Study to Establish Market Opportunities for Sorghum in South Africa

Final Report

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

AIH GROUP

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By

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AMENDMENT HISTORY SHEET

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Executive Summary

1 Executive Summary

Sorghum is regarded as the second most important cereal grain crop in Africa after maize, and globally it is the fifth most important cereal grain crop, after maize, rice, wheat and barley. As a crop, it is ideally suited to marginal environments due to its low water requirement, drought-tolerance, tolerance to high temperatures, multitude of uses (food, animal feed, beverages and ethanol) and ability to produce harvestable grain under diverse farming systems.

In South Africa, sorghum is currently only the sixth largest grain crop, after maize, wheat, soybeans, sunflower, wheat and barley. This is in contrast to a decade ago when sorghum was the third largest grain crop after maize and wheat. A five-year average show that sorghum production in South Africa has been declining, with South Africa moving from being a net exporter of sorghum to a net importer.

The purpose of the study was to assess the current sorghum industry in South Africa, with the objective of identifying viable market opportunities to rejuvenate the sorghum industry, to expand the production of sorghum and to stimulate demand for sorghum. The study was divided into three phases, as illustrated in the Figure below:

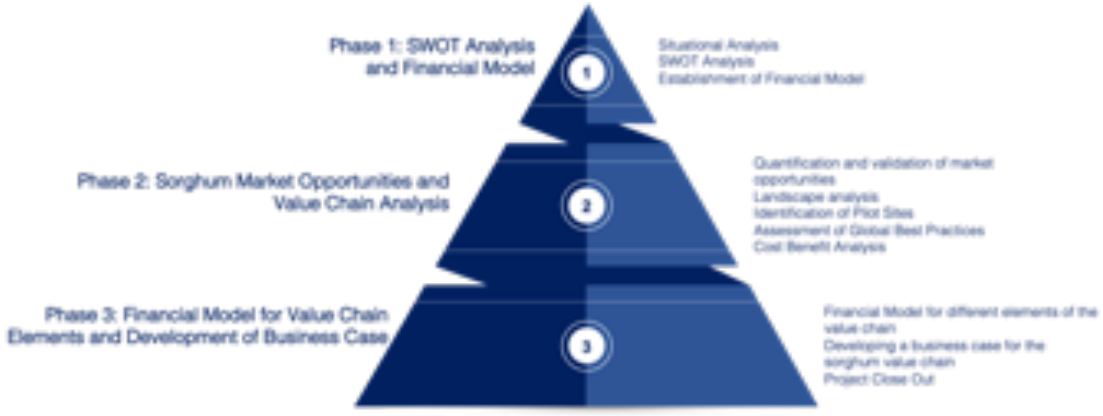


Figure 1: Study Phases

- **Phase 1: SWOT analysis and Financial Model**
  This phase comprised of a situational analysis of the sorghum industry, with a comprehensive SWOT analysis and the development of a financial model for sorghum farming operations;
- **Phase 2: Sorghum Market Opportunities and Value Chain Analysis**
  The second phase of the study built on the findings of the first phase, and comprised of a more in-depth value chain analysis, the quantification of market opportunities identified, the identification of pilot site for identified opportunities, an assessment of global best practices and a cost-benefit analysis of the identified opportunities; and
- **Phase 3: Financial Model for Value Chain Elements and Development of Business Case**
  The development of a financial model for the value chain elements as well as the development of a business case for the proposed upgrades to the sorghum value chain.

Economic background

World economic growth was already slowing prior to the outbreak of the COVID-19 health pandemic, with global growth below 3% in 2019 – the lowest since the 2008 financial crisis. Multiplying global risks have contributed to slowing growth

in both developed and developing economies. Brexit, tariffs, and trade wars have all contributed to an increasingly negative economic outlook, along with a generalised increase in political tension and uncertainty.

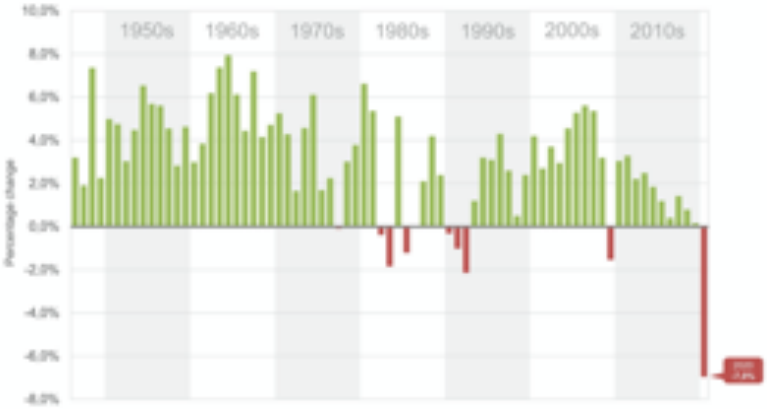
The COVID-19 global health pandemic saw what is now being referred to as "the Great Lockdown" being implemented in most countries around the world. Economic activity in the majority of countries around the world was severely constrained in the first and second quarter of 2020 as national lockdowns were implemented in an attempt to combat the spread of the COVID-19 virus. While most countries have resumed economic activities, there the COVID-19 virus continues to spread, resulting in some countries slowing the reopening of the economy while others are reinstating partial lockdowns to protect susceptible populations.

The latest available data from the Organisation for Economic Cooperation and Development (OECD) estimates a decline of 4.9% in global economic activity for 2020, and a 5.6% increase in global growth for 2021.

South Africa's economic activity contracted by 7% in 2020[1]. The COVID-19 pandemic brought on many challenges for an already struggling economy. Employment saw a steep decline, with the number of people employed falling by 1.4 million people. In the October -December quarter, unemployment in the country stood at a record level of 32.5%, with the expanded definition of unemployment (which includes discouraged work seekers) at 42.6%.

Despite the impact of the pandemic on economic growth, there was one shining star in 2020. Agriculture escaped the effects of the pandemic relatively unscathed, expanding production by 13,1% in 2020. Government also grew marginally in the year, up by 0,7%.

South Africa is likely to see economic growth of 2.9% in 2021 as it rebounds from the -7% collapse of 2020. However, much of this growth will be due to the base effects arising from the large contraction in economic activity in 2020.



The Importance and Value of Sorghum

Sorghum (*Sorghum bicolor* L. Moench) is a versatile cereal crop that can be grown for grain for human food and animal feed, forage, biomass or as a source of sugar. In terms of world cereal production, sorghum is ranked fifth, after wheat, maize, rice and barley. From an agronomic point of view, sorghum is a hardy, drought-tolerant crop with low water requirements. However, it can also withstand periods of excessively heavy rainfall. Sorghum is grown almost exclusively as a rainfed crop and is not normally irrigated. As a C4 cereal, sorghum is more efficient in utilising the high solar radiant energy found in tropical regions than the C3 temperate cereals, such as wheat, barley and rice. Consequently, sorghum has potential for greater cultivation in regions that are now being adversely affected by climate change.

Though sorghum cultivation is reported from more than 100 countries, only eight countries have over 1 million ha area under sorghum, which together contribute more than 60 % of world sorghum production. These countries are:

- United States
- Mexico
- Nigeria
- Ethiopia
- Sudan
- Burkina Faso
- Niger
- India

[1] Stats SA, March 2021

In Africa, although only a few countries (Nigeria, Ethiopia, Sudan, Burkina Faso, Mali and Niger) contribute a major share of cultivation area, sorghum is widely distributed and is a major staple food and beverage grain in large parts of the continent. In spite of its economic importance, the sorghum cropped area around the world has declined over the last four decades at a rate of over 0.15 million ha per year. However, in some countries including Brazil, Ethiopia, Sudan, Australia, Mexico, Nigeria, and Burkina Faso the area used for sorghum cultivation is expanding.

More than 80% of the global sorghum area is characterized by traditional smallholder agriculture, which gives low yields and contributes slightly above half of the total grain production. The remaining sorghum is produced in the developed countries using fully mechanised agriculture with higher yield levels. Sorghum acts as a dietary staple for millions of resource-poor people living in some 30 countries in the subtropical and semi-arid regions of Africa and Asia. It is a source of food and fodder, in the traditional, smallholder farming sector of these regions.

The global economic importance of sorghum stems from the high variety of uses of the crop. Sorghum grain is used primarily for human nutrition in many countries mainly in Africa and in India and Pakistan. In sub-Saharan Africa, a major use for sorghum is for brewing traditional African beer and increasingly for the industrial production of lager and stout beers and non-alcoholic malt beverages. In China, a major use for sorghum is for the baijiu alcoholic spirit. The majority of sorghum grown in Western countries is either for export (primarily for animal feed) or used locally for animal feed. Sorghum grain is used to produce 4% of fuel bioethanol in the United States. Second generation renewable-energy production from sorghum biomass and other industrial uses of sorghum is currently very limited and is mainly still at the research and development stage.

The fact that sorghum is a non-GMO (Genetically Modified Organism) crop and that it is gluten free, contains a range of beneficial phytochemicals and is considered as an ancient grain means that it has become a viable option for high-value food niche markets in the developed and developing world. One important advantage of sorghum in human nutrition is that its starch can be more slowly digestible than that in other cereals. The slow starch digestibility is believed to be protective against development of obesity and its associated diseases of Type 2 diabetes and cardiovascular disease. Slowly digestibility starch is, however, slight disadvantage with respect to its animal feed value.

Among cereal foods, sorghum is probably the richest source of phenolic phytochemicals. These exert positive health effects, notably as protection against oxidative stress and consequent diseases like cardiovascular disease and certain cancers. There is also good evidence that these phenolic phytochemicals are protective against the development of Type 2 diabetes. Sorghum is also considered as one of the best gluten-free flours. The markets for healthy grain foods and gluten-free food products are expanding rapidly in developed countries, albeit from a very low base.

The South African Sorghum Industry

Over the past two decades, overall, there has been a steady decline in sorghum production in South Africa. South Africa's overall sorghum usage was estimated at 159,037 tons in the 2018/19 marketing year, down by 45% from 1999/2000 marketing year. This is primarily due to the ongoing decline in the production of sorghum malt, which in former times was the major market for sorghum. Sorghum malt is used in the brewing of traditional African beer (commonly called sorghum beer), where it comprises approximately one-third of the cereal ingredients with the other two-thirds being maize. Traditional African beer (TAB) brewing, both informal and industrial, has contracted dramatically over the past three decades as consumers have moved to lager-type beer.

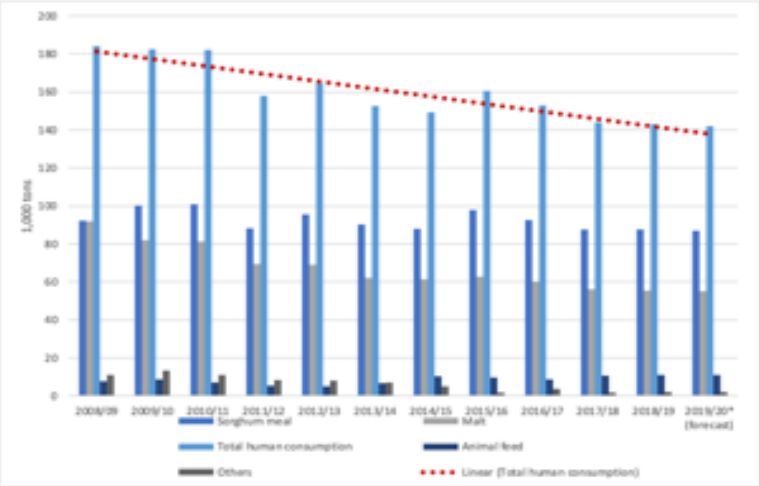
The decline in local demand for sorghum was previously compensated to some extent by export of sorghum to Botswana. However, sorghum exports to Botswana have now all but ceased as Botswana is now producing sorghum commercially

at large scale. There was growth in the South African market for sorghum meal (for porridge making) and for instant sorghum porridge powder (however, this growth was from a small base). The consumer trend towards healthier diets (including gluten-free diets) does not seem to have had the positive effect on sorghum demand as might have been expected. Lately, this is a primarily as a consequence of the high cost of sorghum relative to other cereals, particularly maize.

Sorghum per capita consumption in South Africa was estimated at 1.62 kilograms per year in 2018, down by 16% from the year 2000. A similar trend can be observed with maize consumption, as the per capita consumption of South Africa's maize has also fallen by 15% over the same period to about 77.32 kilograms in 2018. Whilst the per capita consumption of maize has declined over the recent past, overall maize usage continues to increase due to demand from the animal feed market.

In 2014, sorghum was one of the more promising crops in local agriculture, boosted by the hope of the development of a local bioethanol industry based on sorghum, with the benefits of job creation and a new market for farmers, particularly black smallholder farmers.

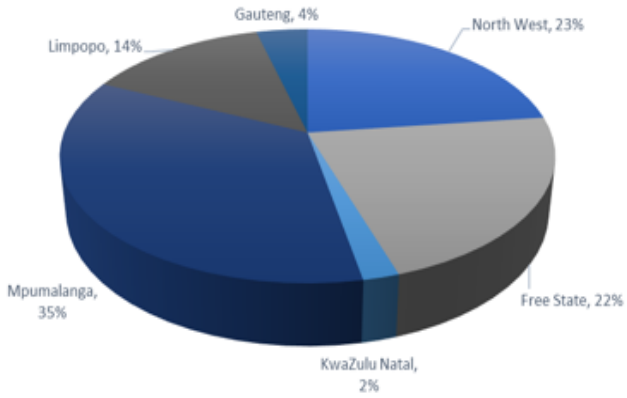
In South Africa sorghum is primarily sued for human consumption, with a very small amount being used as animal feed. The graph below provides a summary of sorghum consumption by use over the past 11 years.



Supply of Sorghum in South Africa

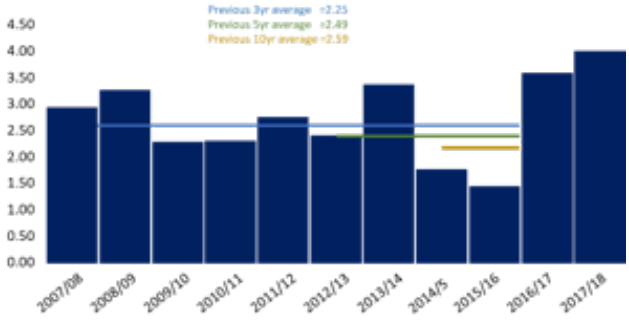
Local production of sorghum

In South Africa, sorghum is cultivated in the drier areas of the summer rainfall region, i.e., the northern provinces, where it is planted between mid-October to mid-December. The major producing regions, in descending order, are Mpumalanga, Free State and North West, Limpopo, Gauteng and Limpopo. In recent years, there has been a dramatic shift in production area importance from the Free State to Mpumalanga. This is because sorghum is able to generate economic returns in marginal areas and on heavy turf soils.



In the 2018/19 marketing year (MY) approximately 50,500 hectares of sorghum was planted. Yields vary from 2.5 to 4 t/ha, depending on climatic and soil conditions. Nationally, the yield has averaged 2.6 t/ha for the period 2007/8 to 2017/18. The average yield for the 2016/17 and 2017/18 seasons was 3.55 and 3.99 tons/ha under dryland (rainfed) cultivation and 5.39 and 5.33 under irrigation, respectively. However, only approximately 2% of the total sorghum area was irrigated. By comparison, average dryland white maize and yellow maize yields for the

2017/18 season were 4.85 and 4.76 tons/ha. However, over a longer period the yield gap between sorghum and maize is rather greater.



Over the 10 years 2007/8 to 2017/18 the average yields for sorghum, white maize and yellow maize were 2.6, 4.3 and 5.2 tons/ha, respectively.

The vast majority of sorghum produced in South Africa is produced by large-scale commercial farmers, with limited sorghum cultivation being produced by smallholder farmers in the former homelands.

Imports and Exports

South Africa has moved from being a net exporter of sorghum to a net importer of sorghum over the past 10 years, with the United States being by far the main supplier of imported sorghum (approx 95% of the sorghum). South Africa currently exports less than 5,000 tons of sorghum per annum, with the majority of exports destined for Eswantini.

The main reason for the decline in local sorghum production is the decline in the area planted, with more and more farmers opting for more profitable crops, particularly maize and soybeans. The productivity of sorghum has failed to increase due mainly to lack of development of new cultivars with agronomic performance, unlike the productivity of other crops such as maize and soybeans.

Sorghum Cultivars in South Africa

There are more than 60 hybrid sorghum cultivars and four open pollinated varieties (OPVs) registered in South Africa (See Annexure B in main report). However, only a very few of these are cultivated in any quantity and these are only hybrid cultivars. Smallholder farmers generally cultivate sorghum landraces, although the Agricultural Research Council has developed and released improved OPVs.

With regard to the cultivars cultivated by commercial farmers, they can be classified into two main types: bitter (tannin – class GH) and sweet (non-tannin – class) cultivars. Preference is given to the sweet cultivars as they have broader application. Bitter sorghums are often planted in areas where bird predation is a severe problem. The tannins give the grain an astringent and bitter taste, and consequently birds avoid eating the kernels if there are more palatable crops in the vicinity. Essentially the only market for bitter sorghum in South Africa is for industrial malting.

In South Africa sorghum cultivars are divided into three classes:

- Class GM: Malt sorghum that does not have a dark testa, i.e. the grain has a low tannin content (actually tannins are completely or essentially completely absent), commonly known as sweet sorghum. GM sorghum is especially suitable for malting (the malt having a high diastatic power (amylase activity) and milling purposes;

- Class GH: Malt sorghum that has a dark testa, i.e. the grain has a high tannin content, commonly known as bitter sorghum. GM sorghum is especially suitable for malting (the malt having a high diastatic power (amylase activity);
- Class Other: Sorghum that does not comply with the standards for Class GM or GH.

