The optimisation of diets is often solved by means of LP models. The APR_OPT model is based on a minimisation problem, entailing that a least-cost diet solution is sought after, with, among other things, meeting the nutritional requirements that are set as a constraint. It is also utilised by farmers, feedlots and feed manufacturers that wish to formulate least-cost rations, given the prices and availability of raw materials, in consideration of a specific animal's daily nutritional requirements.

In essence, there are four general properties that are characteristic to any LP model, namely (Kaiser & Messer, 2011)

- An objective of optimisation, to either maximise or minimise.
- The presence of constraints that limit the activities required to take place.
- All equations are in linear form.
- Activities in the model are mostly non-negative.

Within this context, the specification of the model is built around different indices. The first index (denoted by i), represents the nutritional characteristics (protein, energy, fat, fibre etc.) required by the different categories of animals, with the nutrition requirements being limited between maximum and minimum parameters. The second, index j, represents the raw materials available for use in diet formulation, with variable (F_j) being the amount of raw materials available. Apart from the maximum and minimum nutritional parameters, there is also a non-negativity constraint, and a parameter regarding the total volume of the diet. Essentially, each raw material's nutritional value will be considered to ensure that the minimum nutritional requirements are met, but while remaining within the maximum limits.

Therefore, a_{ij} will be the level of the i^{th} nutrient present in a single unit of the j^{th} raw material. UL_i and LL_i are set as the maximum and minimum amounts of the i^{th} nutrient permitted in the diet, as seen in Equation 4.1 and Equation 4.2 (McCarl & Spreen, 1997). The sum of the nutrients obtained from each raw material ($a_{ij}F_j$) should be lower than UL_i and higher than LL_i, thus:

$$\sum_j a_{ij} F_j > LL_j \quad (4.1)$$

$$\sum_j a_{ij} F_j \leq UL_j \quad (4.2)$$

A third constraint is also included to ensure that the weight of the diet ingredients is equal to the required weight of the diet. This requirement can be expressed as in Equation 4.3, based on the assumption of the weights of the formulated diet and the raw materials being the same.

$$\sum_j F_j = 1 \quad (4.3)$$

Lastly, it is necessary to define the objective function. A parameter for raw material cost (c_j) is included, as well as an equation to calculate the sum of the total diet cost from all raw materials used. The Feed Mix problem, as illustrated in Equation 4.4, thus provides a minimisation procedure, in which an animal diet is formulated, given availability factors and attainment of minimum nutrient requirements at the lowest cost (McCarl & Spreen, 1997).

Subject to $\sum_j a_{ij} F_j > LL_j$ for all i (4.4)

$\sum_j a_{ij} F_j \leq UL_j$ for all j

$\sum_j F_j = 1$

$F_j > 0$ for all j

The General Algebraic Modelling System (GAMS), developed by Brooke, Kendrick, Meeraus and Rosenthal (1998), is used as the basis for the modelling of the least-cost animal feed ration and raw material allocations. In other words, GAMS will be used as the modelling system to determine the absorption rate of triticale at different prices.

As mentioned earlier, De Jager (2016) optimised the APR model so that population and consumption figures can be used in conjunction with animal distribution amounts, animal feed requirements, raw material costs and availability, and the raw material nutrient values to ultimately determine the raw material demand required for each animal category. This enables the formation of an accurate depiction of raw material requirements. Moreover, the different animal types are divided into categories, with sub-sub categories (according to life stage and performance) to view specific consumption patterns and nutrient requirements. For example, feed requirements pertaining specifically to pasture fed cows within the dairy sub-section of cattle, as opposed to cows on roughage and concentrate diets. **Error! Reference source not found.** illustrates the main animal categories that are incorporated into the APR_OPT model.

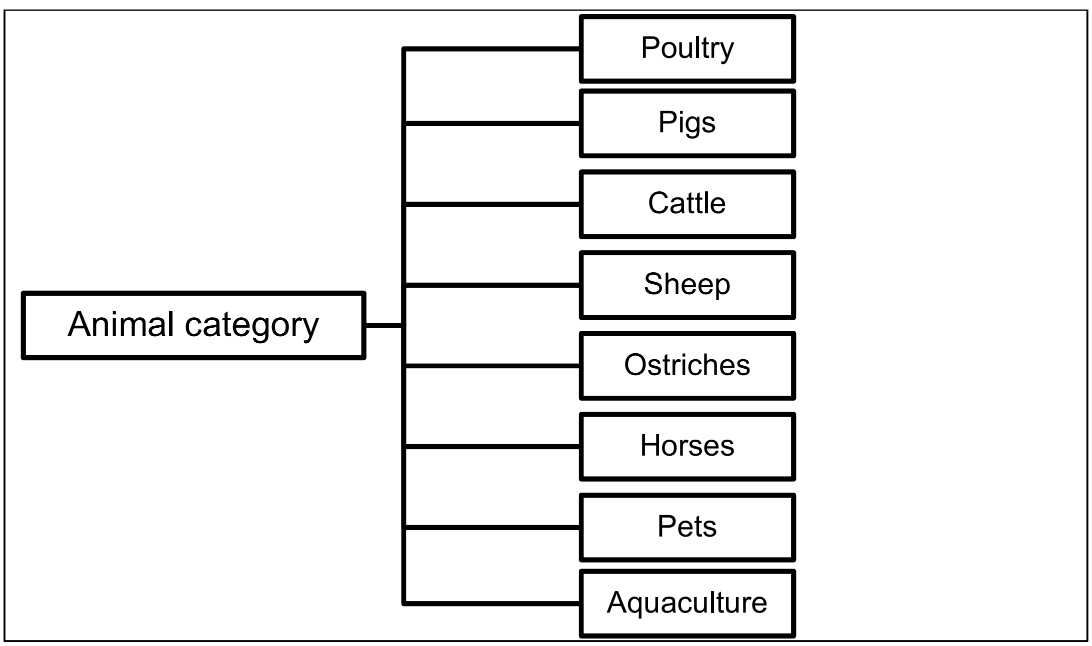

Figure 4.3: Graphical display of the main animal categories

Source: De Jager (2016), from Briedenhann (2001)

The addition of De Jager's (2016) APR_OPT model to the APR model includes, as mentioned earlier, formulating least-cost feed rations for each animal category according to specific requirements. **Error! Reference source not found.** is used as a demonstration, in the form of the organisational chart of cattle, to provide a clearer perception of the classification of sub-sections within each category.

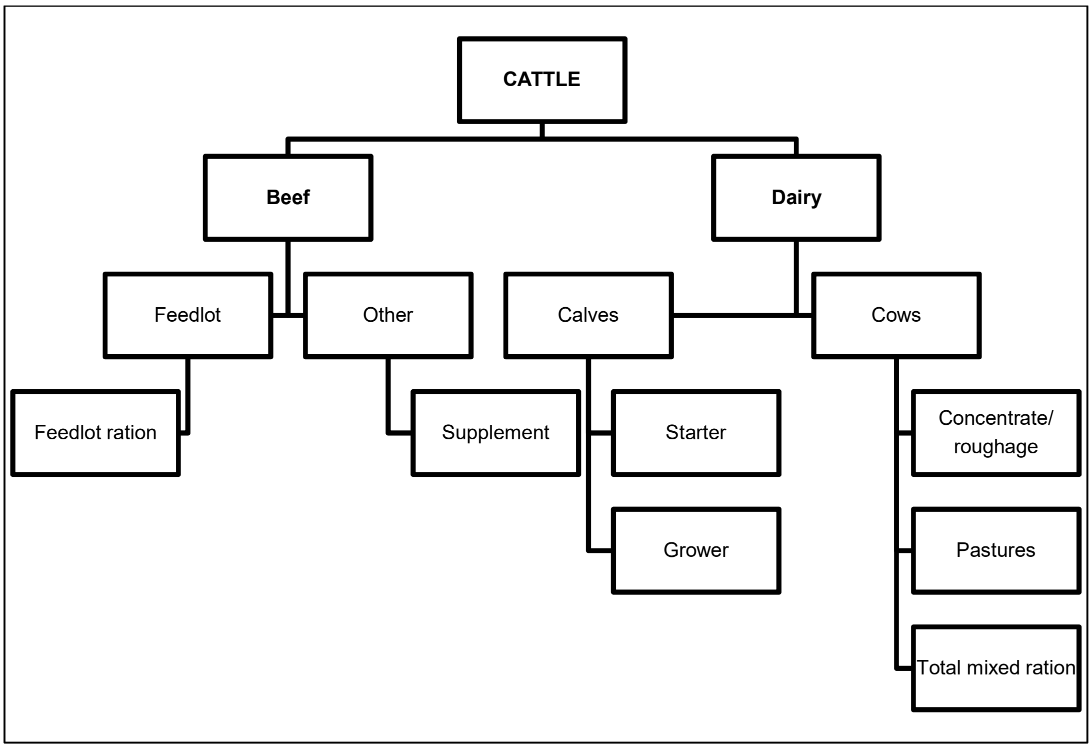

Figure 4.4: Cattle and sub-categories considered in the model
Source: De Jager (2016) from Briedenhann (2001)

In essence, the model allows for the formulation of least-cost rations according to the nutrients required for each animal category, and also for measuring raw material usage and allocation (De Jager, 2016). The amount of animal feed required is determined by using the average slaughter weight of animals multiplied by the feed conversion ratio (FCR). Breeding animals' feed consumption is determined through performance and general daily feed intake (De Jager, 2016).

Table 4.2 and Table 4.3 illustrate the feed consumption factors that are considered in the process of estimating feed demand for beef cattle and dairy cattle respectively. Beef cattle are produced and finished for marketing by means of two practices, i.e. either on extensive grazing conditions or in the feedlot. The model's calculation separates these two practices as different FCRs, which are linked to the systems (De Jager, 2016).

Table 4.2: Cattle beef feed consumption factors

Index	Factors	Units
A	Per capita beef consumption	kg
B	Population size	People
C	Total beef consumption	kg
D	Imported beef meat	kg
E	Exported beef meat	kg
F	Total local beef production	kg
G	Average feedlot weight at slaughter	kg
H	Average other cattle weight at slaughter	kg
I	Weight entering feedlots	kg
J	Weight gain in feedlots	kg
K	Slaughter-out percentage	%
L	Average weight after slaughter: feedlot cattle	kg
M	Average weight after slaughter: other cattle	kg
N	Total number feedlot cattle	Cattle
O	Total number other cattle	Cattle
P	Ratio feedlot cattle to other	Ratio
Q	Total weight feedlot cattle	kg
R	Total weight other cattle	kg
S	FCR feedlot	Ratio
T	FCR other	Ratio
U	Total feedlot feed consumed	kg
V	Total other feed consumed	kg
W	Total cattle beef feed consumption	kg

Source: De Jager (2016) from Briedenhann (2001)

<u>Calculation of cattle beef feed consumption (De Jager, 2016)</u>

C = A x B

F = C – D + E

L = G x K

M = H x K

N = (F ÷ L) x P

O = (F ÷ M) x (1 – P)

Q = J x N

R = H x O

U = Q x S

V = R x T

W = U + V

Calculation of cattle beef ration types

1. Feedlot ration U
2. Supplement ration V

Table 4.3 provide the dairy cattle feed consumption factors, which enables the calculation of various diets in the dairy industry, formulated for calves and cows. Generally dairy farmers make use of three feeding/grazing systems for cows. These three systems include concentrate/roughage diets, pasture feeding, and total mixed rations (TMR), all of which are reckoned in the calculations.

Table 4.3: Dairy cattle feed consumption factors

Index	Factors	Units
A	Per capita milk consumption, dairy products converted to milk equivalent	ℓ/person
B	Population size	People
C	Total milk consumption	ℓ
D	Milk imported (dairy products converted)	ℓ/annum
E	Milk exported	ℓ/annum
F	Milk production local	ℓ
G	Cows in milk	Cows
H	Average milk production per cow	ℓ/cow
I	Dry cows	Cows
J	Average concentrate consumption per cow in lactation	kg/day
K	Average concentrate consumption per dry cow	kg/day
L	Ratio of cows in milk to calves	%
M	Calves required to replace cows	Calves
N	Heifers required to replace cows	Heifers

O	Ratio of cows in milk to heifers	%
P	Feed consumption of calves	kg/day
Q	Feed consumption of heifers	kg/day
R	Total concentrate consumption of cows	kg
S	Total concentrate consumption of calves	kg
T	Total concentrate consumption of heifers	kg
U	Cows on concentrate/roughage system	%
V	Cows on pasture system	%
W	Cows on TMR	%
X	Days in year	Days
Y	Dry cow percentage	%
Z	Calve starter ration	kg
AA	Calve grower ration	kg
AB	Cows concentrate/roughage ration	kg
AC	Cows pasture ration	kg
AD	Cows TMR ration	kg
AE	Total dairy cattle feed consumption	kg

Source: De Jager (2016) from Briedenhann (2001)

<u>Calculation of cattle dairy feed consumption (De Jager, 2016)</u>

C = A x B

F = C – D + E

G = F ÷ (H x X)

I = [F ÷ (H x X)] x Y

M = G x L

N = G x O

R = [(G x J x X) + (I x K x X)]

S = M x P x X

T = N x Q x X

Z = S

AA = T

AB = R x U

AC = R x V

AD = R x W

AE = AB + AC + AD

Calculation of cattle dairy ration types

1.	Calf starter	S
2.	Calf grower	T
3.	Cows concentrate/roughage	AB
4.	Cows pasture	AC
5.	Cows TMR	AD

The explanation of the cattle animal category, and its sub-categories, provides a good indication of how the APR_OPT model quantifies animal feed demand for all animal categories, because other animal categories' feed demand is determined in a similar fashion. With the APR_OPT quantifying the total feed demand, the model is now able to formulate animal feed rations adhering to the nutrient requirements of each animal category, at a minimum cost (De Jager, 2016).

Being a GAMS based model, the APR_OPT model is structured similar to the Feed Mix problem mentioned earlier, with this model's formulation consisting of the following components (De Jager, 2016):

1. Objective function:
   - Minimising the cost of each animal ration mixed, with the consideration of raw material prices and the transport costs of raw materials.

2. Decision variables:
   - The quantity of a raw material within a specific raw material category to originate from a source region to a demand region for a specific diet formulated for a specific animal within an animal category.

3. Resource constraints:
   - To adhere to the minimum nutrient requirements required for each animal ration;
   - Avoid exceeding maximum nutrient requirements;

- A constraint is placed the amount of feed of animal feed that is required to be mixed for each animal category throughout South Africa; and
- Accounting for the availability of local raw materials in South Africa, and the amount of raw materials available for imports from other countries.

De Jager (2016) programmed the GAMS file to consist of three sections. The first section is the input data required in the APR_OPT model. The second section is the mathematical programming, which is performed when the formulation of variables, equations and constraints takes place. The third section includes producing output result files of the optimal solution and exporting it to a Microsoft Excel© 1997-2003 spreadsheet. The three components of the model is visualised by the equations below.

<u>Objective function</u>

$$MIN: Z = \Sigma_{y,a,t,d,m,f,c,r} X_{y,a,t,d,m,f,c,r}(fc_{y,m,f,c} + tr_{y,m,f,c}) \quad (4.5)$$

Where:

$X_{y,a,t,d,m,f,c,r}$ — The quantity of feed ingredient f, as classified under raw material category m, to be used for a specific diet d, formulated for a specific animal t, as classified under animal category a, originating from source region c and transported to demand region r (kg), for specific year y.

$fc_{y,m,f,c}$ — The cost of feed ingredient f, as classified under raw material category m, originating from source region c (R/kg) for specific year y.