All GM and GH sorghum cultivars are red in colour as are virtually all of the Class Other. Very little white sorghum is cultivated in South Africa as the grain is highly prone to moulding in the field.

Key Issues Affecting the Sorghum industry in South Africa

The sorghum industry in South Africa is exposed to local and international commodity prices and elasticities of supply and demand. The current status of the sorghum industry is largely affected by the attractiveness of sorghum as an agriculture commodity to the farming community, the market demand from consumers in the local and international markets and the capacity, capability and profitability of the food, feed and beverage manufactures to convert sorghum into viable and attractive end-user (consumer and animal feed) products.

1. Farming sorghum in South Africa

Farmers target crops that suite the climate and soil conditions of their land. The search for crops the offer the best return on their investment. They are also investigating alternatives to maize because of the declining profitability of the crop over the long term (recent prices have been highly profitable). When considering sorghum instead of maize there are various factors that they take cognizance of:

- Market demand: Domestic sorghum consumption is relatively low (and declining) with the result that overproduction is a distinct possibility resulting in downward pressure on prices.
- International prices for sorghum. Due to decreasing demand, less farmers are growing sorghum contributing to supply shortages and farmers are able to sell their sorghum at import parity prices. Overproduction of sorghum would lead to significant price reductions as farmers will then have to sell at export parity prices and any profit would be minimal;
- Sorghum would compete with maize in terms of production area, in the market for meal, products on the supermarket shelves, and its inclusion in animal feeds. Maize is entrenched in the animal feed market and it would be hard pressed to convert its formulations to sorghum without some pushback from the animal husbandry and poultry industries.
- Diminished support from seed producers and other players. The diminishing role of sorghum in the local consumer market (mostly attributed to loss of market share of traditional African beer (TAB)) and the loss of Botswana as an export market, contributed to the seed companies curtailing and even terminating their seed development programs in South Africa. GrainSA is doing sterling work in support of the farmers by running cultivar yield trials and monitoring input costs and yields. The Sorghum Forum is active but lacks funding to support meaningful industry development.

The dedicated sorghum germplasm development program proposed as an outcome of this study, should support agricultural profitability and attract farmers to plant sorghum. The development programme should also include development of small holder farmers to introduce not only food security but also increased livelihood of small holder farming communities in South Africa.

2. Competitiveness of sorghum

Recently the price of imported sorghum has soared and is achieving record levels. This is currently a favourable position for the local famers (selling at import parity prices) but for the food and beverage processing companies, these prices will force them to pass price increases on to the consumer. Not all price increases can be passed to the

consumer and the producers will experience a decline in profit margins. The food and beverage producers will then tend to divert investment and productive capacity to other, more profitable products.

Maize prices also experienced an increase albeit not as sharp as that of the sorghum grain. The Covid pandemic contributed toward commodity prices coming under pressure early in 2020 but countries such as China are now closing the deficit and stockpiling commodities to secure grain for feed and baijiu production and this has contributed to increased prices for all grain commodities. Local feed producers are forced to pass increased input costs to the consumer with resultant pressure on consumer markets.

Internationally sorghum competes effectively with other grains (eg maize) in the market for animal feeds and biofuels. In the USA and Australia the cost of sorghum production is typically cheaper than maize production which is not the case in South Africa. A comparative analysis of crops budgets for sorghum in USA and Australia revealed that lower input costs (specifically fertiliser) and higher yields are most likely the key drivers. Notably, sorghum is also grown in drier areas of USA (Texas) and Australia.

South Africa still imports yellow maize on a regular basis, primarily through the Cape Town port. During the 2019/20 season more than 500,000 tons of yellow maize was imported from Argentina and Brazil. The high cost of transporting maize from inland grain producing regions to the Western Cape processors is cited as one of the key drivers for the importation of yellow maize. While yellow maize is used predominantly for animal feeds, the maize is not readily replaced with sorghum. In the rest of the world, the price of sorghum and maize is a driver for the demand for these grains by feed producers and the two grains are readily interchanged in animal feeds depending on the price differential. In South Africa, it seems that the animal feed producers are not ready to interchange yellow maize and sorghum if there is not better security of sorghum supply and competitive sorghum pricing.

The germplasm development programme proposed as outcome of this study outcome should aim to increase the competitiveness of sorghum production so that the local sorghum producers are able to compete effectively with imported sorghum and maize. This should contribute to increasing supply of sorghum on a more sustainable basis and restore confidence in the food beverage and feed industry to introduce sorghum in their raw material mix. The local food processors have indicated that the South African produced sorghum is generally of a better quality than the imported sorghum and that the focus of trait development should be on achieving higher yields, thus bringing down the cost of sorghum grain.

3. Climate change

Climate change is already having a definitive negative impact on agriculture and food supply in terms of productivity and food security. The increase in average temperature and increase in extreme weather events are likely to have an impact considerably on the cultivation areas for particular crops in the future. This will result in increased vulnerability in the agriculture sector over the medium to long term. It is generally accepted that agricultural producers will have to adapt to cope with climate change.

With the use of the FAO's AQUACROP crop-water production model by applying historic yield and historic and predicted temperature and rainfall data, predictions have been made as to likely changes in sorghum productivity across South Africa by the middle of this century, 2046-2065 (Kunze and Schulze, 2016). Due to higher temperatures, sorghum yields are predicted to increase in South Africa with more than 18% of the country's 5838 quinaries indicating simulated yields in excess of 12 tons/ha.

The provinces most suited to future sorghum cultivation are predicted to be the eastern Provinces, i.e. Mpumalanga, KwaZulu-Natal and the **Eastern Cape**. Specifically, the central region of Mpumalanga and some inland areas of the Eastern Cape may experience yield increases of 4 tons/ha. However, the entire West of the country: Western Cape, Northern Cape, western parts of the Eastern Cape, Northwest, and western Free State will be unsuitable because they will be too dry. Gauteng and parts of Limpopo should remain suitable.

There are, however, some differences between previous and current studies that point to an acute need for more detailed and up to date modeling of the impact of climate change and mitigation strategies on the yields of sorghum and other crops across the country.

4. Profitability of sorghum in the value chain

The profitability of sorghum production has come under much scrutiny. On the back of increasing sorghum prices, sorghum-based beer (TAB), beverage and meal producers are faced with decreasing margins in order to maintain retail prices and avoid exceeding sensitive market price points (e.g. R10.00 per litre for TAB). Increased sorghum prices (based on import parity) renders the local processing of sorghum into food product and beer unprofitable and the processors might be forced to remove the sorghum-based products from their product mix. Food processing companies use margin velocity as a measure of assessing their product portfolio. Marketing and promotional effort is targeted at those products with the most net contribution to operating profit. In the case of sorghum, the consumer demand for sorghum-based products is keeping these products on the shelves of the retailers (for now) and therefore remains an element of their product mix. However, due to its marginal contribution to company operating profits, little effort is spent on marketing and promoting these sorghum-based products.

Value added tax (VAT) is added to sorghum meal products and not to meal products of its competitor product - maize. This places the sorghum meal at a considerable disadvantage to maize meal. The price conscious consumer will be directed to buy maize. Sorghum buyers will feel the impact of the price differential. In the processed foods and beverages industry, the VAT can be reclaimed. However, the VAT has to be incurred at the procurement of the raw materials and it will, therefore, have a cash flow impact on the processors. This takes out cash from the business as there will always be a VAT accrual of at least 2 months on a perpetual basis that is funded out of cash flow.

Modern extrusion cooking technologies have been developed in South Africa to process a variety of grains and legumes into cooked, ready-to-eat meals. Sorghum is ideally suited to this technology and can be introduced in small scale factories to service regional communities in support of establishing circular economies. The Eastern Cape has been identified as a region that is suitable for sorghum (and maize) production. However, transport costs to the major processing facilities in Gauteng and Durban, renders the produce from Eastern Cape farmers uncompetitive. By establishing localized processing facilities to process sorghum and other grains in the communities, local economies can be stimulated and farmers engaged to supply the raw ingredients.

5. Consumer demand and nutrition

Cereal grains (maize, wheat, sorghum, etc.) make up a considerable portion of daily energy intake in Africa, and South Africa in particular. The growing population of South Africa will thus be a key driver of demand for grains, including sorghum.

At present, 26% of South Africans are considered food insecure, with up to 27% of children under 5 experiencing stunting in natural growth. Because sorghum has higher nutritional qualities than maize in particular it can assist in addressing food insecurity and nutrition challenges in South Africa. However, sorghum and sorghum-based products (meals, beverages, snack foods etc) will have to be competitively priced in order to capture a fair market

share of the growing population's demand for food. Sorghum and sorghum-based products will not only be competing with other basic foodstuffs, such as maize meal, but also with highly processed, nutritionally poor but energy-dense food products e.g. hamburgers which are not only readily available but also affordable and socially acceptable. It is estimated that a basket of healthy food can cost up to 67% more than so-called "junk" food[2]. The dominance of junk foods is placing increasing stress on the public healthcare system as the population undergoes a 'nutrient transition' – from traditional diets high in grains and dietary fibre to a diet high in sugars, fats, salt and animal-source proteins.

The negative impact of junk foods is not only limited to the consumers, but also impacts small food producers and informal trade by undermining healthier, more diverse rural and local food networks and their associated shorter value chains. Up to 70% of households in South Africa source food from informal markets, however, with the rising rate of urbanization and increasing availability of 'cheap, processed foods', this figure is declining, putting at risk the livelihoods of small farmers and informal traders.

Promoting the expanding consumption of sorghum foods is supported by increasing scientific evidence of sorghum's health-promoting attributes and its gluten-free and GMO-free nature. Health-conscious consumers will be attracted to these attributes. A number of new products continue to appear on the market and while the demand in relative terms is small, it appears to be growing in regions such as the USA and Europe at a rate that considerably exceeds the GDP growth.

Importantly, the sorghum industry must place a renewed focus on marketing sorghum, not only to the farming community and food processors, but also directly to consumers, to increase awareness about the nutritional value of the grain, as well as the positive impact of 'buying healthy' on local communities and smallholder farmers and traders.

United National Breweries was recently taken over by Delta Corporation in Zimbabwe and intends to introduce a pasteurised sorghum beer, Chibuku Super, to the South African market. However, this development will only take place if the excise duty leveled on the beer by the South African Revenue Service (SARS) is equitable. This beer will have a 28-day shelf life and bottled in a clear PET bottle. UNB predicts that the Chibuku Super will be successful in the local market, based on the packaging, longer shelf life, acceptable taste and the price of under R10.00 per litre. UNB is also currently in the process of starting to produce sorghum beer powder in South Africa under the Chibuku brand name. Chibuku is the most recognised and popular brand of traditional African beer across central and southern Africa and UNB intends to promote the brand in South Africa. The benefits of Chibuku Super pasteurised beer will stimulate sorghum demand from the current 14,000 tons per annum to more than 56,000 and eventually to 100,000 tons per annum.

A key driver for Chibuku Super success lies in the current excise duty regime for traditional beers. UNB is currently engaging the Department of Trade and Industry, the House of Traditional Leaders and the Department of Agriculture to secure support for pasteurised TAB to be subject to the same excise duty as live TAB as part of supporting traditional African beer.

6. African markets for sorghum and sorghum-based products

In sub-Saharan countries sorghum is still a major crop for internal consumption and smallholder farmers are used to grow sorghum to meet this demand. The demand in Africa is mostly driven by the demand for sorghum value

[2] Agri-Food Systems: Facts and Futures, WWF, 2019

added products as a meal for food or for breweries (for lager beer and stout, malta (non-alcoholic malt beverage) and TAB).

The production of sorghum in African countries varies from year-to-year, with climate change having a major impact on the production and yield of sorghum. Climate change and the impact thereof on the entire agricultural sector in Africa is a major crisis facing the continent. Also, across the region, droughts and pests from time-to-time will impact on sorghum supply and these countries are then forced to import sorghum, which comes primarily from USA. In the African market, countries such as South Sudan, Ethiopia, Sudan, Kenya and Zimbabwe are all importers of sorghum when local production is insufficient, with imports in these countries totally on average in excess of 180,000 tons per annum. The imported sorghum in these countries is primarily being supplied by the US and Argentina. South Africa is closer to these East African countries and this regular shortfall should more readily be accessible to South African sorghum growers provided the sorghum can be produced more competitively.

Upgrade of the Sorghum Value Chain

Upgrading and enhancing the sorghum value chain needs to be aligned to the sorghum industry opportunities and address the industry challenges that are preventing it from capitalising on these opportunities.

Opportunities

The research highlighted market opportunities to support the growth of the sorghum industry in South Africa.

- **Import replacement**. Immediate replacement of imported sorghum, the vast majority being red “sweet” type, which amounts to 40,000-70,000 tpa depending on seasonal local production and availability. This will support the establishment of new productive capacity and lead to creating employment opportunities in the agriculture sector. It also will create new value add and not substitute any other locally produced grain.

- **Targeting the export market.** The USA and Argentina are exporting large amounts of sorghum, nearly all red “sweet” type to the African continent. The USA exported a total of US$80 million worth of sorghum or 370,000 tons, to the African continent in 2018/19 season. Kenya is the leading importer of sorghum in East Africa and is a readily accessible market for South African sorghum growers. Although it is not confirmed, it appears that Kenya imports sorghum for re-export to countries such as South Sudan (63%) and Uganda (35%). Uganda is a landlocked country and dependent for its imported products via Mombasa in Kenya. Logistically, the South Sudan region is closer to Mombasa than the Port of Sudan in the north. The projected prices for sorghum in 2020 ranges from R2550 to R3910 per ton. It therefore makes sense to consider export of sorghum to the region as it represents an estimated 200,000 ton per annum market opportunity. South African exporters will have a distinct geographical advantage over the USA and Argentina exporters in terms of transport costs.

  The export of sorghum to Kenya can be investigated together with other export opportunities such as soybeans or maize to benefit from established trade relationships and trade experiences. The implementation of the Africa Free Trade Agreement could also benefit exports of South African products to East Africa. Uganda is part of East Africa Community and enjoys beneficial trade relations with Kenya for throughfare of products and commodities imported via Mombasa.

- **Exporting value added products**. The most valuable sorghum product exported to African countries is traditional African beer powder representing a market of 5,300 tons per annum in 2019. Growing this market by 10% per annum, however, will add a mere 530 to 600 tons per annum. Although this market should not be neglected, it is not considered one of the key drivers of potentially re-stimulating the sorghum industry in South Africa.

- **Growing the consumer market.** The total consumer demand for sorghum products in South Africa (both malt for brewing and meals and flours) requires currently an annual production of 180,000 tons of sorghum per annum. Educating the market through product promotions, advertisements and consumer education in respect of the nutritional and health-promoting properties of sorghum products could stimulate demand. The development and introduction of new products, such as breakfast cereals and snacks could also support market growth. Achieving a 5% annual growth in demand would be considered a good achievement and will add circa 9,000 to 10,000 tons per annum to the national sorghum production. In all likelihood, the sorghum products will replace other home-grown and produced products resulting in a relatively small net gain in benefit for the country.

  The development of sorghum as a staple food for rural communities is, however, worthwhile considering as part of a growth plan for sorghum.

- **Replacement of maize in animal feeds**. In order to achieve this, the challenge would be to produce sorghum at prices that are up to 15% below that of yellow maize. Yellow maize for animal feed is imported into Cape Town routinely at a large scale as it is cheaper than moving it from inland. In 2019/20, yellow maize imports into Cape Town amounted to 510,000 tonnes with 460,000 tonnes originating from Argentina and 50,000 tonnes from Brazil. The imports of yellow maize are, however, erratic, and mostly driven by seasonal fluctuations in local production to supplement local production to meet animal feed demand. This is therefore not considered an immediate a sustainable market opportunity. The **substitution** of maize with sorghum will not necessarily add value to the local economy and there is not a compelling argument for the feed industry to consider such as substitution at this stage. A dramatic reduction in cost of sorghum production or commensurate increase in sorghum yields would be required to drive this conversion. Overall, it is not seen to be creating new productive capacity with the associated required increase in employment and social impact that is sought from a sorghum growth strategy. However, long term climate change and loss of grain producing areas in South Africa would necessitate the introduction of a suitable alternative to maize. The germplasm development program is therefore a necessary precursor to prepare for such eventuality.

- **New beers.** UNB indicated that it intends to launch new sorghum-based beer products in the foreseeable future. The success of sorghum-based lager beer in East African countries has been due to it being cheaper than barley lager, due largely to reduced excise duty compared to beers made with imported barley . With the high unemployment levels in South Africa, the opportunity is for a cheaper bottled beer as many people are currently trading down. Notably there may also be an opportunity to target this market with a high value-added local beer and why can it not be a sorghum-beer? It would require a detailed study though and UNB might already be well advanced with their new clear beer brands that could target this market. The projected impact of a successful new beer in the local market based on sorghum could be as much as 20,000 to 40,000 ton per annum. It remains pure speculation at this juncture but worth some further investigation.