$tr_{y,m,f,c}$ The costs to transport feed ingredient f, as classified under raw material category m, from source region c to demand region r (R/kg), for specific year y.

The transport costs are included as part of the objective function to account for the unavailability of some raw materials in certain South African regions, thus causing those raw materials to be transported from a supply region to the demand point. The model will in essence allocate raw materials from different supply regions in the country to regions that require raw materials, thereby minimising the ration costs (De Jager, 2016).

Decision variable

$X_{y,a,t,d,m,f,c,r}$ The quantity of feed ingredient f, as classified under raw material category m, to be used for a specific diet d, formulated for a specific animal t, as classified under animal category a, originating from source region c and transported to demand region r (kg), for specific year y.

The decision or positive variable is used in Equation 4.5 and is present in all the constraints implemented in the APR_OPT model.

Constraints of the model

The first constraint is the minimum nutrient requirements that every diet (d) should include, thus adhering to the nutritional requirements of the animals. Equation 4.6 represents the constraint set for minimum nutritional (MiNR) animal requirements (De Jager, 2016).

$$\Sigma_{y,a,t,d,m,f,c,r} \; X_{y,a,t,d,m,f,c,r} \times nut_{m,f,c,n} \geq MiNR_{a,t,d,n} \times acr_{y,a,t,d,r} \quad (4.6)$$

Where:

$nut_{m,f,c,n}$ The amount of n nutrients that each f feed ingredient, as classified under raw material category m, originating from source region c, contains (g/kg).

$MiNR_{a,t,d,n}$ The minimum amount of n nutrients that diet d of each animal type t, as classified under animal category a, should contain to satisfy the minimum animal nutrient requirements n (g/kg).

$acr_{y,a,t,d,r}$ The animal consumption per region, which indicates the amount of each diet d, every animal t, as classified under animal category a, demands in each demand region r (kg), for specific year y.

The process in which animal consumption / feed demand per region is determined is indicated by Equation 4.7.

$$\text{acr}_{y,a,t,d,r} = ad_{y,a,t} \times rbd_{a,t,r} \times dbd_{a,t,d} \quad (4.7)$$

Where:

$ad_{y,a,t}$ This represents the animal feed demand for animal type t (kg), as classified under each animal category a, for specific year y.

$rbd_{a,t,r}$ — The region breakdown is the percentage dividing the three demand regions r in South Africa according to the amount of animals t in each region classified under animal category a (%).

$dbd_{a,t,d}$ — This represents the diet breakdown percentage of the amount of feed required in diet d for animal t, as classified under animal category a (%).

The second constraint makes provision for the maximum nutrient requirements that every diet d should not exceed. Exceeding this limit would cause the diets to become too expensive and create difficulty with the animals' digestion. Equation 4.8 represents the constraint set for maximum nutritional (MaNR) animal requirements (De Jager, 2016).

$$\Sigma_{y,a,t,d,m,f,c,r} \;\; X_{y,a,t,d,m,f,c,r} \times nut_{m,f,c,n} \leq MaNR_{a,t,d,n} \times acr_{y,a,t,d,r} \quad (4.8)$$

Where:

$MaNR_{a,t,d,n}$ — The maximum amount of n nutrients that diet d of each animal type t, as classified under animal category a, should not exceed (g/kg).

The third constraint ensures that the quantity feed mixed is equal to the quantity feed demanded by the animals and is indicated by Equation 4.9.

$$\Sigma_{m,r,c} X_{y,a,t,d,m,f,c,r} = acr_{y,a,t,d,r} \quad (4.9)$$

The fourth constraint limits the amount of raw materials to be used in the formulation of feed rations to the amount of raw materials available. Considering that South Africa has a limited amount of raw materials which are supplemented by import sources, Equation 4.10 regulates the amount of raw materials to be equal or less than what is available.

$$\Sigma_{a,t,d,r} X_{y,a,t,d,m,f,c,r} \ \leq \ rms_{y,m,f,c} \qquad (4.10)$$

Where:

$rms_{y,m,f,c}$	The raw material supply or available feed ingredients f, as classified under raw material category m, that is available for use in each source/supply region c (kg) for specific year y, is denoted as rms.

The fifth and final constraint, illustrated by Equation 4.11, is a non-negativity constraint, stating that the value of a decision variable cannot be smaller than zero, ensuring that raw materials are included in the ration formulation without the inclusion of negative numbers.

$$X_{y,a,t,d,m,f,c,r} \ \geq 0 \qquad (4.11)$$

The components of the model that have been discussed provide a clear background of the functioning of the APR_OPT model, as well as the data that is required for this model to function accurately. These data requirements include the cost of different raw materials used in the animal feed industry, transport costs of these materials, minimum and maximum nutrient requirements per animal category, raw material supply limitations, and the amount of animal feed demanded by each animal category. Most of the data used in this model is obtained from the Bureau for Food and Agricultural Policy (BFAP) sector model, as well as the Food and Agricultural Policy Research Institute (FAPRI) global commodity model.

Considering that the model allocates raw material amounts to the formulation based on its nutritive value and price, the price of triticale will be adjusted to monitor the changes in its usage amount, providing a demand curve for triticale in the process. The demand curves will be generated for two different years, 2016 and 2017 to provide a broader perspective, as these years offer two completely different price scenarios. This will enable budget analyses for two separate conditions, through which one will be able to become more informed when drawing conclusions.

4.3 Summary

Firstly, the budget analysis, being the chosen method to determine the financial viability of triticale, was discussed to provide insight into the approach to be taken. Although simplistic, it is a just and consistent approach that is very easy to draw conclusions from. To ensure that the comparison between the two crops is just and consistent, the APR_OPT model was selected to provide a price for triticale. It has been mentioned in earlier chapters that the study requires a price that specifically reflects the demand of triticale. Several aspects of the model were discussed for gaining a better understanding of how the model manages to determine the demand for animal products, from which one can then estimate raw material demand at different prices.

Chapter 5 – Results

5.1 Introduction

This chapter will begin with a discussion pertaining to the potential substitutions and supplementary effects of triticale in relation to other raw materials. This will be followed by a discussion on the potential demand for triticale at various prices, as obtained from the Agricultural Products Requirements Optimising (APR_OPT) model. The last part of this chapter will deal with the financial viability of triticale compared with milling wheat.

5.2 Results

5.2.1 Overall raw material usage

As mentioned, the APR_OPT model formulates raw material demand based on a region's demand for animal products, and thus the demand for the raw materials required for animal consumption to produce the animal products. The APR_OPT model considers the nutritive value of all available raw materials in order to fulfil the minimum and maximum nutrition requirements of the animals, during which diet formulations are generated at the lowest possible cost. The results generated by the APR_OPT consist, inter alia, of a summary of the amounts of raw materials required to satisfy the demand at the lowest possible cost. If the price of a specific raw material should change, the uptake of that specific raw material in the set animal feed ration would most likely also change.

In this study, the price of triticale was adjusted until a minimum demand of 20 000 tonnes was obtained. As mentioned, for triticale or any other raw material to be considered as a viable option from an animal feed perspective, a supply or uptake potential of at least 20 000 tonnes will be required (Robertson, 2017). The price of triticale, at a minimum uptake of 20 000 tonnes or just above 20 000 tonnes, as required for the respective feed ration, was used as the base price in terms of the financial analyses for both 2016 and 2017. Based on the results from the APR_OPT model, the base price for triticale is reflected at R3 200 per tonne in 2016, and R2 460 per tonne in 2017.

Table 5.1 and Table 5.2 provide an overview of the raw material usage in the different animal feed rations for 2016 and 2017, respectively. In both tables, reference is made to a scenario where triticale is included and excluded as a potential raw material for uptake. The change in usage for each raw material, with the inclusion of triticale at the base price (the price at a minimum uptake of 20 000 tonnes), is reflected in the right-hand column, labelled 'difference'. The total value of the raw materials utilised is also provided at the bottom of the respective tables.