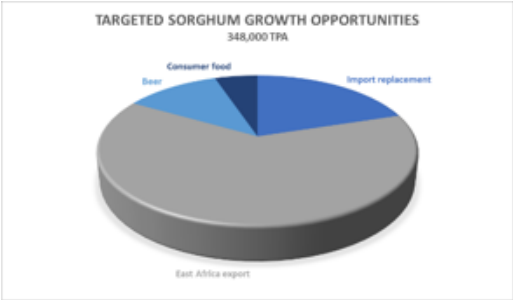
- **New sorghum production area**. The UNB beer developments (Chibuku Super and clear beer) could support the introduction of sorghum in the Eastern Cape and the engagement of emerging commercial farmers in an out-grower programme whereby the farmers are empowered and contracted to grow sorghum for a local brewery in the Eastern Cape. In such event, it is also proposed that the brewery engage the farmers and provide them with the seed and fertiliser requirements and extension support – the cost of which is only deducted from the purchase price once harvested and collected by the brewery. Extension services provided by the provincial Department of Rural Development and Agrarian Reform should be included in the support provided to these farmers. The establishment of small sale food processing plants, such as provided by the CFAM (the Centre for

Advanced Manufacturing) in Potchefstroom, could contribute towards the establishment of circular economies in marginalized farming communities in the Eastern Cape. The investment needed to one such facility is just under R44 million and will contribute circa R120million in revenue to the local GDP and create 34 direct employment opportunities in the processing plant. It will require 6,000 tons of sorghum per annum, supporting the establishment of 3,000 ha farmland (2ton/ha yield). The Eastern Cape sorghum farmers have received support previously from Diageo and the Coca Cola Foundation.

Summary

On their own, each opportunity has merit and worthwhile pursuing. Combined, these sorghum market opportunities identified herewith, amounts to 348,000 tons per annum on the upside and 219,000 ton per annum conservatively.

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement (direct)	40,000	70,000
East Africa export (Kenya, etc)	150,000	220,000
Beer (new products)	20,000	40,000
Consumer food (organic growth)	9,000	18,000
TOTAL potential	**219,000**	**348,000**



Actions to Upgrade the value chain

For the sorghum industry to achieve its potential in the local market and potentially target the more challenging market opportunities identified above, it has to take serious steps to reposition itself to produce and compete effectively in both these markets.

Upgrading the value chain requires the following actions:

- **Competitive position of sorghum in the grains industry**. Increase the competitive position of sorghum in the local and international grain and sorghum industry specifically. The current local production costs and yields of sorghum do not support sorghum's competitive position in the market. A germplasm development programme is needed to develop new sorghum cultivars that can improve yield and drive down production costs e.g. by improved pest resistance and better adaptation to climate change. The target price for sorghum should be in the region of R2,500 per ton.

  Germplasm development is aimed at improving certain traits of sorghum that support the key drivers of adoption. The development of improved cultivars is therefore seen as a supporting activity that enhances the sorghum product in terms of its competitiveness. Support of the local sorghum germplasm development programme should be developed as part of the implementation plan and include players such as the seed companies, the ARC and institutions such as GrainSA and SAGL, and Universities such as UKZN and UFS. The comparisons with the USA and Australia position of sorghum relative to maize in these countries points to the likelihood that in South Africa, this should be achievable.

- **Industry structure.** The local market for sorghum is dominated by a single manufacturer of a range of sorghum-based products. The market dynamics associated with this monopolistic structure of the industry impacts on the local producers and affects the ability of smaller manufacturers to effectively compete for local supply of

sorghum. These smaller manufacturers also do not have the luxury of readily importing sorghum from USA or Argentina or stockpiling the sorghum at the end of the harvest season. The introduction of a pricing mechanism will assist the local farmers and contribute towards the smaller manufacturers also having a fair opportunity to source sorghum at competitive prices and gain access to production loans.

- **Market related price fixing mechanism.** Establishing a market related price finding mechanism such as SAFEX. Due to the very low volume of sorghum traded on the open market, the SAFEX mechanism does not function optimally. Prices are either too high (based recent trends) at the end of a season or at the beginning of the season too low. Both these extreme prices have a negative effect on the industry. Due to these fluctuations, the benchmark price used is 15% below the SAFEX price of yellow maize. Using this price places the smaller farmers at a disadvantage as they need to raise production loans for the growing season. Production loans based on this price are insufficient to cover the production costs that the farmer has to incur. The result is that smaller farmers are not able to enter the market.

- **Food product development.** Research institution (e.g. CSIR) and university food scientists and the food manufacturers in South Africa should be encouraged to work in partnership develop and promote new food applications for sorghum to maximise the health benefits of sorghum-based foods. Key drivers for adopting sorghum by the food manufacturers, is in the first instance the consumer demand/pull. The US United Sorghum Checkoff Program's promotion of sorghum is a good example of more aggressive promotion that could be implemented on the South African Sorghum Trust's website to promote and encourage increased use of sorghum in the consumer food basket. The competitive position of sorghum products will be enhanced if the food manufacturers are able to meet their targeted profit margins. This would require that the price of sorghum be more competitive and this links to the first requirement of upgrading the sorghum value chain.

- **Modern processing technologies.** Other activities that can contribute towards upgrading the sorghum value chain include the development of applications and food recipes using modern processing technologies. The development of extrusion cooking processes enables the production of pre-cooked and processed grain products at much reduced costs by directly processing the milled grain through an extruder to produce a pre-cooked porridge flour, breakfast cereal or snack, cutting out the wet cooking step. The twin-screw extruder technology developed by CFAM in Potchefstroom is a case in point.

- **Support sorghum promotion.** The United States Department of Agriculture is responsible for overseeing the formation of Checkoff organizations. The **United Sorghum Checkoff Program** commenced in 2008 and has contributed enormously to the growth and development of the industry, with the program currently being managed by National Sorghum Producers organization. Sorghum stakeholders in Europe recently unanimously supported the creation of an organisation called **Sorghum International Development (Sorghum ID**) to promote of the interests of its sorghum industry and improve sorghum hybrid genetics for several end-uses (grain sorghum for food and feed, silage sorghum, sorghum for energy and other non-food uses). To this end, a European inter-branch sorghum organisation was established in 2017 in Brussels. It is proposed that the Sorghum Cluster supports the Sorghum Trust and Sorghum Forum to expand and enhance its activities and actively engage industry players and promote sorghum in the food, beverage and feed markets.

Recommendations for implementation

The upgrade of the sorghum value chain rests on the implementation of the following initiatives that can be seen as pillars to establish a new platform from which the sorghum industry can compete and grow:

- **The Advanced Germplasm Development (Pre-Breeding) Programme**
  A well-resourced sorghum pre-breeding Advanced Germplasm Development programme to apply modern genomics-based breeding technologies to develop elite sorghum lines that are well-adapted to South and Southern African climatic conditions and have specific resistance to locally important pests and diseases. For the pre-breeding programme to achieve its goals, it must have the full buy-in by all relevant stakeholders and especially the commercial seed companies. They will need to commit to taking up the developed improved germplasm and releasing improved new sorghum cultivars. An indicative annual budget of between **R3 million - R5 million per annum** will be required for **the five years of the programme to establish it.** This is with the assumption that the institute undertaking the programme already has an employed experienced doctoral level sorghum breeder and the basic breeding infrastructure is in place.

- **The Establishment of a Sorghum Cluster Initiative**
  The clustering approach is aimed at encouraging strategies that create closer market linkages, improve supply chains and foster co-operation among value-chain participants. Various stakeholders form part of the cluster programme, forming vertical relationships (among suppliers, producers, processors, buyers and retailers), horizontal relationships (between processors and farmers) and support relationships (between government, service providers, R&D facilities, etc.). The objective of the sorghum cluster will be to promote the growth and development of the industry through the strengthening of these relationships and the upward and downward linkages within the industry value chain. The cost of **establishing the cluster (12 months)** and running the cluster for the **first 12 months** is estimated at **R3.8 million**.

- **The Eastern Cape – a special focus area**
  To support the integration of emerging commercial farmers into the sorghum value chain, it is proposed that the Eastern Cape be considered as a pilot site to demonstrate the value of establishing a local processing centres and engagement of emerging commercial farmers to supply sorghum to such centres. The reason for selecting the Eastern Cape is supported by the fact that it is considered to have high potential for sorghum cultivation, especially as climate change increasingly negatively impacts on South African grain agriculture in some of the current high potential regions . Additionally, United National Breweries, the traditional African beer brewing company, has already been sourcing sorghum from smallholder farmers in the Eastern Cape to supply its Isithebe malting plant in KwaZulu-Natal. This activity was originally supported by the Diageo Foundation, Diageo being the company that up until 2020 owned UNB. In addition to producing sorghum in the Eastern Cape to meet requirements of the of the processing centre it will also help improve the viability of sorghum farming to supply UNB.

  The establishment of an extrusion cooking food processing facility at one of the RED Hubs should be considered to produce added-value, ready-to-eat foods for the Eastern Cape market using sorghum produced in the area. An estimated **R43,6 million investment (CAPEX and working capital)** is required to set up such an extrusion facility, assuming that existing buildings and infrastructure can be used. This excludes the establishment of farms to supply the processing facility with up to 30 tons of sorghum per day.

Key Role Players

The major organisational role players for the implementation of the proposed recommendations include the Department of Science and Innovation (DSI) as the lead, supported by the Departments of Agriculture, Land Reform and Rural Development (DALRRD) and Department of Trade Industry and Competition (dtic), as well as the Sorghum Forum and

Grain SA. The Department of Science and Innovation (DSI) should lead and provide guidance and facilitation in approaching government departments for support.

- The Sorghum Forum with advice from DSI, should be engaged to motivate to Treasury to remove VAT on sorghum grain and meal. This initiative remove unfair tax and duties should be aligned to the initiatives by UNB to achieve the same outcome;
- Sorghum Forum and UNB, with the advice from DSI, to motivate to SARS the amendment of the definition of Traditional African Beer so as to allow an equitable excise duty on pasteurised Traditional African Beer. UNB is also actively engaging the Council for Traditional Leaders to gender support for this specific request;
- DSI, the Sorghum Trust and Grain SA, and possibly the Department of Trade, Industry and Competition (the dtic), to fund the sorghum Germplasm Development (pre-breeding) programme;
- The Sorghum Forum and Grain SA with advice from DSI, to motivate to the Department of Higher Education and Training to create a Chair in Precision Agriculture at a university;
- The Sorghum Forum with advice from DSI, to motivate to the Department of Trade, Industry and Competition for the creation of a Sorghum Cluster. The Department of Trade, Industry and Commerce (the dtic) funded cluster initiatives in the past, while the Jobs Fund (administered by Treasury) could also be a potential source to finance the cluster initiative if it is appropriately structured and the job creation benefits highlighted.

The value chain upgrade research and outcome pointed out real opportunities and requirements to capitalise on these opportunities. In order to continue with implementation of the recommendations, it is proposed that the CMO proceeds to implement the following programs:

1. **Sorghum Cluster.** Establish a sorghum cluster to draw in the participation of all the key role players in the value chain from the seed suppliers through to the retailers. Such a collaborative initiative can focus on promoting sorghum in the local market and developing the export markets.

The following **programmes can be implemented by the Sorghum Cluster**

2. **Germplasm Development**. Compile a comprehensive germplasm development programme and motivation for funding together with key role players such as NAMC, SANSOR, DSI, GrainSA and participating seed companies. This will fine tune the programme elements, resources needed and funding requirement. The germplasm development programme is the foundation for the improvement of the competitiveness of the locally produced sorghum and therefore a key requirement for unlocking higher yields and more cost-effective production of sorghum.

3. **Precision farming.** Precision farming has proven to contribute towards yield improvement. Modern farms and agricultural operations work far differently than those of a few decades ago, primarily because of advances in technology, including sensors, devices, robotics, and information technology. Today's agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial remote multispectral imaging (drones), and GPS technology. The application of these advanced devices and robotic systems in precision agriculture technology allow farming enterprises to be more profitable, efficient, safer, and more environmentally friendly. Microsoft has engaged the dtic in South Africa to introduce Agritech innovations are already disrupting the sector in South Africa, and innovation will grow exponentially as more solutions continue to be introduced. This includes the adoption of technology such as smart farming apps that assist farmers in keeping and maintaining accurate farm records; blockchain technology that allows the transparency and traceability of commodity trading from the farmer to the buyer; smart farming sensors that reveal changes in temperatures, rainfall and weather patterns; and lastly the use of drones for effective and efficient crop

management and on-demand fertilisation and irrigation. These possibilities are why Microsoft South Africa has introduced its Agritech initiative as part of its Equity Equivalent Investment Programme (EEIP) strategy with the dtic. The EEIP allows Microsoft to invest in programmes designed to meet the goals of Broad-Based Black Economic Empowerment (B-BBEE) in key sectors — of which agriculture is one because of its high job absorption capacity and impact on food security in the country.

It is proposed that the creation of a funded Chair in crop precision agriculture at a local university be considered. The Chair must include formal extension training in its mandate in addition to just purely research as has been the case with such Chairs to-date.

4. **Farmer development** and specifically Emerging and smallholder farmer development.

    a) Investigate smallholder farmer engagement models, such as used in Nigeria and East Africa Breweries Limited (EABL). A key consideration of the industry upgrade project is to include marginalized smallholder farmers. EABL and Nigeria seem to have achieved success with such initiatives – what can we learn from them?
    b) Conduct a feasibility study to enhance the feasibility and sustainability of the RED hubs (Rural Enterprise Development Hub) in the Eastern Cape through the addition of sorghum (and grain) extrusion / processing technology. The establishment of small-scale processing facilities such as that provided by CFAM, the South African extrusion cooking technology company, could stimulate rural social upliftment and economic growth and create demand for locally sourced grains (eg sorghum).
    c) The training of officials and establishment of extension services to support small holder farmers, emerging and established farmers with the introduction of precision farming techniques and new cultivars.

5. **Statutory Framework**. VAT removal. Support the sorghum industry and specifically the initiatives from the Sorghum Forum to have VAT removed from sorghum and sorghum meal. Excise duty. Support UNB that pasteurised TAB to be subject to the same excise duty as live TAB as part of supporting traditional African beer.

6. **Export market development.** The cluster could introduce a detailed logistics and demand study of the East African and Sub-Saharan market for sorghum (all types) in support of the cultivar selection / optimization and germplasm development programme.

7. **End-user market engagement**.

    a) Consumer awareness. The establishment of a sorghum promotion programme such as the United Sorghum Checkoff program (USA) and the Sorghum ID (Europe) should be an initiative of the Sorghum Cluster. The appropriate vehicle for the establishment of such a programme and its funding could be the responsibility of the Sorghum Forum and/or Sorghum Trust in collaboration with DSI and other industry players such as the food processing companies.
    b) Animal feeds. The increased utilisation of sorghum on the local animal feed industry can be introduced as a separate initiative together with the feed processing companies such as AgriFeeds, Alzu, Epol, RCL etc.

8. **Import tariff.** Investigate whether there is a case for introduction of an import tariff on sorghum as is done with wheat in support of expansion of local production.

The following table provides an indication of potential projects that can be implemented by DSI:

Note: The proposed Sorghum Cluster can be utilised and the implementation agent to engage government and the sorghum industry.

	Sorghum Cluster	Motivation SARS to remove VAT on sorghum	Equitable excise duty on Pasteurised traditional African beer (TAB)	SADC Sorghum Advanced Germplasm development (Pre-breeding) Programme	University Chair in Crop Precision Agriculture and Extension	Quelea Bird Predation Control	Sorghum RED Hub in the Eastern Cape
Key stakeholders and Roles and Responsibilities	Sorghum Forum – Coordinating body The dtic - Funding Implementation agency to set up Cluster	Sorghum Forum – Coordination and Lead DSI - Advisory	Sorghum Forum – Support from wider sorghum industry and other stakeholders UNB – Lead DSI – Advisory	ARC and ACCI-UKZN – Hosting institutions SANSOR and Commercial seed companies – Oversight and Technical coordination Grain SA - Advisory DSI and DALRRD and SADC Food, Agriculture Natural Resources (FANR) Directorate – Oversight, Obtaining Funding from donors, Technology sharing agreements with ICRISAT and other international organisations	DSI and NRF-Funding and coordination ARC and Grain SA-Advisory Grain SA – Coordination and Implementation Advice	DALRRD – Implementation Grain SA - Coordination	ECRDA, DESTEA, IDC of SA
Timeframe	Establishment – 12 months	12 months to prepare proposal and present it to SARS	12 months to prepare proposal and present it to SARS	Full establishment of the pre-breeding programme	Call for Chairs and Establishment – 12 months Chair duration – Minimum 5 years	Ongoing	12 months for feasibility study
Indicative budget	R3.8 million for establishment only	None – Costs to be met by the individual Forum members	None – Costs to be met by the commercial companies	R3 to 5 million per annum then less once the Programme is fully running.	R 2 million per annum	R3 million for new equipment R2 annually	R3 million for feasibility study

Group – interest groups with potential participation in sorghum cluster	Roles and responsibilities	Key players
Support service providers	Provide data analysis and industry overview. Economic analysis	Grain-SA, AgriSA, SAGIS, ARC, DALRRD, University and agricultural training institutions NAMC
Seed producers	Support germplasm development and cultivar selection programmes	SANSOR and major seed companies, e.g. Pannar-Corteva, AGRICOL, AGT Foods,K2, Zamseed,
Farmers and farming organisations	Development of equitable contracting systems with sorghum processing companies	Grain-SA, Black farmers associations
Agritechnology	Promote agritechnology and precision farming to support commercial and small holder farms.	Microsoft, the dtic, Universities, farmer associations such as Grain-SA and Sorghum Forum. Input suppliers such as seed companies and fertiliser producers (FERTASA)
Processors – alcoholic and non-alcoholic beverages	Development of plan for sustained growth of the traditional African beer industry	Major traditional African beer brewing companies and sorghum maltsters e.g. UNB, AB-InBev, Sorgho, Dannhauser Malt.
Processors – human consumption	Promotion of sorghum as a nutritious and healthy food. Development of equitable contracting systems with sorghum farmers	Major sorghum food processing companies e.g. Tiger Brands, RCL Foods, Pride Milling, Denmar Estates etc.
Processors – animal feeds	Identification of market opportunities for grain sorghum as an animal feed in South Africa	AFMA and major animal feed companies
Retailers	Facilitation of product purchasing from SMEs, Promotion of sorghum as a nutritious and healthy food.	Grocery Manufacturers Association and major retailers
Government departments	Enabling environment and policy formulation as well as funding (seed capital) for research and cluster initiative.	DSI, the dtic, DoA etc

The Sorghum Cluster is proposed as the vehicle through which these key stakeholders are engaged and through which the proposed programmes are launched and funded.

The final report was presented to the DSI EXCO on 26th of July 2021. The EXCO was supportive of the outcomes and implementation of the recommendations. The EXCO recommended the outcomes of the study should also be incorporated onto the draft Agriculture and Agro-processing Masterplan currently being developed by DALRRD. It was also proposed that the DSI take the lead in implementation of the outcomes and recommendations from the report in partnership with DALRRD and the dtic.

Part 2:
Situational Analysis – Overview

2 Situational Analysis

2.1 Economic Overview of South Africa

World economic growth was already slowing prior to the outbreak of the COVID-19 health pandemic, with global growth below 3% in 2019 – the lowest since the 2008 financial crisis. Multiplying global risks have contributed to slowing growth in both developed and developing economies. Brexit, tariffs, and trade wars have all contributed to an increasingly negative economic outlook, along with a generalised increase in political tension and uncertainty.

The COVID-19 global health pandemic saw what is now being referred to as "the Great Lockdown" being implemented in most countries around the world. Economic activity in the majority of countries around the world was severely constrained in the first and second quarter of 2020 as national lockdowns were implemented in an attempt to combat the spread of the COVID-19 virus. While most countries have resumed economic activities, there the COVID-19 virus continues to spread, resulting in some countries slowing the reopening of the economy while others are reinstating partial lockdowns to protect susceptible populations.

The latest available data from the Organisation for Economic Cooperation and Development (OECD) estimates a decline of 4.9% in global economic activity for 2020, and a 5.6% increase in global growth for 2021.

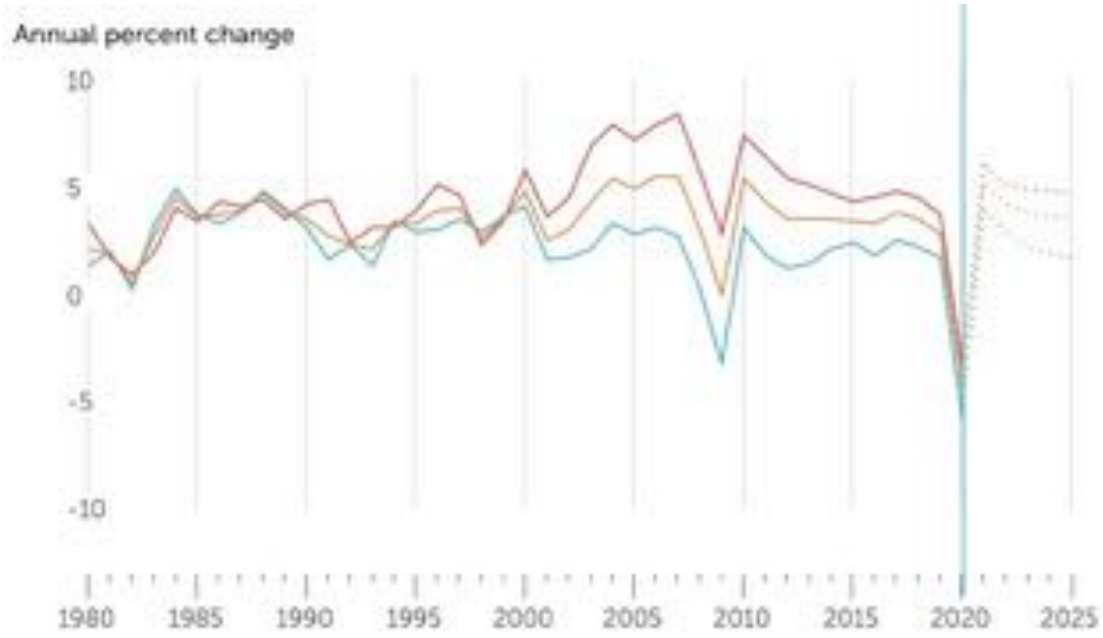


Figure 2: Global Economic Growth Trend (1980-2025)

Source: IMF October 2020

South Africa's economic activity contracted by 7% in 2020[3]. The COVID-19 pandemic brought on many challenges for an already struggling economy. Employment saw a steep decline, with the number of people employed falling by 1.4 million people. In the October -December quarter, unemployment in the country stood at a record level of 32.5%, with the expanded definition of unemployment (which includes discouraged work seekers) at 42.6%.

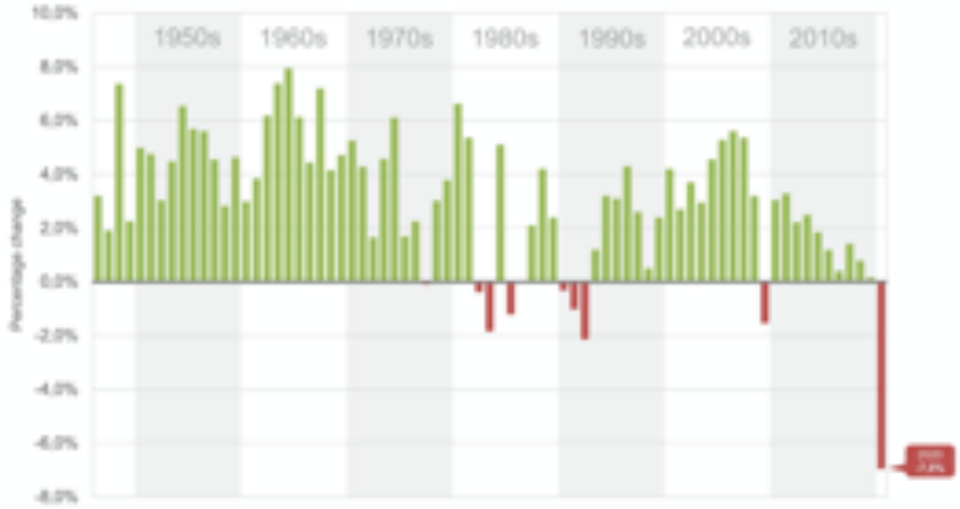


Figure 3: South Africa GDP Growth

Source: Stats SA

Despite the impact of the pandemic on economic growth, there was one shining star in 2020. Agriculture escaped the effects of the pandemic relatively unscathed, expanding production by 13,1% in 2020. Government also grew marginally in the year, up by 0,7%.

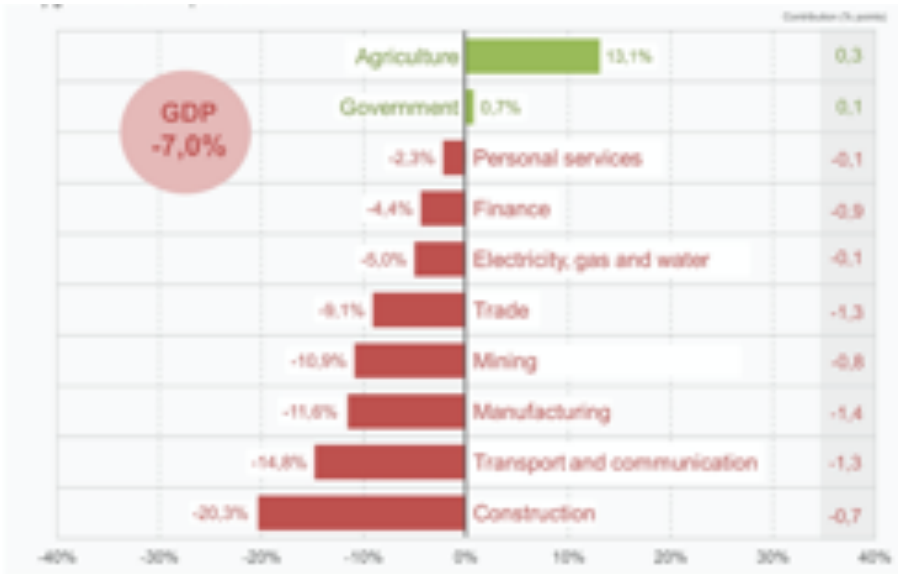


Figure 4: Growth per Industry Sector 2020

Source: Stats SA

[3] Stats SA, March 2021

All economic sectors except for Government and agriculture declined. The construction industry, already in deep trouble before the pandemic, contracted by 20,3%. This marks the industry's fourth consecutive year of economic decline.

A decline in air travel contributed to the contraction in the transport and communication industry. Rail and road freight operators also found themselves hamstrung by restrictions placed on the production and movement of various goods during the second quarter.

Despite a strong showing in the fourth quarter, manufacturing production was down for the entire year, falling by 11,6%. This was mostly due to work stoppages in the second quarter and a fall in the demand for steel, amongst other reasons.

South Africa is likely to see economic growth of 2.9% in 2021 as it rebounds from the -7% collapse of 2020. However, much of this growth will be due to the base effects arising from the large contraction in economic activity in 2020.

2.2 Sorghum Industry Overview

Sorghum (*Sorghum bicolor* L. Moench) is a versatile cereal crop that can be grown for grain for human food and animal feed, forage, biomass or as a source of sugar. In terms of world cereal production, sorghum is ranked fifth, after wheat, maize, rice and barley. From an agronomic point of view, sorghum is a hardy, drought-tolerant crop with low water requirements. However, it can also withstand periods of excessively heavy rainfall. Sorghum is grown almost exclusively as a rainfed crop and is not normally irrigated. As a C4 cereal, sorghum is more efficient in utilising the high solar radiant energy found in tropical regions than the C3 temperate cereals, such as wheat, barley and rice. Consequently, sorghum has potential for greater cultivation in regions that are now being adversely affected by climate change.

Sorghum was first domesticated in Africa, probably in the Ethiopia-Sudan region. The date of domestication is questionable depending on the reference source but is between 3000 and 5000 years ago. It is grown primarily in drought-prone tropical and subtropical regions of the world and as such sorghum plays a major role in ensuring local food security in these regions, particularly in sub-Saharan Africa and India.

2.2.1 Importance and Value of Sorghum in the World Markets

Though sorghum cultivation is reported from more than 100 countries, only eight countries have over 1 million ha area under sorghum, which together contribute more than 60 % of world sorghum production. These countries are:

- United States
- Mexico
- Nigeria
- Ethiopia
- Sudan
- Burkina Faso
- Niger
- India

In Africa, although only a few countries (Nigeria, Ethiopia, Sudan, Burkina Faso, Mali and Niger) contribute a major share of cultivation area, sorghum is widely distributed and is a major staple food and beverage grain in large parts of the continent.

In spite of its economic importance, the sorghum cropped area around the world has declined over the last four decades at a rate of over 0.15 million ha per year. However, in some countries including Brazil, Ethiopia, Sudan, Australia, Mexico, Nigeria, and Burkina Faso the area used for sorghum cultivation is expanding.

More than 80% of the global sorghum area is characterized by traditional smallholder agriculture, which gives low yields and contributes slightly above half of the total grain production. The remaining sorghum is produced in the developed countries using fully mechanised agriculture with higher yield levels.

Sorghum acts as a dietary staple for millions of resource-poor people living in some 30 countries in the subtropical and semi-arid regions of Africa and Asia. It is a source of food and fodder, in the traditional, smallholder farming sector of these regions. Animal traction and manual labour are used to farm mainly open pollinated varieties (OPV) of sorghum, where seed can be retained for planting. Local landraces are being replaced in some areas by improved varieties with better yield potential and disease resistance. However, traditional small-holder farming systems use minimal fertiliser addition and there is very low, if any pesticide and herbicide use, resulting in chronically low yields.

Intensive limited mechanised farming of sorghum is carried out mainly in China but also in some African countries, for example, Ethiopia. Tractors are used for ploughing and threshing and winnowing is carried out mechanically. Manual labour is still extensively used especially for weeding. Improved OPVs are grown with some hybrid cultivars. Yields are much higher than those obtained by traditional farming methods mainly due to the extensive use of both inorganic and organic fertilisers.

Intensive highly mechanised farming methods are used for sorghum production in United States, Argentina, Brazil, Australia, Italy, France and South Africa. Here all the farming operations are mechanised, and hybrid cultivars are grown. There is a high use of inorganic fertilisers and integrated use of pesticides and herbicides resulting in much higher yields than either traditional or intensive limited farming methods. In all these countries with the exception of South Africa, this intensive farming system is used to produce grain primarily for animal feed for both local and export markets.

The global economic importance of sorghum stems from the high variety of uses of the crop. Sorghum grain is used primarily for human nutrition in many countries mainly in Africa and in India and Pakistan. In sub-Saharan Africa, a major use for sorghum is for brewing traditional Africa beer and increasingly for the industrial production of lager and stout beers and non-alcoholic malt beverages. In China, a major use for sorghum is for the baijiu alcoholic spirit. The majority of sorghum grown in Western countries is either for export (primarily for animal feed) or used locally for animal feed. However, the fact that sorghum is a non-GMO (Genetically Modified Organism) crop and that it is gluten free, contains a range of beneficial phytochemicals and is considered as an ancient grain means that it has

become a viable option for high-value food niche markets in the developed and developing world. Sorghum grain is used to produce 4% of fuel bioethanol in the United States. Second generation renewable-energy production from sorghum biomass and other industrial uses of sorghum is currently very limited and is mainly still at the research and development stage.

Human Consumption	Animal Feed	Biofuels
		
Sorghum is processed into a variety of products, both traditional and modern. It can be malted (sprouted grains), decorticated into rice, or milled into coarse and fine meals and flours.	Both sorghum grain and plant biomass (leaves and stalks) are used as animal feed. Worldwide sorghum is being increasingly used as fodder. In some countries (but not in SA), sorghum can be a less expensive alternative to maize and wheat as animal feed due to its adaptability to dry conditions.	Currently in USA some grain sorghum is used to product bioethanol. Bioethanol production from sorghum has been seriously considered in countries such as Australia, South Africa and Uruguay. However, none of these countries are yet commercially producing bio-ethanol from sorghum.

Figure 5: Sorghum Uses Summary

2.2.2 Nutritional Quality of Sorghum

Sorghum constitutes a major source of energy and protein for millions of people in Africa and India. The nutritional quality of sorghum (like that of all cereal grains) is dictated mainly by its macronutrient (starch, protein, lipids (fat) and dietary fibre) and micronutrient composition (B and E vitamins and minerals) and the presence of antinutritional factors. These are (substances in the grain which inhibit the digestion, uptake and metabolic use of macro- and micronutrients, collectively called bioavailability. In terms of its gross nutritional composition, sorghum is very similar to other cereal grains. One important advantage of sorghum in human nutrition is that its starch can be more slowly digestible than that in other cereals. The slow starch digestibility is believed to be protective against development of obesity and its associated diseases of Type 2 diabetes and cardiovascular disease. Slowly digestibility starch is, however, slight disadvantage with respect to its animal feed value.

Among cereal foods, sorghum is probably the richest source of phenolic phytochemicals. These exert positive health effects, notably as protection against oxidative stress and consequent diseases like cardiovascular disease and certain cancers. There is also good evidence that these phenolic phytochemicals are protective against the development of Type 2 diabetes. Sorghum is also

considered as one of the best gluten-free flours. The markets for healthy grain foods and gluten-free food products are expanding rapidly in developed countries, albeit from a very low base.

2.3 World Sorghum Industry Trends

In sub-Saharan Africa, sorghum has significant presence in most of the countries. In the Americas, it is also grown extensively in the United States and Mexico in North America and Argentina, Nicaragua, Peru, Uruguay, Honduras, Brazil, Colombia, El Salvador, Guatemala, Haiti and Venezuela in Central and South America. In Europe sorghum is grown in France, Italy, Spain, Romania and Albania. Australia is also a significant producer of sorghum.

The United States Department of Agriculture (USDA) estimates that the World Sorghum Production 2019/20 will be 59.17 million tonnes, Sorghum Production 2018/19 was 59.28 million tonnes.

Figure 6: Global Sorghum Production 2019/2020

**Estimate 201920*

Africa, North America and Asia are the top sorghum producing regions globally. In Asia, production is dominated by China and India, while in North America, the United States and Mexico are the top producers. In Africa, Nigeria and Sudan are leading producers of sorghum.

Global sorghum production is described in detail in the first report of the study, the Situational Analysis. However, the Table below provides a summarized overview of sorghum production in key regions.