From Table 5.1, it is clear that the availability of triticale will mainly result in it substituting yellow maize in terms of raw material usage to adhere to the animal feed ration requirements in the Western Cape Province (WCP). Overall, the uptake of just over 22 000 tonnes of triticale will result in a decline in terms of the amount of yellow maize being used, to the extent of almost 18 000 tonnes. In addition, the model also revealed that the availability of triticale will result in a decline in usage of other raw materials such as wheat middlings and sunflower oil, with lucerne being the only raw material that is likely to report an increase. The availability or uptake of triticale will also contribute towards total feed cost (value of the feed ration) reducing by 0.14%, which, for all practical reasons, implies that the cost of producing a kilogram of animal protein will be slightly lower.

Table 5.1: Raw material usage for 2016 (tonnes)

Raw material description		Triticale @ R 3 200.00	Without Triticale	Difference (tonnes)
Amino_Acids	Lysine	8 462.45	8 469.29	-6.84
Amino_Acids	Methionine	3 021.33	3 023.74	-2.42
Byprod_Industry	Vegetable_Oil	16 008.74	16 275.49	-266.76
Byprod_Industry	Molasses	123 146.07	123 146.07	-
Byprod_Milling	Maize_Germ	370 545.39	370 625.62	-80.23
Byprod_Milling	Wheat_Middlings	205 138.72	208 063.39	-2 924.67
Byprod_Wet_Mill	Maize_Germ_FF	140 000.00	140 000.00	-
Byprod_Wet_Mill	Gluten_20	119 437.50	119 437.50	-
Byprod_Wet_Mill	Gluten_60	11 144.35	11 064.12	80.23
Fishmeal	FM_HP	11 625.75	11 625.75	-
Full_fat	Canola_FF	2 481.84	2 481.84	-
Full_fat	Cotton_FF	11 201.49	11 238.89	-37.40
Full_fat	Soya_FF	110 600.00	110 600.00	-
Grain	YM	1 419 827.73	1 437 727.87	-17 900.13
Grain	Sorghum	9 853.21	9 853.21	-
Grain	Triticale	22 786.84		22 786.84
Lupin	Lupins	14 000.00	14 000.00	-0.00
Minerals	DCP	7 300.21	7 302.39	-2.18
Minerals	Limestone	104 853.20	104 847.17	6.03
Minerals	MCP	37 300.59	37 405.96	-105.38
Minerals	Salt	14 034.83	14 137.62	-102.79
NPN	Urea	10 854.76	10 871.10	-16.34
Oilcake	Canola_OC	81 577.14	81 577.14	-
Oilcake	Soya_HP	40 848.94	41 365.15	-516.20
Oilcake	Sunflower_HP	224 571.23	225 708.06	-1 136.83
Other	Lucerne	320 185.17	319 910.25	274.92
Other	Bagasse	107 146.92	107 196.78	-49.86
Rendering	Bloodmeal	233.75	233.75	-
Rendering	Feathermeal	10 328.20	10 328.20	-
Rendering	PBP	58 461.50	58 461.50	-
Total value of ration (R '000)		*R 11 951 998.21*	*R 11 969 096.48*	*-R 17 098.27*
			Percentage of difference:	*-0.14%*

Source: Own calculations

The 2017 season is slightly different, in that white maize constitutes the main energy feed source. This is mainly because the price of white maize (R1 921 per tonne) was even lower, compared with that of yellow maize, at the time of modelling. As a result, triticale will primarily substitute white maize. It is clear from Table 5.2 that the uptake of approximate 24 000 tonnes of triticale will result in a decline of just over 22 000 tonnes in terms of white maize. Similarly, the uptake of triticale will result in lower levels of sunflower, soybean and lucerne usage. Sunflower, soybean oilcake, and lucerne will be replaced mainly as a result of the higher protein content of triticale. Apart from protein, lucerne is also a source of fibre in the ration, and with its replacement it will, in this instance, be accounted for by the increased use of a cheaper source of fibre, being bagasse. The inclusion of triticale into diets will always cause such replacement and supplementary effects (thus interactive responses) primarily due to triticale containing higher levels of nutrients such as protein and minerals than maize does, and therefore need not be supplemented from other sources. Such effects will, of course, vary slightly every year due to the movement in prices of the raw materials.

Table 5.2: Raw material usage for 2017 (tonnes)

Raw Material Category	Raw Material	Triticale @ R 2 460.00	Without Triticale	Difference
Amino_Acids	Lysine	8 654.98	8 655.53	-0.55
Amino_Acids	Methionine	2 924.92	2 924.42	0.50
Byprod_Industry	Vegetable_Oil	17 600.88	17 600.88	-0.00
Byprod_Industry	Molasses	126 419.40	126 419.40	-
Byprod_Milling	Maize_Germ	360 733.47	360 737.58	-4.11
Byprod_Milling	Wheat_Middlings	190 564.24	190 282.65	281.60
Byprod_Wet_Mill	Maize_Germ_FF	140 000.00	140 000.00	-
Byprod_Wet_Mill	Gluten_20	125 409.38	125 409.38	-
Byprod_Wet_Mill	Gluten_60	16 342.31	16 338.20	4.11
Fishmeal	FM_HP	11 769.88	11 769.88	-
Full_fat	Canola_FF	2 740.48	2 740.48	-
Full_fat	Cotton_FF	2 559.74	2 441.62	118.12
Full_fat	Soya_FF	99 600.00	99 600.00	-
Grain	WM	1 630 326.20	1 652 613.29	-22 287.10
Grain	YM	19 725.60	19 725.60	-
Grain	Triticale	24 386.86	-	24 386.86
Lupin	Lupins	14 000.00	14 000.00	-
Minerals	DCP	5 733.15	5 733.15	-
Minerals	Limestone	116 175.57	116 095.91	79.66
Minerals	MCP	37 172.71	37 368.44	-195.74
Minerals	Salt	14 229.60	14 236.96	-7.36

NPN	Urea	13 056.10	13 056.10	-
Oilcake	Canola_OC	89 825.60	89 825.60	-
Oilcake	Soya_HP	40 592.75	41 439.60	-846.84
Oilcake	Sunflower_HP	229 462.63	230 643.69	-1 181.06
Other	Lucerne	113 757.07	114 393.38	-636.31
Other	Bagasse	167 458.85	167 170.63	288.21
Rendering	Bloodmeal	239.60	239.60	-
Rendering	Feathermeal	6 422.99	6 422.99	-
Rendering	PBP	62 000.00	62 000.00	-
Total value of ration (R '000)		*R 9 211 565.41*	*R 9 203 359.47*	*R 8 205.95*
			Percentage of difference	*0.09%*

Source: Own calculations

Interestingly though, the nutritive compositions for the specific years, with and without the inclusion of triticale, are more or less the same. This is noteworthy, considering the difference in costs (although marginal), as well as the varying levels of substitution. It illustrates the model's ability to ensure the attainment of the animals' nutrient requirements for the specific year at the lowest cost, given the availability and prices of raw materials. Table 5.3 provides the overall nutritive composition of the rations formulated for 2016 and 2017. For both years, the raw material usage at the selected base price of triticale is compared with the usage without the inclusion of triticale, indicated as 'triticale excluded'.