Region	Key Facts
The United States	- Currently the largest producer of grain sorghum in the world – accounting for approximately 16.2% of global production. - Almost all grain sorghum cultivated is red-tannin (non-sweet) - Sorghum is primarily used for livestock feed, with some use for bio-ethanol production - Becoming popular in the consumer food market due to the presence of health promoting phytochemicals and it being gluten free

Africa	- In 2019, sorghum production in Africa was estimated at between 25 million to 26 million tons
	- Sorghum is grown first and foremost for human consumption
	- 53% of the world's sorghum production area is located in sub-Saharan Africa
	- After the USA, Nigeria is the 2nd largest producer of sorghum, with Sudan and Ethiopia being 5th and 8th respectively
	- Nigeria:
	  - Produce an estimated 6.9 million tons per year
	  - Currently accounts for 65-70% of total sorghum produced in West Africa, and 25% of African sorghum production
	  - More than 70% of sorghum production is used domestically for food and commercial processing, with around 30% used as animal feed
	  - Research and development focused across the entire value chain of sorghum
	  - Predominant types of sorghum cultivated is white tannin (bitter) and white non-tannin (sweet)
	  - Sorghum is traditionally used to produce thick porridges, gruels and cloudy beers and is a staple food in most parts of the country
	  - Extensive sorghum processing industry where malted and un-malted sorghum are used in the brewing of lager and stout beer, non-alcoholic brewed type malt beverages.
	  - Processed sorghum flour has been developed by the one of the largest flour mills in the country. The product has a 6 month shelf life
	- East Africa
	  - Ethiopia, Kenya, Tanzania and Uganda
	  - Ethiopia is the world's third largest sorghum producer, estimated annual production of 4.3 million tons, grown by an estimated 4.8 million smallholder farmers
	  - Kenya produces only 100,000 – 150,000 tons of sorghum annually and essentially all sorghum is produced by smallholder farmers
	  - Tanzania is one of Africa's largest sorghum producers, approximately 1,000,000 tons produced annually. All the sorghum is produced by smallholder farmers.
	  - Uganda produces approximately 300,000 tons of sorghum annually
	  - In Kenya and Uganda sorghum is widely used in commercial lager beer brewing
	- Cameroon
	  - Produces approximately 400,000 tons per annum
	  - Guinness Cameroon is one of the key drivers for an increase in demand for sorghum – for lager and stout and malt-type non-alcoholic beverages

Region	Key Facts

	- Sudan
	  - Sorghum is the largest crop (ranked by area), with the majority of it rainfed
	  - In 2019/20 Sudan produced an estimated 5.1 million tons
	  - Decline in production due to farmers switching to more remunerative crops
	  - In 2018, Sudan exported 90,000 tons of sorghum, and in the same period the country imported 110,000 tons of sorghum, mainly from the USA
	  - In April 2020, a ban was placed on all sorghum exports as the country worked towards increasing food stockpiles in line with the global COVID-19 pandemic
	- Southern Africa Development Community
	  - Botswana
	  ○ Sorghum is the traditional staple crop. Up until 2013 Botswana was the largest importing country for South African sorghum (estimated at 40,000 tons per year). Botswana is now self-sufficient
	  ○ Botswana production varies between 6,000 – 35,000 tons per annum depending on rainfall
	  - Zambia
	  ○ Annual sorghum production is only about 15,000 tons
	  ○ The country has a large traditional African beer brewing industry and uses sorghum in lager brewing
	  - Zimbabwe
	  ○ Produces approximately 20,000 tons per annum (2016 figures). The country has the region's largest traditional African beer industry

Australia	- Grain sorghum is a major component of the dryland cropping system of subtropical Australia - Grain sorghum is Australia's most significant summer crop - Key feed grain for the beef, dairy, pig and poultry industries - Annual production of sorghum has varied immensely over the past few years. In 2017/18 sorghum production was estimated at 430,000 tons - Essentially all sorghum cultivated in Australia is non-tannin (sweet) and used almost exclusively as stock feed, primarily for cattle, pigs and poultry - Much of the sorghum is exported to China
India	- India produces approximately 5 million tons of sorghum per annum - ICRISAT and CGIAR are working together to promote sorghum and other traditional grains - Sorghum is used as food but is consumption is a decline due to rising living standards and people changing to wheat, rice and maize

Table 1: Main Sorghum Producing Regions

2.3.1 Sorghum Trade

The most recent data regarding world sorghum production obtainable was from the United States Department of Agriculture, Foreign Agricultural Service (USDA FAS). According to these data, world sorghum production, which was 57.6 million tons in the 2012/13 season, reached 60.9 million tons in the 2013/14 season and 66 million tons in the 2014/15 season. This production decreased to 61,4 million tons in the 2015/16 season increased to 63 million tons in the 2016/17 season. The latest

USDA report estimates that the World Sorghum Production 2019/20 will be 59.17 million tons, with sorghum production reaching 59.28 million tons in 2018/19.

China is the greatest consumer of sorghum. The sorghum is used for animal feed and production of the baijiu spirit. According to USDA data, China's sorghum consumption, which was only 3.2 million tons in the 2012/13 season, was 6.8 million tons in the 2013/14 season and 12.9 million tons in the 2014/15 season. However, the sorghum consumption of the country decreased to 11 million tons in the 2015/16 season and continued to decline in the 2016/17 season.

During the 2016/17 season, China consumed 8.8 million tons of the global sorghum production of 63.2 million tons. Historically, Nigeria was the largest consumer of sorghum. Nigeria consumed 6.7 million tonnes of sorghum in the 2016/17 season and is now displaced by China from being the largest to the second largest consumers of the grain in the world. The big difference, however, is that the majority of sorghum consumed in China is imported, whereas in Nigeria it is all domestically produced. China and Nigeria are followed by the USA, Sudan, Mexico, India, Ethiopia and Argentina in terms of global sorghum consumption. According to USDA data, during the 2016/17 season, the USA consumed 6.2 million tons of sorghum, Sudan 5.8 million tonnes, Mexico 5.3 million tons, India 4.5 million tons, Ethiopia 3.7 million tons, and Argentina 3.1 million tons. In all these countries, with the exception of Mexico, consumption is essentially from domestic production only. Mexico imports sorghum from the US.

2.3.1.1 Importers and Exporters of Sorghum

The following table lists the main sorghum importing and exporting countries in the world:

	2015/16	2016/17	2017/18	2018/19	2019/20 DEC	2019/20 JAN
TRADE YEAR EXPORTS (1000 TONNES)						
ARGENTINA	772	457	329	196	200	200
AUSTRALIA	717	542	449	91	50	50
CHINA	23	34	43	49	40	40
ETHIOPIA	75	75	75	75	75	75
INDIA	74	24	123	53	50	50
NIGERIA	50	100	100	100	100	100
UKRAINE	119	164	123	93	75	75
OTHERS	133	311	306	196	105	105
SUBTOTAL	1 963	1 707	1 548	853	695	695
UNITED STATES	7 918	6 031	4 839	2 479	2 800	3 000
WORLD TOTAL	9 881	7 738	6 387	3 332	3 495	3 695
TRADE YEAR IMPORTS (1000 TONS)						
CHILE	134	54	73	70	100	100
CHINA	8 284	5 209	4 436	652	900	900
COLOMBIA	64	0	56	0	50	50
EUROPEAN UNION	119	194	486	666	400	250
JAPAN	649	561	594	452	500	500
KENYA	54	146	141	109	150	150
MEXICO	661	548	98	596	550	700

	2015/16	2016/17	2017/18	2018/19	2019/20 DEC	2019/20 JAN
SOUTH AFRICA	83	82	27	59	50	50
SOUTH SUDAN	19	36	148	26	150	150
SUDAN	200	120	150	160	200	200
OTHERS	596	364	513	509	429	439
SUBTOTAL	10 863	7 314	6 722	3 299	3 479	3 489
UNACCOUNTED	-1 080	380	-386		16	205
UNITED STATES	98	44	51	1	0	321
WORLD TOTAL	9 881	7 738	6 387	3 332	3 495	3 695

Table 2: Main Sorghum Importing and Exporting Countries

The main importers in 2018/2019 (Sept. 1- Aug. 31) were the European Union (in excess of 660,000 tons), China (in excess of 650,000 tons) and Mexico (in excess of 590,000 tons).

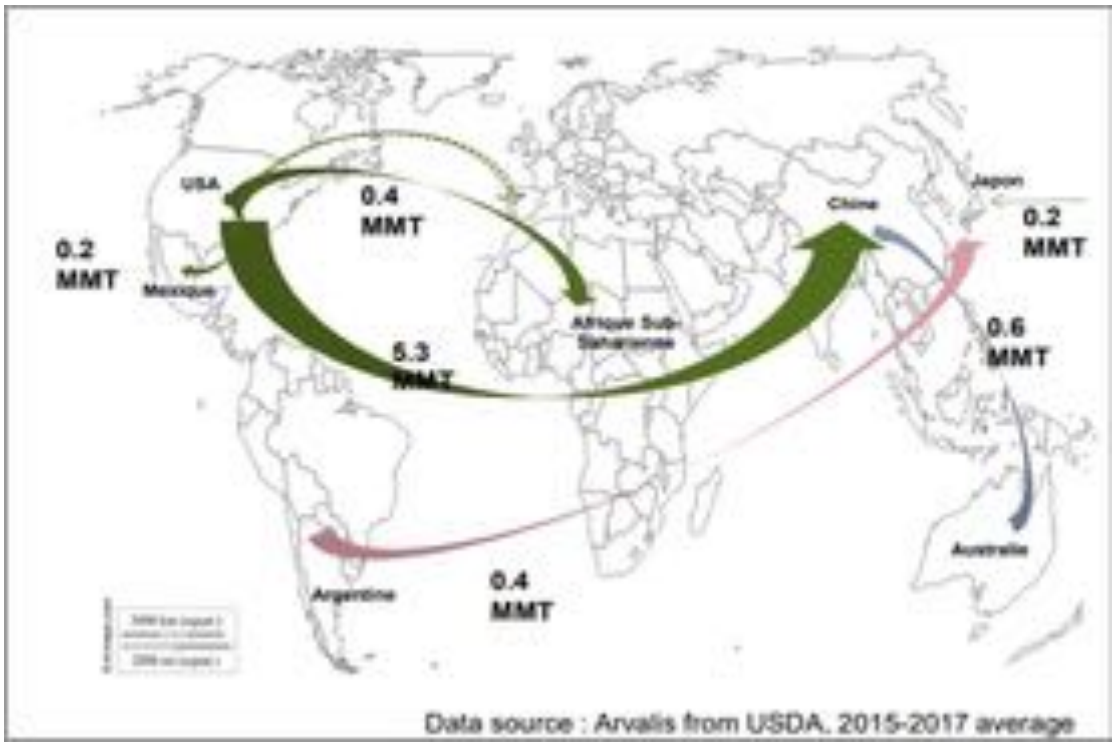


Figure 7: International trade of sorghum (exports)

The above illustration indicates the large demand for sorghum from China and the major exporters of the sorghum to that country. Considering the high Australian prices and the long distance from USA and Argentina to China, South Africa may possibly be in a position to capitalise on this export market opportunity if the price of its sorghum was competitive.

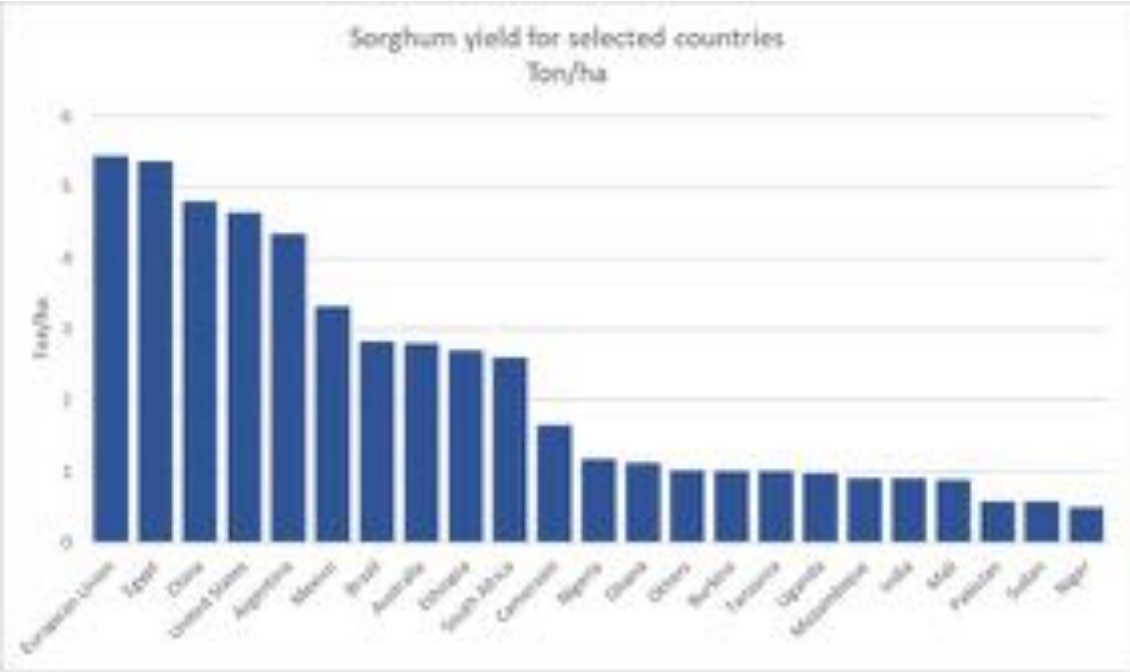


Figure 8: Sorghum yield in selected countries around the world.

The sorghum yield (ton/ha) from selected countries across the globe, is reflected in the previous graph[4]. South Africa is currently in the middle, at 2.7t/ha. Improved sorghum yields in South Africa and consequently a lower price, could see it competing on the African continent with sorghum imported from the USA.

2.4 South African Sorghum Industry Overview

Over the past two decades, overall, there has been a steady decline in sorghum production in South Africa. South Africa's overall sorghum usage was estimated at 159,037 tons in the 2018/19 marketing year, down by 45% from 1999/2000 marketing year. This is primarily due to the ongoing decline in the production of sorghum malt, which in former times was the major market for sorghum. Sorghum malt is used in the brewing of traditional African beer (commonly called sorghum beer), where it comprises approximately one-third of the cereal ingredients with the other two-thirds being maize. Traditional African beer (TAB) brewing, both informal and industrial, has contracted dramatically over the past three decades as consumers have moved to lager-type beer. Also, traditionally, one of the major markets for TAB was to the country's mine workers. However, as the country's mining industry has contracted and mechanised, there has been a concomitant reduction in the manual labour force and consequently in the demand for TAB.

The decline in local demand for sorghum was previously compensated to some extent by export of sorghum to Botswana. However, sorghum exports to Botswana have now all but ceased (see Figure below) as Botswana is now producing sorghum commercially at large scale. There was growth in the South African market for sorghum meal (for porridge making) and for instant sorghum porridge

[4] USDA World Agriculture Production

powder (however, this growth was from a small base). However, this sorghum meal market has stagnated over the past decade. The consumer trend towards healthier diets (including gluten-free diets) does not seem to have had the positive effect on sorghum demand as might have been expected. Lately, this is a primarily as a consequence of the high cost of sorghum relative to other cereals, particularly maize.

Sorghum per capita consumption in South Africa was estimated at 1.62 kilograms per year in 2018, down by 16% from the year 2000. A similar trend can be observed with maize consumption, as the per capita consumption of South Africa's maize has also fallen by 15% over the same period to about 77.32 kilograms in 2018. Whilst the per capita consumption of maize has declined over the recent past, overall maize usage continues to increase due to demand from the animal feed market.

Figure 9: South African Sorghum Exports to Botswana

In 2014, sorghum was one of the more promising crops in local agriculture, boosted by the hope of the development of a local bioethanol industry based on sorghum, with the benefits of job creation and a new market for farmers, particularly black smallholder farmers. A private company Mabele Fuels and the Industrial Development Corporation (IDC) were the first organisations to embrace this initiative. Mabele Fuels was to build a processing plant in Bothaville in the Free State, with a potential to create roughly 16,700 jobs and a market for sorghum farmers in the area. The IDC production plant was to be near Craddock in the Eastern Cape and sorghum production was to be developed in that region.

It was envisaged that ultimately these plants were going to utilise roughly 500,000 tons of sorghum a year, treble the total tonnage of sorghum that South Africa was producing at the time. The government was the key player in the processes, with the aim of creating jobs, boosting the economy, and creating a market for smallholder farmers, while reviving the sorghum industry. Unfortunately, government incentives did not materialise and the projects have not commenced.

By early 2016, it was clear that the biofuel industry was not taking off and farmers were opting for other opportunities, such as accessing new export markets. But this was a difficult task as South Africa is not an established exporter of sorghum. The country's sorghum exports are concentrated in southern Africa, with key markets being Botswana and Swaziland. However, since Botswana started increasing domestic production of sorghum, this has hardly been a viable export market for the sorghum industry.

2.4.1 Sorghum Uses in South Africa

In South Africa sorghum is primarily sued for human consumption, with a very small amount being used as animal feed. The Table below provides a summary of sorghum consumption by use over the past 11 years.

MARKETING YEAR	SORGHUM MEAL	MALT	TOTAL HUMAN CONSUMPTION	ANIMAL FEED	OTHERS	TOTAL
	1 000 TONS					
2008/09	92,3	91,9	184,2	7,9	11,0	203,1
2009/10	100,3	82,0	182,3	8,6	13,4	204,3
2010/11	100,9	81,3	182,2	7,1	11,1	200,4
2011/12	88,4	69,4	157,8	5,6	8,5	171,9
2012/13	95,7	69,0	164,7	5,1	8,0	177,8
2013/14	90,3	62,2	152,6	6,8	7,0	166,4
2014/15	88,0	61,4	149,4	10,4	5,2	165,0
2015/16	97,9	62,7	160,6	9,7	1,9	172,2
2016/17	92,7	60,1	152,8	8,6	3,9	165,3
2017/18	87,7	56,3	144,1	10,7	1,8	156,6
2018/19	87,5	55,5	143,0	11,0	2,0	156,0
2019/20* (FORECAST)	87,0	55,0	142,0	11,0	2,0	155,0

Table 3: Trend in Demand for Sorghum in South Africa from 2008 – 2019

**In this Table commas indicate the decimal place*

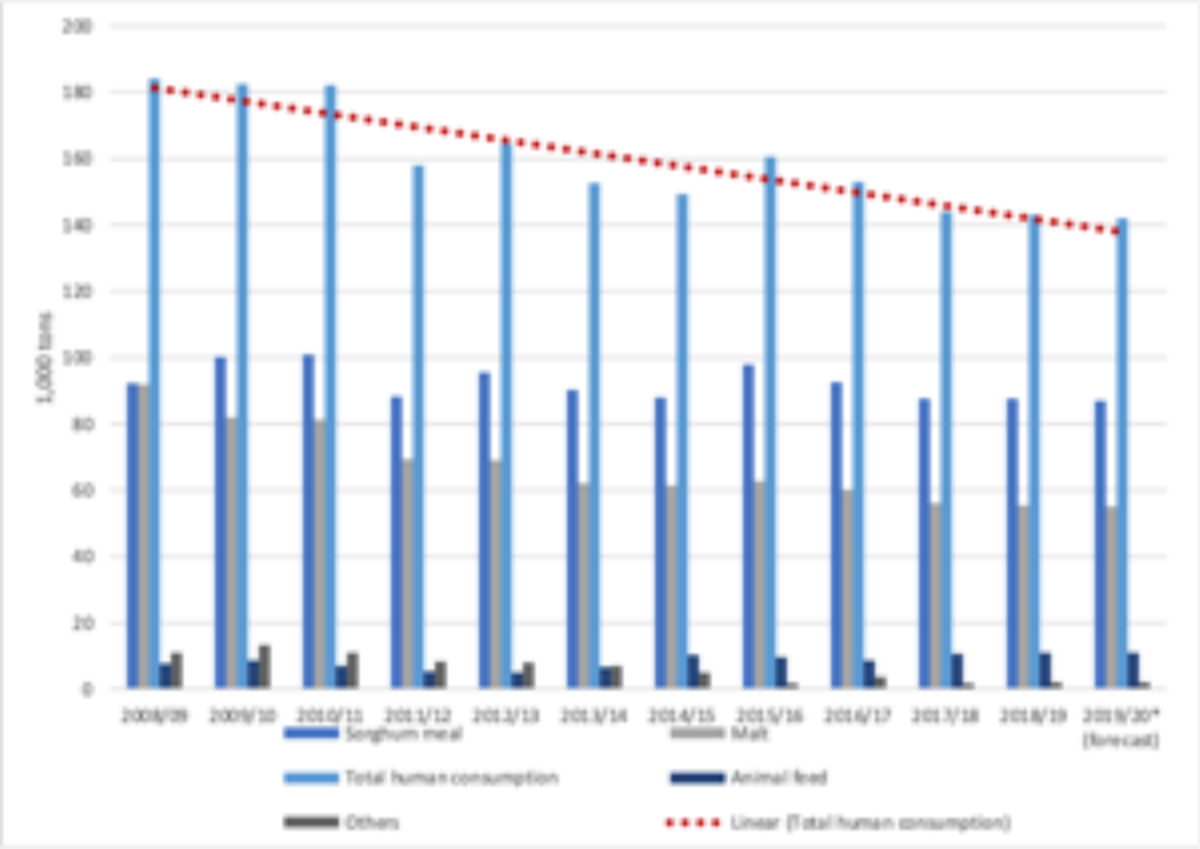


Figure 10: Trend in Sorghum Consumption

The downward trend in sorghum consumption is evidenced from the above graphic illustration.

2.4.2 Supply of Sorghum in South Africa

In South Africa, sorghum is cultivated in the drier areas of the summer rainfall region, i.e., the northern provinces, where it is planted between mid-October to mid-December. The major producing regions, in descending order, are Mpumalanga, Free State and North West, Limpopo, Gauteng and Limpopo.

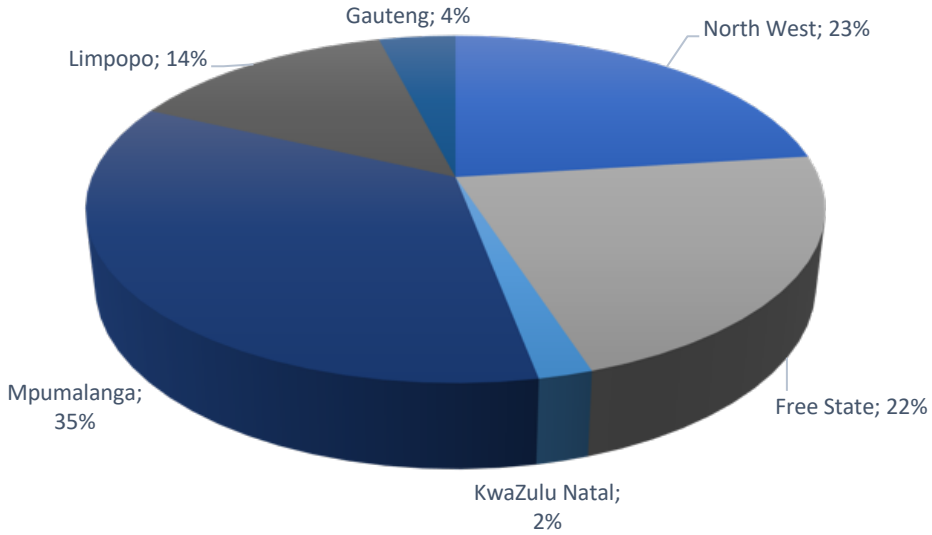


Figure 11: Provincial Contribution of Sorghum Production in South Africa

In recent years, there has been a dramatic shift in production area importance from the Free State to Mpumalanga. This is because sorghum is able to generate economic returns in marginal areas and on heavy turf soils.

PROVINCE	TYPE OF PRODUCTION	2017/2018			2016/2017		
		HECTARES PLANTED, HA	PRODUCTION, TONS	YIELD, T/HA	HECTARES PLANTED, HA	PRODUCTION, TONS	YIELD, T/HA
WESTERN CAPE	Dryland	-	-	-	-	-	-
	Irrigation	-	-	-	-	-	-
	Total	-	-	-	-	-	-
NORTHERN CAPE	Dryland	-	-	-	-	-	-
	Irrigation	-	-	-	-	-	-
	Total	-	-	-	-	-	-
FREE STATE	Dryland	8 000	23 600	2.95	6 000	23 600	3.93
	Irrigation				300	1 600	5.33
	Total	8 000	23 600	2.95	6 300	25 200	4.00
EASTERN CAPE	Dryland	-	-	-	-	-	-
	Irrigation	-	-	-	-	-	-
	Total	-	-	-	-	-	-
KWAZULU-NATAL	Dryland	500	1 500	3.00	500	2 200	4.40
	Irrigation	-	-	-	-	-	-
	Total	500	1 500	3.00	500	2 200	4.40
MPUMALANGA	Dryland	7 500	36 000	4.80	7 500	40 500	5.40
	Irrigation	-	-	-	-	-	-
	Total	7 500	36 000	4.80	7 500	40 500	5.40
LIMPOPO	Dryland	24 650	44 625	1.81	5 000	15 500	3.10
	Irrigation	350	1 500	4.29	-	-	
	Total	25 000	46 125	1.85	5 000	15 500	3.10
GAUTENG	Dryland	1 000	3 200	3.20	1 500	4 950	3.30
	Irrigation	-	-	-	-	-	-
	Total	1 000	3 200	3.20	1 500	4 950	3.30
NORTH WEST	Dryland	8 300	15 725	1.89	7 700	25 050	3.25
	Irrigation	200	2 350	4.25	300	1 600	5.33
	Total	8 500	16 575	1.95	8 000	26 650	3.33
RSA	Dryland	49 950	124 650	2.50	28 200	111 800	3.96
	Irrigation	550	2 350	4.27	600	3 200	5.33
	Total	50 500	127 000	2.51	28 800	115 000	3.99

Table 4: Sorghum Production in South Africa (over two seasons)

Source: The Southern African Grain Laboratory NPC, 2018/19 Report

In the 2018/19 marketing year (MY) approximately 50,500 hectares of sorghum was planted. Yields vary from 2.5 to 4 t/ha, depending on climatic and soil conditions. Nationally, the yield has averaged 2.6 t/ha for the period 2007/8 to 2017/18. The average yield for the 2016/17 and 2017/18 seasons was 3.55 and 3.99 tons/ha under dryland (rainfed) cultivation and 5.39 and 5.33 under irrigation, respectively. However, only approximately 2% of the total sorghum area was irrigated. By comparison, average dryland white maize and yellow maize yields for the 2017/18 season were 4.85

and 4.76 tons/ha. However, over a longer period the yield gap between sorghum and maize is rather greater. Over the 10 years 2007/8 to 2017/18 the average yields for sorghum, white maize and yellow maize were 2.6, 4.3 and 5.2 tons/ha, respectively.

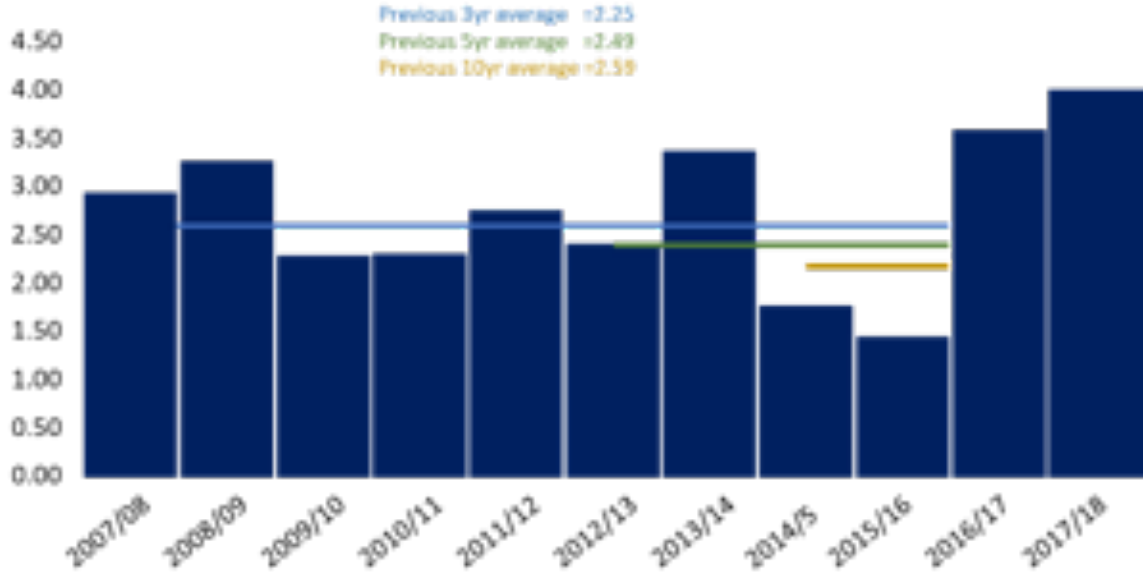


Figure 12: Sorghum Average Yield 2009-2019

Source: The Southern African Grain Laboratory NPC

The vast majority of sorghum produced in South Africa is produced by large-scale commercial farmers, with limited sorghum cultivation being by smallholder farmers in the former homelands.

2.4.2.1 Sorghum Cultivars in South Africa

There are more than 60 hybrid sorghum cultivars and four open pollinated varieties (OPVs) registered in South Africa (See Annexure B). However, only a very few of these are cultivated in any quantity and these are only hybrid cultivars. Smallholder farmers generally cultivate sorghum landraces, although the Agricultural Research Council has developed and released improved OPVs.

With regard to the cultivars cultivated by commercial farmers, they can be classified into two main types: bitter (tannin – class GH) and sweet (non-tannin – class) cultivars. Preference is given to the sweet cultivars as they have broader application. Bitter sorghums are often planted in areas where bird predation is a severe problem. The tannins give the grain an astringent and bitter taste, and consequently birds avoid eating the kernels if there are more palatable crops in the vicinity. Essentially the only market for bitter sorghum in South Africa is for industrial malting.

In South Africa sorghum cultivars are divided into three classes:

- Class GM: Malt sorghum that does not have a dark testa, i.e. the grain has a low tannin content (actually tannins are completely or essentially completely absent), commonly known as sweet sorghum. GM sorghum is especially suitable for malting (the malt having a high diastatic power (amylase activity) and milling purposes;

- Class GH: Malt sorghum that has a dark testa, i.e. the grain has a high tannin content, commonly known as bitter sorghum. GM sorghum is especially suitable for malting (the malt having a high diastatic power (amylase activity);
- Class Other: Sorghum that does not comply with the standards for Class GM or GH.

All GM and GH sorghum cultivars are red in colour as are virtually all of the Class Other. Very little white sorghum is cultivated in South Africa as the grain is highly prone to moulding in the field.

2.4.3 Imports and Exports

South Africa has moved from being a net exporter of sorghum to a net importer of sorghum over the past 10 years, with the United States being by far the main supplier of imported sorghum (approx 95% of the sorghum) (see Figure below).

Figure 13: Sorghum Imports and Exports South Africa

**Source: SAGIS*

Other countries that South Afirca imports sorghum from include Zimbabwe, Botswana and Ukraine.

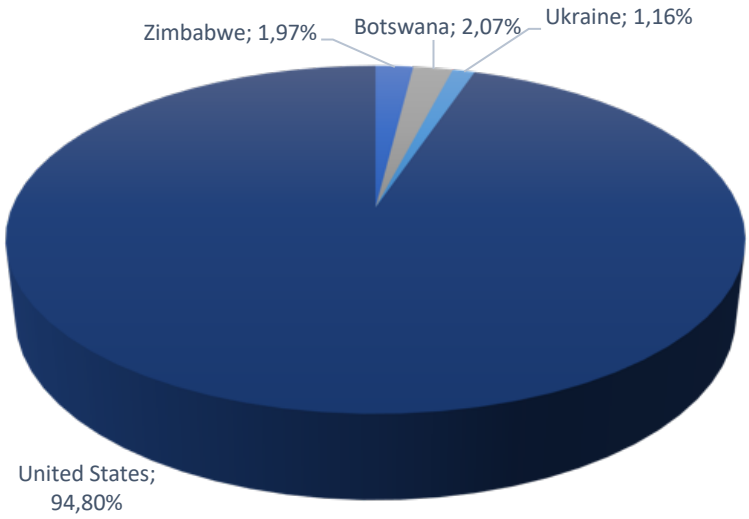


Figure 14: Sorghum Imports South Africa

**Source: SAGIS*

South Africa currently exports less than 5,000 tons of sorghum per annum, with the majority of exports destined for Eswantini.

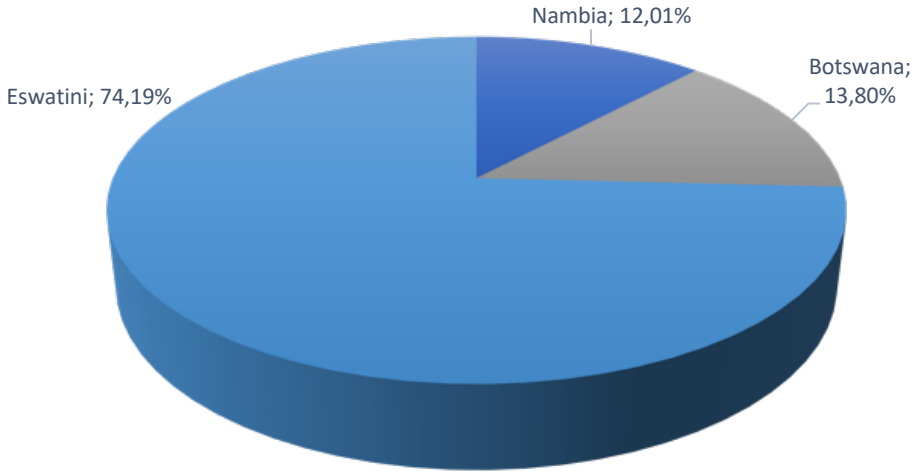


Figure 15: Sorghum Exports from South Africa

**Source: SAGIS*

The main reason for the decline in local sorghum production is the decline in the area planted, with more and more farmers opting for more profitable crops, particularly maize and soybeans. The productivity of sorghum has failed to increase due mainly to lack of development of new cultivars with agronomic performance, unlike the productivity of other crops such as maize and soybeans.