Table 5.3: Nutrition table

2016			**2017**	
At base price	**Triticale excluded**	**Nutrients**	**At base price**	**Triticale excluded**
16.02%	16.02%	Protein (%)	15.65%	15.65%
3.78%	3.79%	Fat (%)	3.67%	3.67%
8.38%	8.39%	Fibre (%)	7.34%	7.35%
0.35%	0.35%	Methionine (Total) (%)	0.35%	0.35%
0.30%	0.30%	Methionine Available – Poultry (%)	0.31%	0.31%
0.62%	0.62%	Total Sulphur Amino Acid (%)	0.61%	0.61%
0.51%	0.51%	Total Sulphur Amino Acid Available – Poultry (%)	0.53%	0.53%
0.80%	0.80%	Lysine (Total) (%)	0.77%	0.77%

0.62%	0.62%	Lysine Available – Poultry (%)	0.63%	0.63%
12.30	12.30	Digestible Energy – Pigs (MJ/kg)	12.68	12.68
69.07%	69.09%	Total Digestible Nutrients (%)	68.70%	68.72%
10.93	10.93	Metabolizable Energy – Poultry (MJ/kg)	11.35	11.36
0.19%	0.19%	Sodium (%)	0.19%	0.19%
1.48%	1.48%	Calcium (%)	1.58%	1.58%
0.59%	0.58%	Phosphorus (Total) (%)	0.69%	0.69%
0.32%	0.32%	Phosphorus Available (%)	0.32%	0.33%

Source: Own calculations

Considering potential changes in population figures, and human consumption patterns annually, it is likely that the demand for animal products will differ each year, and therefore the total composition of animal rations will, as well. The aforementioned discussion has focused mainly on the substitution and supplementary effects of the introduction of triticale. In the following sub-section, a more in-depth discussion will be provided in terms of the demand and the successive base prices that were used in the analysis to compare the financial viability of triticale with that of milling wheat.

5.2.2 Demand estimates for triticale

Figure 5.1 and Figure 5.2 present demand curves for triticale at various prices for the periods 2016 and 2017, respectively. Considering that in the previous section maize was revealed to be the raw material most affected by the inclusion of triticale, the price of maize (both white maize and yellow maize) will have a significant impact on the price levels at which triticale can be considered as a viable alternative from a demand perspective. In 2016, the demand for triticale exceeded the minimum threshold of 20 000 tonnes at a price equal to or below R 3 200 per tonne.

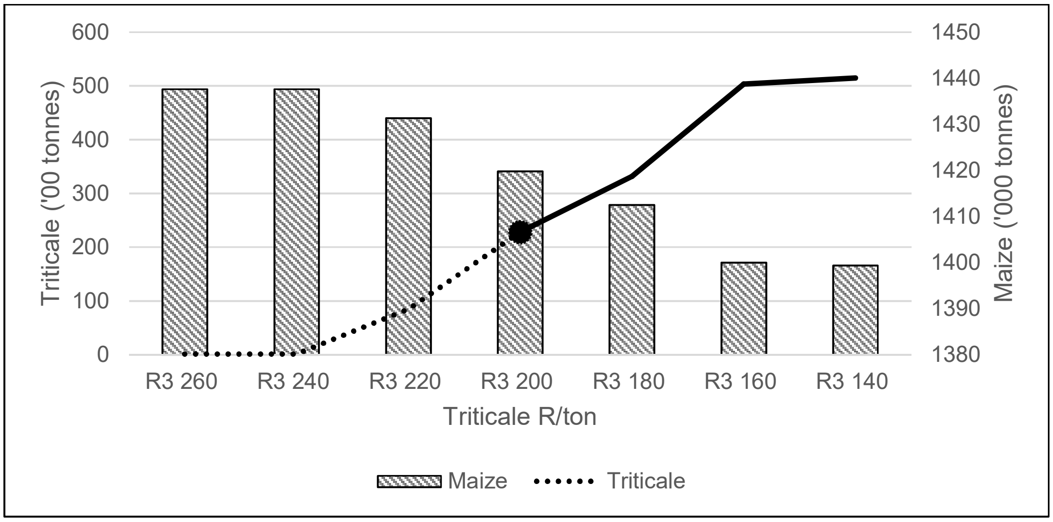

Figure 5.1: Demand curve for triticale (2016)

Source: Own calculations

The picture for 2017 (Figure 5.2) is slightly different, with the minimum demand threshold for triticale only being met at a price equal to or below R 2 460 per tonne. This is mainly because of the maize prices, with maize accounting for more than 50% of the raw materials which are being substituted by triticale in the different animal feed rations. In the event of an increase in maize prices, the likelihood exists that the price at which triticale will reach the minimum demand threshold will also be higher. This is important, as it will have a significant impact on the financial viability of triticale compared with milling wheat.

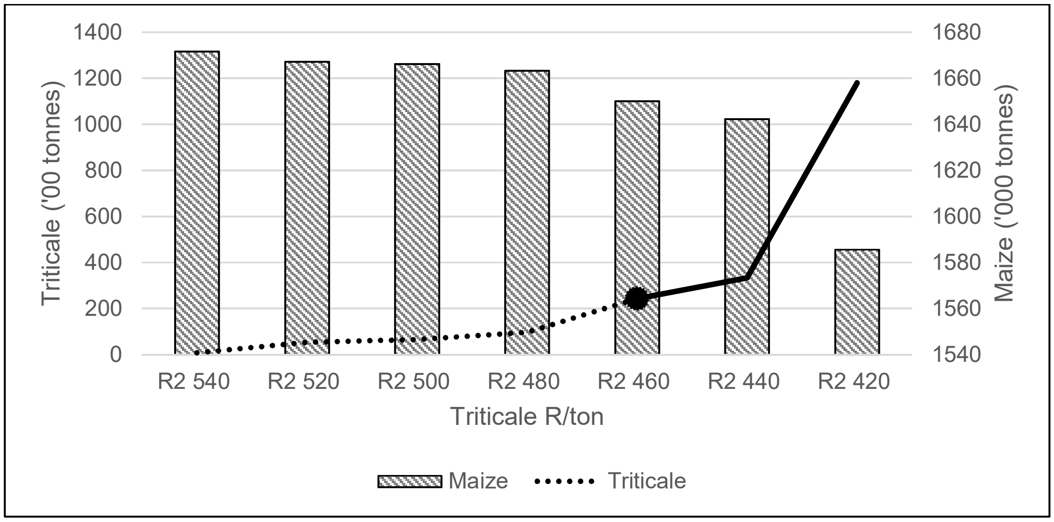

Figure 5.2: Demand curve for triticale (2017)

Source: Own calculations

One would have noticed that the demand curves provided by Figure 5.1 and Figure 5.2 are portrayed as having positive slopes, and not negative slopes in which demand is generally portrayed (since quantity demanded and price is negatively correlated). The figures are compiled in this fashion to allow for the reader to notice the effects that increased triticale usage has on maize usage, because maize usage, in these figures, is a function of the triticale price.

5.2.3 Financial viability of triticale

As mentioned previously, the financial viability of triticale is determined by comparing the profitability of triticale with that of milling wheat. The profitability of both triticale and milling wheat is calculated on the principles set in terms of partial budgets.

As mentioned earlier, the data regarding production costs has been obtained from Overberg Agri's projected budgets that are available prior to the production season. Unfortunately, though, these values, being projected, do not necessarily reflect reality, as conditions change throughout the production season. Other production information was found that reveals triticale to be more competitive to milling wheat in terms of allocatable cost per tonne spent, per unit revenue generated (more competitive than what is the case in the projected budgets). However, this information is unfortunately not available for recent years, and was also produced in a trials setting, and not on a commercial scale. The projected budgets were, therefore, used and were fitting, in the sense that the projections are based on production in the same region/conditions. Table 5.4 provides an overview of the financial gains and losses, based on the profitability calculations of triticale and milling wheat for 2016. The output price used for the gross margin calculation in terms of triticale reflects the base price (R 3 200 per tonne), i.e. the price at which at least 20 000 tonnes of triticale would be absorbed into the animal feed industry in the WCP.

Table 5.4 Partial budget (2016 prices)

Existing practice (Milling Wheat)		Alternative (Triticale)	
(i) Lost income: Producer price for milling wheat in Caledon (R2 952.14/tonne) * Yield (3.20 tonne/ha)	R9 446.85	**(i) Additional income** Price for Triticale (@ consumption level of >20 000 tonnes – R3 200/tonne) * Yield (2.60 tonne/ha)	R 8 320.00
(ii) Saved costs Total Allocatable cost (R/ha)	R6 658.31	**(ii) Additional costs** Total Allocatable costs (R/ha)	R5 102.80
Difference (sacrifice)	R2 788.54	Difference (benefit)	R 3 217.20

Source: Own calculations based on data obtained from Overberg Agri (2017) as well as the outputs from the APR_OPT model

The results suggest that triticale has the potential to yield a gross margin of R3 217.20 per tonne, compared with the R2 788.54 reported for milling wheat (Table 5.4). In the specific season, triticale could have been considered a financially viable alternative to milling wheat in the WCP. Although not presented in Table 5.4, a similar scenario is evident, based on the profitability comparison between triticale and milling wheat for the 2015 season.