The following Table shows the supply and demand levels of sorghum for South Africa in the 2018/19 Marketing Year:

	SAGIS	NAMC (S&DEC)	INTERNATIONAL (IGC)	
MARKETING YEAR:	**Mar - Feb**		**Sep - Aug**	
	Final 2018/19 '000t	**Projection: 2019/20** '000t	**Estimate: 2018/19** Mil ton	**Projection: 2019/20** Mil ton
OPENING STOCKS	59.2	51.9	4.1	4.8
PRODUCTION	115.4	134.0	58.5	58.3
IMPORTS	45.7	42.4	3.1	3.3
TOTAL USE	157.4 [a]	176.1	57.8	58.2
EXPORTS	9.5	7.1	3.1	3.3
CLOSING STOCKS	51.9	45.3	4.8	5.0

Table 5: South African (columns 1 and 2) and Global (columns 3 and 4) Sorghum Supply and Demand, 2018/19 Marketing Year

**Source: SAGIS*

2.4.4 Local Supply and Demand of Sorghum

The split in supply and demand for sweet (non-tannin) and bitter (tannin) sorghum in South Africa is shown below:

MARKETING YEAR: MAR - FEB	**SAGIS**			**NAMC (S&DEC)**		
	Final 2018/19 '000t			**Projection: 2019/20 '000t**		
	Sweet	**Bitter**	**Total**	**Sweet**	**Bitter**	**Total**
OPENING STOCKS	31 211	28 035	59 246	34 954	16 906	51 860
PRODUCTION	64 887	50 507	115 394	91 870	42 155	134 025
IMPORTS	43 620	2 119	45 739	42 000	400	42 400
TOTAL USE	99 131	55 613	154 744	132 950	43 150	176 100
EXPORTS	6 821	2 661	9 482	6 000	1 100	7 100
CLOSING STOCKS (A)	34 954	16 906	51 860	30 074	15 261	45 335

Table 6: South African Sweet (non-tannin) and Bitter (tannin) Sorghum Supply and Demand

As can be seen in the Table above, sweet sorghum is in higher demand than bitter sorghum. This is mainly because it has much broader food and feed applications.

2.4.5 Key Issues Affecting Sorghum Supply

The following are key issues affecting the local supply of sorghum in South Africa:

7. Farmer decisions regarding crops

A study conducted by the US Department of Agriculture's Foreign Agricultural Services[5] in 2018 indicated that the main cause for a decline in local sorghum production in South Africa

[5] https://www.feednavigator.com/Article/2018/10/09/South-Africa-drops-sorghum-production-bumps-US-imports

and subsequent increase in imports was due to a decrease in area planted. In the study, as well as through interviews conducted during this current study, it became apparent that farmers are searching for alternative crops such as soybeans, which offer higher profitability.

Some farmers, however, are also searching for alternatives to maize because of the declining profitability of the crop. When considering sorghum instead of maize there are various factors that need to be considered:

- Domestic sorghum consumption is relatively low (and declining) with the result that overproduction is a distinct possibility;
- Overproduction of sorghum would lead to significant price reductions as farmers will then have to sell at export parity prices and any profit would be minimal; and
- Sorghum would compete with maize in terms of production area, in the market for meal, products on the supermarket shelves, and its inclusion in animal feeds. Maize is entrenched in the animal feed market and it would be hard pressed to convert its formulations to sorghum without some pushback from the animal husbandry and poultry industries.

8. Competitiveness of imports

The following 2 graphs illustrate the impact of increased commodity prices on local grain prices – sorghum and maize.

High global supply of sorghum is projected to keep international sorghum prices under pressure for a number of years going forward. This would contribute to reducing South African farmers' profitability especially considering the high input costs to which they may be exposed to particularly if the Rand were to devalue drastically resulting in increases in the price of diesel and agrochemicals.

However, recently the price of imported sorghum has soared and is achieving record levels. This is currently a favourable position for the local famers but for the processing companies, the prices will force them to pass price increases on to the consumer. Sorghum-based beer (TAB) and meal producers are faced with decreasing margins in order to maintain retail prices and avoid exceeding sensitive market price points (e.g. R10.00 per litre for TAB). However, this would then render the local processing of sorghum into food product and beer unprofitable and the processors might be forced to remove the sorghum-based products from their product mix.

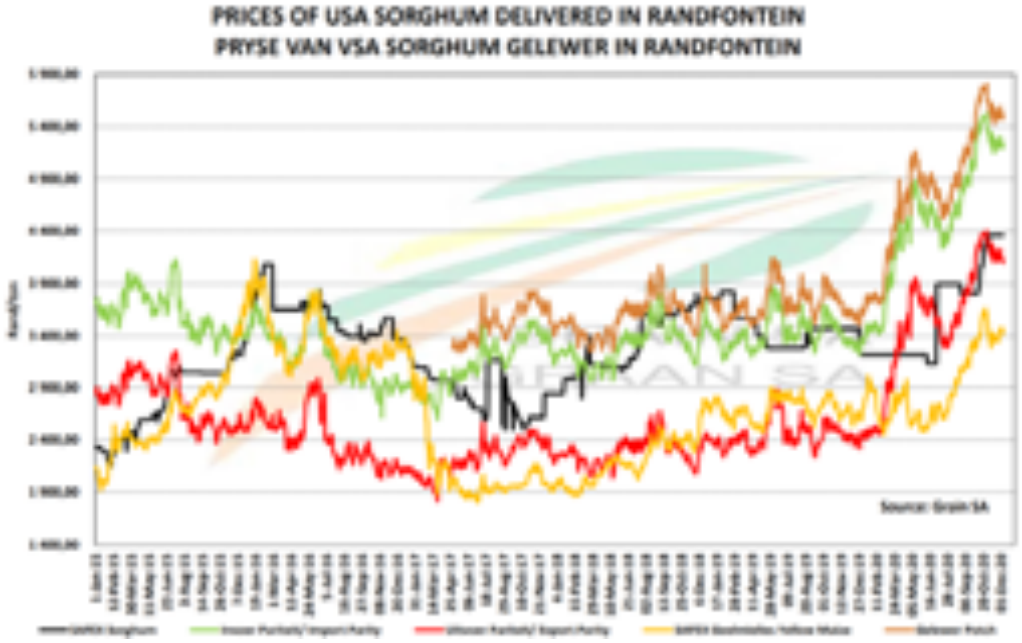


Figure 16: Price of USA Sorghum Delivered in Randfontein

Source: Grain SA

Maize prices also experienced an increase albeit not as sharp as that of the sorghum grain. The Covid pandemic contributed toward commodity prices coming under pressure early in 2020 but countries such as China are now closing the deficit and stockpiling commodities to secure grain for feed and baijiu production and this has contributed to increased prices for all grain commodities.

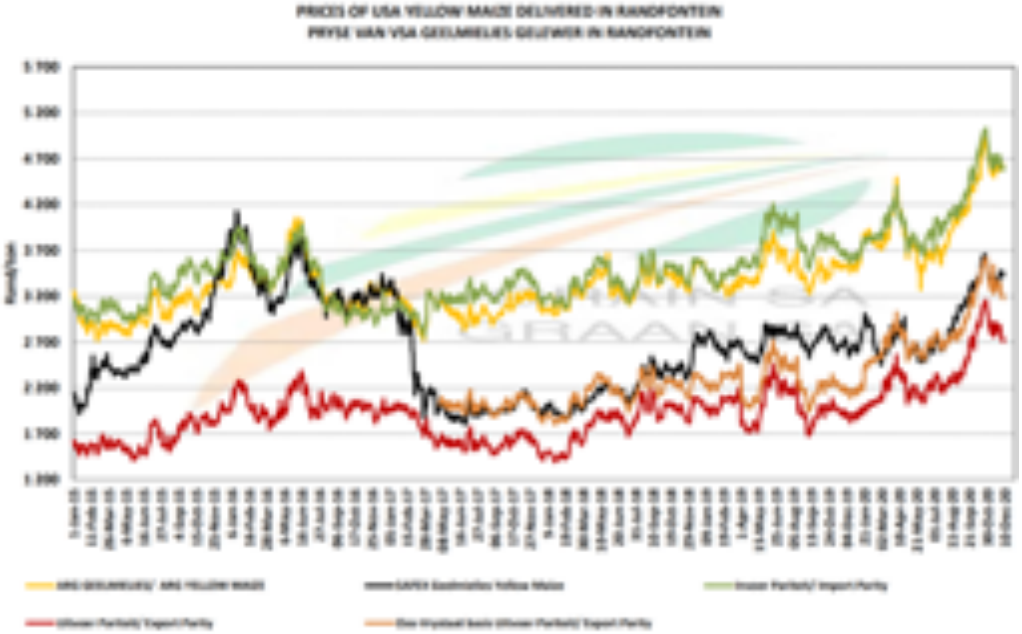


Figure 17: Price of Yellow Maize Delivered in Randfontein

Source: Grain SA

At these elevated prices for sorghum, local sorghum production is very profitable. Internationally, the cost of sorghum production is typically cheaper than maize production (e.g. in these and Australia) which is not the case in South Africa. The cultivar development programme proposed as outcome of this study outcome should aim to increase the competitiveness of sorghum production so that the local sorghum producers are able to compete effectively with imported sorghum. The local food processors have indicated that the South African produced sorghum is generally of a better quality than the imported sorghum and that the focus of the cultivar development programme should be on achieving higher yields, thus bringing down the cost of sorghum grain.

Imported sorghum represents an immediate target market for local sorghum growers of at least 60,000 tons per annum.

In addition to sorghum imports, South Africa still imports yellow maize on a regular basis, primarily through the Cape Town port. During the 2019/20 season more than 500,000 tons of yellow maize was imported from Argentina and Brazil. The high cost of transporting maize from inland grain producing regions to the Western Cape processors is cited as one of the key drivers for the importation of yellow maize. While yellow maize is used predominantly for animal feeds, the maize is not readily replaced with sorghum. In the rest of the world, the price of sorghum and maize is a driver for the demand for these grains by feed producers and the two grains are readily interchanged in animal feeds depending on the price differential. In South Africa, it seems that the animal feed producers are not ready to interchange yellow maize and sorghum if there is not better security of sorghum supply and competitive sorghum pricing. The development of the sorghum industry commencing with a cultivar development programme, should bolster the confidence of the feed producers and support greater use of sorghum over the long run.

9. Climate change

Being drought tolerant and have a low water requirement, i.e. requiring < 300 units of water to produce 1 unit of dry matter, sorghum can tolerate erratic rainfall and will recover even if wilted for up to 14 days.

In South Africa, the planting date of sorghum is determined primarily by the first spring rain, but also distribution of the seasonal rainfall, soil temperature, frost-free period and the cultivar to be planted. Normally sorghum is planted in South Africa from mid-October to mid-December.

Sorghum is sensitive to low temperatures. The ideal soil temperature for germination is 15ºC at a depth of 10 cm. The crop is also sensitive to frost, and planting needs to be delayed until the last frost has passed.

The planting date should be chosen so that the period of critical moisture need i.e. during ear initiation does not coincide with a drought period. Recently, as a result of climate change droughts and periods of extreme high temperature have occurred unexpectedly in South Africa, like elsewhere in the world. These extreme weather events can be detrimental to any crop should they occur at critical times during the crop's lifecycle.

Unfortunately, as a result of the recent droughts in some production areas of the country, grain crop irrigation has not possible because many of the dams supplying irrigation water have been completely or very nearly empty.

10. Profitability of sorghum

The profitability of sorghum production has come under much scrutiny. Sorghum is one of the less profitable crops when compared to maize, soybeans, groundnuts and sunflower. Farmers are thus more likely to produce these more profitable crops, if the climate and soil conditions permit, than sorghum.

Part 3:
PESTLE Analysis

3 PESTLE Analysis

3.1 Political

South Africa is a country that currently faces various challenges in terms of household food security and poverty. The Directorate Food Security within the Department of Agriculture, Land Reform and Rural Development acknowledges that food security has three dimensions. Firstly, a country must have sufficient quantities of food available on a consistent basis at both national as well as household level. Secondly, a country must have the ability to acquire sufficient food for its nation and households on a sustainable basis (import). Thirdly, food should be used appropriately based on a thorough knowledge of nutrition and care. South Africa is largely perceived to be a food secure nation, but that cannot be said of households in rural areas where food security is widely lacking. Agricultural produce such as sorghum, maize and wheat grains have the potential to provide significantly for those in need. However, the correct policy frameworks and government support is required to make the production of such crops more profitable and sustainable.

3.1.1 South African Policies for Food Security

Significant efforts have been made by the South African government to promote food security and to domesticate international indicators on food security to monitor development in different organs of the State. An inter-ministerial National Food Security and Nutrition Plan has been developed by the SA Government and its coordination occurs at the Presidency. Additionally, the country's National Development Plan (NDP) recognises agricultural productivity and rural development among the essential priorities for creation of employment, economic growth, reducing poverty and addressing food insecurity in South Africa.

The right to food is enshrined in the South African Constitution. Section 27(1) (b) of the Constitution of the Republic of South Africa states that, "everyone has the right to sufficient food and water" and Section (27) (b) emphasises that "the State must formulate reasonable legislative efforts and take other measures within its available resources, to achieve the progressive realisation of these rights." The right to food requires that food be available, accessible, and adequate for everyone without discrimination. The Department of Agriculture, Land Reform and Rural Development is responsible for developing agricultural policies and initiate support programmes to ensure that South Africans are able to produce their own food and reduce food insecurity. The Food and Nutrition Security Policy is key in achieving the objectives of the National Development Plan and that of the UN Sustainable Development Goals (SDGs). Goal 2 of the SDGs commits to ending hunger, achieving food security, improved nutrition, and promote sustainable agriculture by 2030.

3.1.2 Policy Uncertainty in South Africa

One of the greatest uncertainties facing South African agriculture at present relates to the implementation of land reform policies, in particular the possibility of expropriation without compensation. On 27 February 2018, the National Assembly made a landmark decision to review Section 25 of the Constitution of the Republic of South Africa in order to cater for the principle of land expropriation without compensation (Parliament of the Republic of South Africa, 2018).

A widespread perception is that overall execution of strategies and programmes on land reform has been poor to date, resulting in various failures. A focused and effective land reform policy is required to support economic development and food security. It is important that land reform supports the core of the commercial agricultural sector, which is a key driving force of the economy and food security in the country.

Figure 18: Role of Agriculture in the Economy

**Source: Hamlet Hlomendlini and Pusho Makgolane, Hlomendlini and Pusho Makgolane, Land Expropriation without Compensation: Possible Impact on the South African Agricultural Economy*

The National Development Plan (NDP), identified agriculture as one of the critical sectors for economic development with a potential to create about one million jobs by 2030 but with the current uncertainty around the land, this target might not be reached.

In addition, agriculture is critical to the development of the economy as the sector that has strong backwards and forwards linkages with the rest of the economy. Through backwards linkages, agriculture purchases goods such as fertilizers, agrochemicals and equipment from the manufacturing sector. On the forwards linkages side, agriculture supplies raw materials to food, beverage and feed industries and the food supply chain in general. Approximately 70% of agricultural output is used as intermediary products in other sectors, particularly the agro-processing sector which contributes almost 20% to employment in the manufacturing sector.

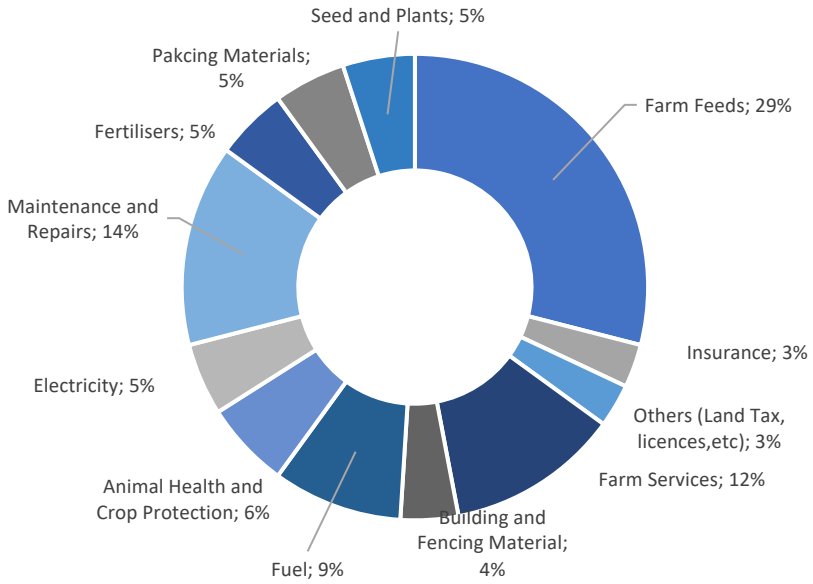


Figure 19: Capital Expenditure on Intermediary Products

**Source: Hamlet Hlomendlini and Pusho Makgolane, Land Expropriation without Compensation: Possible Impact on the South African Agricultural Economy*

What this suggests is that any distress in the agricultural sector will lead to distress in the rest of the economy. Unemployment which is currently at a record high (nominally 32% but probably in reality considerably higher) could increase further, more and more people could be excluded from participating in economic activities, with the ultimate result of further slowing of economic growth, weakening of the currency, and higher inflation.

Given the importance of the agricultural sector in the economy, there is need to speed up transformation in the sector. This, however, should be done with the aim to better position the sector to effectively and sufficiently deliver on its triple objectives of ensuring that the nation is food secure, employment is created and contributing to growth of the GDP.

The uncertainty around the amendment of Section 25 of the Constitution is currently causing extreme uncertainties in the agricultural sector and is likely inhibiting investment into the sector.

3.1.3 South African Policy on Biofuels

In 2007 the South African government committed to a short-term goal in the production of biofuels, amounting to 2% of the total road transport pool. To date, large-scale procurement has not yet commenced. According to the Biofuels Industrial Strategy, mandatory blending was expected to commence in October 2015. However, this has not materialised and owing to the potential cost to the fiscus of the existing support mechanism during the ongoing period of low oil prices. In 2015 the government revised the processing of allocating the subsidy to one which is based upon companies submitting competitive bids, rather receiving a sum based upon a commodity price index. The low oil prices, together with concerns around food security and the policy framework led to the government temporarily halting the policy development process around biofuels. However, in December 2019

government approved the Biofuels Regulatory Framework, which will give effect to the implementation of the Biofuel Industrial Strategy.