The picture is slightly different for 2017 (Table 5.5). Although triticale is still likely to report a positive gross margin, the relatively high milling wheat price, coupled with a low maize price, resulted in milling wheat being potentially more profitable compared with triticale.

Table 5.5: Partial budget (2017 prices)

Existing practice (Milling Wheat)		**Alternative (Triticale)**	
(i) Lost income: Producer price for milling wheat in Caledon (R3 362.00/tonne) * Yield (3.20 tonne/ha)	R10 758.40	**(i) Additional income** Price for Triticale (@ consumption level of >20 000 tonnes – R2 460/tonne) * Yield (2.60 tonne/ha)	R6 396.00
(ii) Saved costs Total Allocatable cost (R/ha)	R6 771.26	**(ii) Additional costs** Total Allocatable costs (R/ha)	R5 256.22
Difference (sacrifice)	R3 987.14	Difference (benefit)	R1 139.78

Source: Own calculations based on data obtained from Overberg Agri (2017) as well as the outputs from the APR_OPT model

It is therefore clear from the above that a blanket answer to the question of whether triticale presents a financially viable alternative to milling wheat in the WCP will not suffice. Although a potential demand for triticale exists in terms of the animal feed industry, much of the financial viability, or rather financial superiority, will depend on the maize and milling wheat prices. In a year with a relatively high maize price, coupled with lower milling wheat prices, triticale will definitely present milling wheat producers with a more profitable alternative.

5.3 Conclusions

The results from this study do not present a straightforward answer to the question of whether triticale can be considered as a financially viable alternative to milling wheat. The determination of financial viability is, however, dependent on the way in which financial viability is defined in this study, i.e., triticale needs to yield a higher gross margin compared with milling wheat to be considered a financially viable alternative.

The results revealed that although triticale is likely to yield a positive gross margin, given the demand threshold and successive price, it would not always be more profitable than milling wheat might be. The profitability of triticale compared with milling wheat will, to a large extent, depend on the market price of maize and milling wheat. The maize price is an important component in cases where it accounts for more than 50% of the raw materials that are being substituted by triticale. On the other hand, the market price of milling wheat has a direct impact on the gross margin and consequently on the financial viability, when compared with triticale. Therefore, triticale is more likely to present producers in the WCP with a financially viable alternative to milling wheat in those years when the market price for maize is relatively high, and that of milling wheat is relatively low.

Chapter 6 – Conclusions and Recommendations

6.1 Introduction

The necessity of having an alternative crop to wheat in the Western Cape Province (WCP) is mainly attributable to financial profitability, and the concomitant challenge for wheat producers to remain viable. Moreover, a better performing crop will not only aid producers in their quest to remain financially viable, but will also have the potential to contribute towards the welfare of the broader farming community and consequently the country as a whole. Resource endowments are decisive factors for what can be produced in the region, remembering that wheat, similar to most other grain crops in the WCP, is predominantly produced under dry-land conditions. Climatic conditions, such as precipitation levels (rainfall season) therefore comprise one of the major constraining factors in terms of alternative crops. The fact that the WCP receives most of its rain during the winter months implies that producers are largely confined to the production of winter crops. The situation is therefore entirely different from that of their counterparts, with producers in provinces such as the Free State Province (FSP) having the option to produce a number of alternative grain crops, such as maize. This is mainly a result of them falling within the summer rainfall areas of South Africa.

Other factors that have an influence include the existing equipment and machinery on farms that could necessitate alternative crops to be similar than what is currently produced, as well as the similarity of crops that influence the sequences of crop rotation systems, a practice that is common in the WCP. With this being said, most of the studies conducted in the past have focused on the comparison of the profitability of different crops in combination or rotation production systems, or the comparison of profitability in terms of different production methods. No attention, however, has been given to the financial viability of alternatives for wheat production in the WCP. It is therefore necessary to determine whether there are potential financially viable alternatives for wheat producers in the WCP.

A potential alternative for wheat, therefore, is triticale, provided that the resource endowments needed for the production of triticale are similar to those for conventional wheat. The market for triticale is, however, under-developed, mainly because triticale is, in most instances, produced as fodder and not a cash crop. Therefore, a market analysis (identification of a potential market) for triticale forms an integral part of the investigation into the viability of triticale as an alternative for conventional wheat.

6.2 Objectives of the study

The main objective of this study was to determine whether triticale provides a financially viable alternative to milling wheat in the WCP of South Africa. To achieve the main objective, the following sub-objectives needed to be achieved:

- To conduct a thorough literature review in terms of previous studies that have dealt with similar research questions to determine an effective method of establishing whether triticale can be considered financially viable;
- To provide insight into the importance of milling wheat as a field crop in the WCP, and to reflect on the usefulness of triticale as an alternative;
- To determine the appropriate methodological approaches for assessing the financial viability of triticale as an alternative for milling wheat in the main wheat producing areas in the WCP;
- To draw conclusions from the results generated by the methods and make recommendations in terms of the financially viable of triticale as an alternative for conventional wheat production in the WCP.

6.3 Summary

6.3.1 Literature review

Considering that triticale is a winter grain, and is very similar to wheat, it has been considered feasible for production in the WCP, given the available resources. In addition to its suitability for production, it was necessary, however, to determine its financial viability, as that will largely determine whether triticale production can be considered a sustainable alternative in the long run. Establishing what is meant by financial viability was essential, which would then assist in discerning the methods that would enable the study to determine this. The concept of farm viability was referred, from the study of Salant et al. (1986), back to the principle of whether on-farm activities can sustain the farming household and increase net worth. The declining profitability of an enterprise threatens the welfare of the farming household, as well as stakeholders such as the suppliers and employees. Conditions such as decreasing competitiveness in domestic wheat production and drought conditions appear to have reduced the viability of milling wheat production, which threatens the welfare of the stakeholders. The question, therefore, was whether triticale could, with a lucrative feed market in the WCP (AFMA, 2016) and higher drought resistance (Botes, 2017), be a crop that will increase a farming business's viability.

As financial viability is defined, inter alia, as "the ability of an entity (or venture) to continue to achieve its operating objectives and fulfil its mission over the long term" (Venture Line, 2017), and considering that the purpose of triticale production in this case is that it should provide a more profitable alternative for the WCP, the method that was to be used should be able to measure triticale's profitability compared with that of milling wheat.

A review of crop selection methods was then used to distinguish between different approaches for crop selection. Dury et al. (2012) categorised the crop selection methods into two categories, namely multi-attributive objectives selection and mono-attributive objective selection. The approach and usefulness of each category with regard to accomplishing specific objectives were discussed. Multi-attribute objectives solutions were discovered to be very comprehensive in taking various factors into account (profitability, impact on soil fertility, etc.), and thus do not focus alone on ensuring profitability from returns, but also on being environmentally sustainable and utilising the available resources optimally. This is especially important when planning crop rotation sequences – i.e. which crops to include and what the frequency should be for producing a certain crop in a sequence.

Considering that the focus can be directed to a specific stage/season within a rotation sequence (which spreads over a number of years), and that the agronomic traits of wheat and triticale are very similar (Botes, 2017), it will be adequate to only focus on profitability in the case of this study. Methods of selecting crops, based on profitability as a primary objective, generally entail the comparison of gross margins, and are performed by means of budget analyses. Nelson and Meikle (2001), Lu et al. (2003) and Adisa and Sofoluwe (2013) all focused on different approaches to select crops/varieties or production methods, based on profitability. The studies of Nelson and Meikle (2001) and Lu et al. (2003) specifically made mention of the trade-offs that will be present when choosing between different varieties to plant, or management practices to implement. This can be applied to this study, considering that although trade-offs between different prices obtained for milling wheat and triticale will exist, there will also be a trade-off in different production costs spent, with triticale most likely having lower production costs, in general. The data items necessary to perform budget analyses include yield, price, and production costs. As stated in previous chapters, it was necessary in this study to move away from the conventional way of determining the triticale price (which is to derive it from another commodity), and to determine a price that specifically relates to the value of triticale.

Several methods that are able to estimate raw material demand and thus raw material value were considered and evaluated. The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) is amongst the international models that are able to determine raw material demand. Although widely applied to global projections on agricultural supply, and demand and trade, as well as ex-ante assessments of the long-run impacts of changes in drivers of agricultural production (such as technological and climate change) (Msangi et al., 2014), the IMPACT model does not account for the nutrient composition of feed rations. The Australian Bureau of Agricultural and Resource Economics (ABARE) model is very similar to the Agricultural Products Requirements Optimising (APR_OPT) model, being a mathematically programmed model that combines feed formulation and market components in order to obtain regional usage of raw materials used in feeds, its prices and amount traded in that region. However, it is compiled exclusively for an Australian setting (given its infrastructure, market set-up and grain handling facilities). Lastly, there was the model by Brennan et al. (2002) that evaluated the economic potential for improving the nutritional characteristics of feed grains. Being derived from the ABARE model, it had the same basis but was not disaggregated into regions so as to measure the value of improvements in feed grains over the broad Australian context.

Considering the local methods, the APR_OPT model was considered to be the best suited, with regard to its ability to determine the demand for animal products in the WCP (with the use of data from the Bureau for Food and Agricultural Policy's (BFAP) model), from which one can then determine raw material demand, at the raw materials' respective costs. Also considered was the McGuigan and Nieuwoudt model, which could be thought of as very useful in its time of development, but is currently outdated and perhaps lays too much emphasis on the determining of protein feed demand among animals for it to be fitting for analysing triticale as an energy source. Other studies nevertheless provided important principles that were applied in this study. Amongst them is the study of Brennan et al. (2002) who specifically include an arbitrary quantity into the model, creating a hypothetical raw material supply, which the model then uses to evaluate the added feed grain's nutritional characteristics and estimate demand levels at different prices. Moreover, the assumption is included that grain producers will only produce feed (triticale) if it provides a financial return at least similar to that of food grain (wheat).

Having established the approach for determining triticale's viability, and obtaining direction from past studies with similar problems, it was then necessary to shed light on both the global and domestic wheat industries to understand how external pressures are affecting local producers, as well as to provide background regarding how the alternative was identified.

6.3.2 Industry overview

Global wheat production has increased gradually since 1990, with the European Union (EU) and China being the regions contributing the most to global production. Significant growth figures can be seen from Russia and Ukraine, which although not the largest producers, show the highest annual growths in yields, and thus in production. However, decreased expenditure on agricultural Research and development (R&D) has resulted in annual growth being lower during the period 1990–2017, as compared with 1961–1990 (Pardey, 2011). This raises a matter of concern, considering that wheat, as a source of calories, provides up to 45% of the calorie intake for regions such as Central and West Asia and North Africa (CWANA) (Tadesse et al., 2016).

Lower R&D expenditures may have caused lower growth in efficiency over the past three decades. However, despite a general decline in spending on R&D, some countries have managed to increase productivity and, as a result, global wheat prices have come under pressure. Unfortunately though, producers in countries such as South Africa were not able to mitigate the financial pressure resulting from lower global wheat prices with an increase in efficiency. As a result, government support in the form of import tariffs were required to ensure that local producers remain competitive. Apart from the global environment being extremely competitive, the South African wheat producers are faced with the problem of wheat cultivar breeders pursuing higher quality levels at the cost of improving yield levels, due to a power imbalance caused by the bargaining power of buyers in the wheat industry. Although increased quality should increase wheat's value, wheat producers are not rewarded for superior quality in instances where their wheat exceeds the standards of class

B1-wheat. Van der Merwe (2015) questioned the quality of foreign wheat that is used as the reference in determining the price of South African wheat. Additionally, when comparing the quality of imported wheat with domestic wheat, one cannot help but wonder whether importers are benefiting from a situation where domestic wheat is undervalued, and importers therefore import lower-quality wheat to achieve a good balance of quality at a low cost.

Unfavourable market and weather conditions have seen the producers in the FSP, a major wheat-producing region the country, resorting to alternatives that are perceived to be more profitable when compared with wheat. The shift was mainly towards the production of summer crops such as maize. Unfortunately, the WCP producers are limited by resource endowments, and therefore cannot consider switching towards the production of summer crops. WCP producers are also experiencing even more pressure from a pricing point of view, considering the region's high location differential that is subtracted from their marketing price. Viability, from both a resource and financial point, is among the factors that need to be taken into account when considering alternatives.

For a commodity to be financially viable, it is essential that a market should exist for it, thus providing a need to be satisfied. Based on this, the feed manufacturing sector in the WCP, with its reliance on maize (most of which is produced outside of the borders of the province), was identified as the main market for an alternative such as triticale, as it has a nutritive value similar to that of maize. Moreover, triticale was also considered to be the best option with regard to its suitability for production. The problem exists, however, that since the marketing of triticale grain seldom takes place, and when marketed, its value is usually derived from another commodity. To enable a just comparison of the profitability of milling wheat and triticale, it was necessary to use the APR_OPT model to attach a monetary value to the worth of triticale specifically.

6.3.3 APR_OPT model

The APR_OPT model determines the total demand for feed raw materials required to produce and satisfy the demand for animal products, through allocating the usage amounts of each raw material, based on its cost and nutritive value, and on the animals' feed requirements, thus formulating a least-cost ration. Bearing this in mind, the price of triticale was adjusted until usage amounts of triticale were obtained at different price levels. At each price level at which triticale was included, the results displayed varying usage levels for most raw materials. The base price for triticale for each year (2016 and 2017) was selected at a uptake of close to 20 000 tonnes, at which comparisons were then made relating to the usage levels of all raw materials, with and without the inclusion of triticale at base price. The amount of 20 000 tonnes was used as reference to determine the base price for the specific year, based on a specialist opinion stating that a minimum amount of 20 000 tonnes is required for feed manufacturers to consider triticale as an alternative raw material and to adjust their formulations (Robertson, 2017)

Triticale's high energy content resulted in maize being the raw material that is most affected by the inclusion of triticale, with other raw materials also being affected due to triticale's higher levels of amino acid and minerals. During 2016, a triticale uptake of just over 22 000 tonnes resulted in almost 18 000 tonnes less yellow maize being used, with other raw materials, such as wheat middlings and sunflower oil, also displaying lower usage amounts. Lucerne was the only raw material likely to report an increase, which could be attributed to triticale's higher protein content causing decreased use of a more expensive higher protein source, and permitting increased usage of a cheaper source of protein, thus creating an interactive response.

The year 2017 provided similar results, with slight exceptions being that, due to its extremely low prices, white maize was the main energy feed source, and therefore also the main raw material substituted by triticale, considering 22 000 tonnes less white maize being included due to a 24 000 tonnes' uptake. Triticale's higher protein content also resulted in lower levels of sunflower and soybean oilcake and lucerne usage amounts. The increased usage level of bagasse provided another example of interactive responses due to the inclusion of triticale, as the higher protein content of triticale caused less lucerne to be used, and the fibre lost from the lucerne being sourced from bagasse, a cheaper raw material. It was noted that the inclusion of triticale into diets will always cause such replacement and supplementary effects, primarily due to triticale containing higher levels of nutrients such as protein and minerals than maize does, and therefore need not be supplemented from other sources. The usefulness of the APR_OPT model, being able to use differing amounts of raw materials and still formulate rations with the same nutritive composition, as prescribed by the animals' nutrient requirements, was then displayed.

The demand curves for triticale, with the addition of maize usage according to the triticale price, highlighted the influence that the prices of these two substitute raw materials will have on one another. The results for 2016 provided a triticale price of R3 200 per tonne at a 22 000-tonnes uptake level, with 2017 results providing a price of R2 460 per tonne at a 24 000-tonnes uptake level. Much of the substitutability of triticale was therefore considered to be dependent on the maize prices for a specific year, considering the effect of lower maize prices during 2017, which cause the inclusion price of triticale to be significantly lower. Having obtained the base prices, this study commenced to performing the budget analyses.

6.3.4 Budgetary technique

Since the mere comparison of the profitability of two similar crops can be achieved through following a simplistic approach, bearing in mind that the data required in the method should be a true reflection of each enterprise, this study made use of budgetary analysis. It is an ideal method to compare the effects that a change in practice (such as production methods, or alternative enterprises) might have, as is the case in this study.

Subsequent to obtaining base prices for triticale at which it can be compared with milling wheat in analyses for 2016 and 2017, partial budgets were compiled. As the accuracy of the analysis is dependent on how justly the data resembles each enterprise, it is unfortunate that the only available data that comprises triticale and wheat production in the same conditions were projected data. It would be interesting if this analysis could be based on actual production outcomes. Nevertheless, the analyses were performed and differing results for 2016 and 2017 provided an indistinct outcome. During 2016, triticale could have yielded a R428.66 per hectare higher gross margin than milling wheat, but higher milling wheat prices in 2017, as well as lower maize prices that brought down the inclusion price of triticale, caused a significant R2 847.36 per hectare higher milling wheat gross margin than that of triticale. The 2017 gross margin seems to overshadow the 2016 gross margin, which may result in milling wheat appearing to be more favourable in the comparisons, but positive gross margins for triticale in both years, and a better performance during 2016 than milling wheat, should not be overlooked. As this method was used to determine the financial viability of triticale as an alternative, the outcome is unfortunately not straightforward. Although triticale could potentially yield a positive gross margin frequently, it could not necessarily, as it is required in this case, be an alternative that improves the financial position of WCP producers in the long run.

6.4 Conclusions and recommendations

The purpose of this study was to evaluate the financial viability of an alternative for wheat production in the WCP. The need stems from the declining performance of the South African wheat industry, and the consequent financial difficulties experienced by wheat producers in parts of South Africa such as the WCP. Moreover, the alternatives for wheat producers in the WCP are limited by resource endowments and, as a result (unlike their counterparts in provinces such as the FSP), wheat producers in the WCP are unable to switch to the production of summer grain crops such as maize. Additional to external pressures faced by wheat producers in general, the WCP producers are also burdened with location differentials, causing a much lower producer price compared with other regions.

In an endeavour to find alternatives for WCP producers, a market was sought that could potentially be more lucrative than supplying milling wheat is, thus constituting a more profitable market. The WCP's large share in the growing national animal feed industry was identified as providing an opportunity for a new product, considering the province's high demand for yellow maize and its inability to produce sufficient amounts. Triticale is suitable for answering this opportunity, considering that it is feasible for production in the WCP, and also its high energy content to substitute yellow maize to a certain degree in WCP feed rations.

Triticale was therefore included into the APR_OPT model to measure its value as a raw material by generating different quantity amounts at different price levels until a suitable uptake of close to 20 000 tonnes was obtained. At this usage level, 2016 and 2017 had large differences in prices, which were mostly caused by extreme highs and lows in maize prices in consecutive years. Fluctuating milling wheat prices also influenced the outcomes of the budget analyses, revealing triticale to be reasonably more profitable in 2016, but with milling wheat performing exceedingly better in 2017. The mixed results, therefore, do not allow direct recommendations of whether or not one should consider triticale as an alternative.

There is uncertainty, therefore, regarding the adoption of triticale as a commercially produced crop. Firstly, it is uncommon for use in feed manufacturing due to its low availability, and thus a low awareness of its qualities exists, and it is necessary to have at least a 20 000-tonnes supply before feed manufacturers might adjust their formulations. This need to acquire 20 000 tonnes from producers brings in the other reason for uncertainty. In Chapter 3, it was mentioned that triticale is regarded by many producers to be an inferior crop, and is thus only grown for on-farm uses such as grazing and silage, or as a cover crop. For producers to allocate more resources towards the production of triticale on a larger level, more concrete results should be provided than what have been revealed by the outcome of this study. Due to insufficient production information of triticale being available, one may question whether the competitiveness of triticale production is accurately depicted in this study's analyses, considering expert opinions regarding triticale production to be more efficient than wheat is. However, one cannot use arbitrary values in such analyses, but should make use of actual projections, or more ideally, actual production figures.

Nevertheless, the financial viability of triticale can be seen as being plausible, considering that it had positive gross margins in both the years analysed, and in one year, was more profitable than milling wheat. More research, as well as more defining results, is required to make reliable recommendations.

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Annexure A: Enterprise budgets for 2016

		Milling wheat	Triticale
	UNIT		
INCOME FROM PRODUCTION			
Yield	tonne/ha	3.20	2.60
Producer price	R/tonne	R 2 952,14	R 3 200,00
GROSS INCOME	R/ha	R 9 446,85	R 8 320,00
DIRECT ALLOCATABLE COSTS	R/ha	R 5 439,17	R 3 901,06
Seed		R 683,41	R 649,65
Fertilizer		R 2 488,00	R 1 928,00
Herbicide		R 777,61	R 386,52
Fungicide		R 562,09	R 300,31
Pesticide		R 192,09	R 192,09
Trace minerals		R 33,60	R 0,00
Water costs		R 21,64	R 14,43
Contract services		R 306,50	R 167,50
Seasonal labour		R 5,00	R 5,00
Statutory levies and silo costs		R 265,92	R 189,80
Soil and plant analyses, Mapping		R 72,50	R 60,00
Insurance		R 31,21	R 25,77
NON-DIRECT ALLOCATABLE COSTS	R/ha	R 1 219,14	R 1 201,74
Fuel		R 600,78	R 587,97
Repair and maintenance		R 618,36	R 613,77
TOTAL ALLOCATABLE COSTS	R/ha	R 6 658.31	R 5 102,80
GROSS MARGIN	R/ha	R 2 788,54	R3 217,20

Source: Overberg Agri (2017) and triticale price obtained from own calculations

Annexure B: Enterprise budgets for 2017

		Milling wheat	Triticale
	UNIT		
INCOME FROM PRODUCTION			
Yield	tonne/ha	3.20	2.60
Producer price	R/tonne	R 3 362,00	R 2 460,00
GROSS INCOME	R/ha	R 10 758,40	R 6 396,00
DIRECT ALLOCATABLE COSTS	R/ha	R 5 614,39	R 4 115,76
Seed		R 760,18	R 882,00
Fertilizer		R 2 337,17	R 1 819,01
Herbicide		R 760,41	R 386,62
Fungicide		R 681,20	R 361,27
Pesticide		R 192,64	R 192,64
Trace minerals		R 33,60	R 0,00
Water costs		R 23,64	R 15,76
Contract services		R 316,50	R 172,50
Seasonal labour		R 6,25	R 6,25
Statutory levies and silo costs		R 397,60	R 202,80
Soil and plant analyses, Mapping		R 65,83	R 53,33
Insurance		R 39,37	R 23,58
NON-DIRECT ALLOCATABLE COSTS	R/ha	R 1 156,88	R 1 140,46
Fuel		R 532,92	R 521,55
Repair and maintenance		R 623,96	R 618,91
TOTAL ALLOCATABLE COSTS	R/ha	R 6 771,27	R 5 256,22
GROSS MARGIN	R/ha	R 3 987,13	R 1 139,78

Source: Overberg Agri (2017) and triticale price obtained from own calculations