While the biofuels policy supports both biodiesel and bioethanol blending, bioethanol has attracted more attention due to country's large sugarcane sector that could contribute to ethanol production, alongside the large petroleum liquid fuel market. In contrast, biodiesel production is at a much earlier stage of development.

Initial expectations for the biofuels industry in South Africa were based heavily on specific crops as feedstock but the main contenders, maize and jatropha, have been removed from the sector. Maize is banned as an energy source as it is a staple food. Jatropha, which was once a leading contender, is also banned because its oil extraction leaves behind a toxic seedcake by-product.

Grain sorghum used to be cultivated extensively, but production declined as the local market demand for sorghum decreased. However, parts of South Africa are well-suited to sorghum cultivation (some more than for maize) and its hardiness make it a potentially attractive crop, as a feedstock for local ethanol manufacture for example.

Sweet (sweet stalked, i.e. sucrose containing) sorghum has up until recently been considered one of the most promising crops for the production of ethanol at relatively low cost. However, interest in sweet sorghum has declined of late in the USA and India, the two countries pioneering sweet sorghum research, because of low oil prices, which rendered it uneconomical. In South Africa, sugar cane is probably a much more viable option than sweet stalked sorghum, as there is already a large and well-developed sugar cane industry, which is struggling due in part to falling demand for sugar as a sweetener.

3.1.4 South African Policies on Climate Change

The South African government has designed several policies, strategies and plans to understand, identify and address the impacts of climate change on the economy:

- *Department of Agriculture Strategic Plan 2015/16 – 2019/20*
  The plan acknowledges that the increasing threat of climate change, combined with inadequate investment in agricultural production, poses a serious risk to food security. As part of the implementation strategy, the plan notes that the department will implement sustainable development programmes that ensure protection of biomes and endangered species, the rehabilitation of degraded land, and climate change mitigation and adaptation strategies. However, it does not address issues related to climate change adaptation for crops and livestock.
- *The Integrated Growth and Development Plan*
  With regard to climate change, the plan recognises the need to develop both adaptation and mitigation strategies for the sector. The plan suggests the need for adaptive management strategies at five to ten-year intervals in order to keep up with changes in the productivity and distribution of resources.
- *The Department of Environmental Affair's (DEA) National Climate Change Response White Paper (2011)*

The White Paper highlights the need to invest in and improve research on water, nutrient and soil conservation technologies and techniques; develop climate-resistant crops and livestock; and develop production, ownership, and financing models to promote the development of climate smart agriculture. However, such interventions are not currently reflected in strategic agriculture-specific documents, such as DALRRD's Strategic plan and the Agricultural Policy Action Plan.

- *The National Food and Nutrition Security Policy*
  The Policy is relatively strong in terms of envisioning food security measures, the impact of climate change, and the creation of a centralised food security control. However, the policy is silent on climate change adaptation and disaster risk reduction interventions to ensure food security, despite the significant challenges they cause for food security. The policy only focuses on ensuring sustainable access to food and food availability, which are less likely to be achieved if issues pertaining to climate change are not addressed in a more structured manner.

3.2 Economic

3.2.1 Economic overview

World economic growth was already slowing prior to the outbreak of the COVID-19 health pandemic, with global growth below 3% in 2019 – the lowest since the 2008 financial crisis. Multiplying global risks have contributed to slowing growth in both developed and developing economies. Brexit, tariffs, and trade wars have all contributed to an increasingly negative economic outlook, along with a generalised increase in political tension and uncertainty.

The COVID-19 global health pandemic saw what is now being referred to as "the Great Lockdown" being implemented in most countries around the world. Economic activity in the majority of countries around the world was severely constrained in the first and second quarter of 2020 as national lockdowns were implemented in an attempt to combat the spread of the COVID-19 virus. While most countries have resumed economic activities, there the COVID-19 virus continues to spread, resulting in some countries slowing the reopening of the economy while others are reinstating partial lockdowns to protect susceptible populations.

The latest available data from the Organisation for Economic Cooperation and Development (OECD) estimates a decline of 4.9% in global economic activity for 2020, and a 5.6% increase in global growth for 2021.

South Africa's economic activity contracted by 7% in 2020[6]. The COVID-19 pandemic brought on many challenges for an already struggling economy. Employment saw a steep decline, with the number of people employed falling by 1.4 million people. In the October -December quarter, unemployment in the country stood at a record level of 32.5%, with the expanded definition of unemployment (which includes discouraged work seekers) at 42.6%.

Despite the impact of the pandemic on economic growth, there was one shining star in 2020. Agriculture escaped the effects of the pandemic relatively unscathed, expanding production by 13,1% in 2020. Government also grew marginally in the year, up by 0,7%.

[6] Stats SA, March 2021

All industries except for Government and agriculture declined. The construction industry, already in deep trouble before the pandemic, contracted by 20,3%. This marks the industry's fourth consecutive year of economic decline.

As reported in our article covering the GDP results for the second quarter3, a decline in air travel contributed to the contraction in the transport and communication industry. Rail and road freight operators also found themselves hamstrung by restrictions placed on the production and movement of various goods during the second quarter.

Despite a strong showing in the fourth quarter, manufacturing production was down for the entire year, falling by 11,6%. This was mostly due to work stoppages in the second quarter and a fall in the demand for steel, amongst other reasons.

South Africa is likely to see economic growth of 2.9% in 2021 as it rebounds from the -7% collapse of 2020. However, much of this growth will be due to the base effects arising from the large contraction in economic activity in 2020

The country has reliable communications, energy and transport infrastructure which ensure good connectivity between major urban centres on the one hand and between urban and rural centres on the other. However, economic inequality in South Africa is among the highest in the world. The poorest 20% of the South African population accounts for less than 3% of total expenditure on goods and services, while the wealthiest 20% accounts for approximately 65% of total expenditure. Reducing inequality and eliminating poverty are the two key priorities of the 2030 National Development Plan. Looking ahead over the next 30 years and beyond, the annual average growth rate of South Africa is expected to remain below 2%.

The New Growth Plan has identified the agriculture sector as a priority sector for employment and job creation, especially in rural areas. Available data indicates that South Africa's agriculture sector contributes less than 5% to the country's GDP and only employs about 6% of the total labour force. However, it is widely recognised that these figures fail to take into account the whole agricultural value chain. Taking, for example, food processing into consideration it is significant that the industry contributes 20% of employment in the manufacturing industry, which in turn contributes approximately 11% to formal employment in South Africa. In essence, the contribution of the agricultural industry to GDP and employment is in all likelihood higher than available data suggests. In the current economic environment, the proportion of the national workforce engaged in agriculture as its primary source of income is expected to remain low, with most new economic opportunities expected to remain highly concentrated in urban areas.

A key consideration for the growth of the agricultural sector is the extent to which it contributes to international trade. In 2018, South Africa's agricultural exports grew by 7% y/y to US$10.6 billion, a record level in a dataset starting from 2001. This was underpinned by increased exports of oranges, grapes, wine, maize, apples, wool, lemons, mandarins and pears, amongst other products.

Over the same period, imports increased marginally by 0.1% y/y to US$6.7 billion. The key imported products were rice, wheat, offal, palm oil, whiskey, live cattle and oilcakes for animal feed. Overall, this subsequently led to a 21% y/y increase in South Africa's agricultural trade balance to a record US$3.9 billion.

Another key consideration when looking at a county's growth and the need for a well-established agricultural sector is population growth. By 2050, the South African population is expected to reach 73 million; double its size in 2000. Eighty percent of the population is expected to be living in urban areas; current projections lean towards negative growth of the country's rural population as rural areas become increasingly less attractive economically and socially. To mitigate the potential population reduction in rural areas, on the one hand, and the increase in urban populations on the other, South Africa must promote rural investment in both on-farm and off-farm opportunities. Various initiatives by the South African Government have been initiated to promote rural agricultural development, such as the Rural Enterprise Development (RED) hubs, which is geared to support rural communities with agricultural production – specifically in the grain (maize, and to a limited degree, sorghum) industries. The objective of the RED Hubs is to promote economic development in rural areas and increase agricultural production in these areas.

3.2.2 South Africa Agriculture, Food and Beverages Sector

South Africa has a strong agricultural production which is supported by having about 10% of its considerable land area being used for crop production. South Africa is roughly one-eighth the size of the USA however the country incorporates a wide variety of climatic regions that stretch from Mediterranean to semi-desert, this biodiversity allows South Africa to produce an abundance of varied agricultural products. The biggest hurdle to farming in South Africa comes from the availability of freshwater with uneven and unreliable rainfall being a common feature in the nation, it is estimated that up to half of the water used in South Africa is used in the agricultural sector. South Africa has a largely dual agricultural economy; on the one hand, there is a well-developed commercial sector in the country and on the other hand, the majority of people engaged in agriculture are involved in subsistence-oriented practices in rural areas.

The South African agricultural industry has emerged strong from the Covid-19 pandemic, with a growth of 13% in 2020. The exceptions are wine and tobacco, where trade has been restricted through various stages of the lockdown.

While the weaker exchange rate combined with above average harvests supported the rebound in performance in 2020, the outlook beyond that remains under pressure. Many structural challenges, (such as infrastructure maintenance, reliable electricity supplies, capacity of critical public services and municipalities) have now been exacerbated by the pandemic, and low economic growth over the next few years does not provide the demand base conducive to rapid growth in the sector. In fact, sustained growth is only expected to return over the second half of the outlook period.

In South Africa, much of the decline in global crop prices was offset by the sharp depreciation in the exchange rate. While South Africa's bumper maize crop will push prices to export parity, these parity

levels have increased as a result of the weaker Rand and hence prices will not decline to the same extent that would normally be expected in a bumper year. Oilseed prices are expected to increase substantially, supported by high import parity prices for products such as vegetable oil and protein meal. The success of the 2020 summer crop should however not detract from the fact that many producers, particularly in more marginal areas in the Western production regions, have experienced severe financial strain over the past 5 years. However, while the revenue generated in 2020 provides some respite, the long-term prospects for the more marginal growing areas remain a challenge, with increased diversification into livestock enterprises likely to occur to ensure long term sustainability.

In the weak economic environment, the long-term decline in per capita maize consumption is expected to turn around, yielding an increase in per capita consumption levels over the coming decade. This trend is further supported by relative price movements, as maize prices decline to export parity levels, with import parity-based wheat and rice prices increasing on the back of the weaker exchange rate. In 2020, the value of the bumper maize crop cannot be over emphasised, as it keeps maize meal prices fairly affordable, despite the weakness of the Rand. While the demand for maize meal is set to increase in 2020, the lockdown's severe impact on the livestock sector is expected to result in a marginal decline in the demand for animal feeds. Furthermore, the weight of the economic downturn in 2020 and the prolonged recovery suggest that some of the improvements in dietary diversification over the past decade may be reversed. Over the course of the outlook, demand growth is projected to slow drastically from the past decade and emanates from population growth more than per capita gains. Despite this slowdown in consumption, there are still opportunities to grow production for sectors able to compete effectively in the global market and drive an export led strategy, or alternatively improve their competitive position sufficiently to replace imports.

While South Africa remains a net exporter of agricultural products, a substantial share of the inputs required to produce this surplus is imported. The risks associated with the high dependence on imports for critical inputs are twofold: Firstly, it relates to short term availability – while many economies have started to open up, others continue to restrict operations in an effort to contain the disease. Secondly, there are also risks related to affordability, which is influenced by the macroeconomic environment and the relative weakness of the exchange rate.

While agriculture has risen to the occasion to ensure food availability in a challenging year and looks set to contribute positively to the economy in 2020, the reality is that reductions in consumer income and increases in unemployment still resulted in food being unaffordable to many. Furthermore, progress with respect to transformation remains too slow. To compete effectively in this new global environment and harness the full potential of the agriculture and food value chain to ignite inclusive growth throughout the value chain and thereby drive broader economic prosperity, a continuation of business as usual will be insufficient.

The vision contained in the National Development Plan of an inclusive and thriving agricultural and agro- processing sector is now just as applicable as it was during its launch in 2011. Recent simulations, where the basic principles of the NDP are incorporated in the BFAP modelling systems, presents an alternative scenario of the future, with 12% growth in real terms above the baseline by 2030.

However, this growth can only be achieved with very specific targeted interventions that are implemented, monitored and adjusted as required.

The agricultural sector is currently in another planning phase with the development of an Agriculture and Agro-Processing Master Plan (AAMP), which has the potential to provide a solid basis for inclusive growth going forward. It is envisioned that the AAMP's 'social compact' will bind the partners into a set of agreed targets and commitments, but only time will tell if this process will be robust enough to drive effective implementation of key interventions that has been lacking in the past. Negotiations amongst the social partners will have to carefully assess the basic principles of sustainable value chains. Practical solutions need to be researched, debated and implemented rather than spending more time on the old debates of large versus small, and industry concentration issues that really should be dealt with through the effective operations of the Competition Commission. It will be tragic if this sorely needed opportunity for inclusive growth is missed due to a lack of alignment and unity between government, labour and private sector.

3.3 Social

In South Africa, agriculture is critical for not only the economic but also the social wellbeing of the country. Many families in the rural areas of South Africa rely on farming to directly provide their basic food requirements, as well as an income (in some cases agriculture is the only income in the household). Smallholder and informal farming plays a critical role in food security and income for rural communities. In these communities, traditional farming practices are used widely. Looking at sorghum, entrepreneurs in rural areas are already making products such as traditional beer (Umqombothi), non-alcoholic soured beverages (Motoho) and sour porridge (Ting) for occasions like weddings and there is a potentially attractive market aimed at international tourists wanting to try a "Taste of Africa". However, one of the key findings regarding consumer preference in the sorghum industry is that many young people view sorghum as a "poor man's food". This also applies to traditional African beer, with the rapid rate of urbanization and the falling away of traditions and rituals, the beer seems to have become less popular. Discussions with key stakeholders (AB InBev) also revealed that consumer preference with regards to the packaging of beer also has an influence. In South Africa, glass bottled beer is preferable in terms of status, and the carton containers that traditional sorghum beer is sold in is often associated with rural, poorer areas.

3.4 Technology

Modern farms and agricultural operations work far differently than those of a few decades ago, primarily because of advances in technology, including sensors, devices, robotics, and information technology. Today's agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial remote imaging (drones), and GPS technology. The application of these advanced devices and robotic systems in precision agriculture technology allow farming enterprises to be more profitable, efficient, safer, and more environmentally friendly. However, on the negative side, these technologies also reduce the requirement for labour, particularly unskilled labour, which makes up a large proportion of the labour force in South Africa.

Specific benefits of these new agricultural technologies include the fact that farmers no longer have to apply water, fertilizers, and pesticides uniformly across entire fields. Instead, they can use the minimum quantities required and target very specific areas, or even treat individual plants differently. Benefits include:

- Higher crop productivity;
- Decreased use of water, fertilizer, and pesticides, which in turn keeps food prices down;
- Reduced impact on natural ecosystems;
- Less runoff of chemicals into rivers and groundwater; and
- Improved worker safety.

Robotic technologies enable more reliable monitoring and management of natural resources, such as air and water quality. They also give producers greater control over plant and animal production, processing, distribution, and storage, which results in:

- Greater efficiencies and lower prices;
- Safer growing conditions and safer foods; and
- Reduced environmental and ecological impact.

Technology development and innovation helps with the adaptability of crops to climate changes and drought conditions. New sorghum types (multi-seed (head) traits) are being developed that potentially can produce better yields (some companies argue by as much as 60%), as well as cultivars that will be less attractive to birds, which have a preference for non-tannin (sweet) sorghum.

Other developments include a herbicide-resistant grain sorghum which features resistance to ALS herbicide “Zest.” This is being developed by DuPont (Corteva) in the USA. The non-GM trait will allow grain sorghum growers to control grassy weeds such as foxtail, barnyardgrass and crabgrass.

In South Africa, research and development initiatives within the sorghum agricultural industry are limited. The main focus of cereal agricultural R&D is on maize and wheat. As such, the country is currently lagging behind in terms of cultivar improvement and agronomy technologies.

3.5 Legal

The Department of Agriculture, Land Reform and Rural Development (DALRRD) derives its core mandate from Section 37(ii) of the Constitution. It is currently responsible for over 30 pieces of legislation. Underpinning this definition of the scope of the mandate of DALRRD is the understanding of agriculture, as being inclusive of all economic activities from the provision of farming inputs, farming and value adding. In view of the reality that the agricultural sector is continuously subjected to changes in the production and marketing environment, the policy and legislative environment that governs the sector, continuously adjusts through amendments and sometimes replacement of legislation. This is not unique to South Africa but is found to be the case globally. The following legislation is relevant to the sorghum industry:

- Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947)

- Plant Breeders' Rights Act, 1976 (Act No. 15 of 1976)
- Plant Improvement Act, 1976 (Act No. 53 of 1976)
- Perishable Products Export Control Act, 1983 (Act No. 9 of 1983)
- Agricultural Pests Act, 1983 (Act No. 36 of 1983)
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)
- Liquor Products Act, 1989 (Act No. 60 of 1989)
- Agricultural Research Act, 1990 (Act No. 86 of 1990)
- Agricultural Product Standards Act, 1990 (Act No. 119 of 1990)
- Agricultural Produce Agents Act, 1992 (Act No. 12 of 1992)
- Agricultural Development Fund Act, 1993 (Act No. 175 of 1993)
- Marketing of Agricultural Products Act, 1996 (Act No. 47 of 1996)
- Agriculture Laws Extension Act, 1996 (Act No. 87 of 1996)
- Genetically Modified Organisms Act, 1997 (Act No. 15 of 1997)
- Agricultural Laws Rationalisation Act, 1998 (Act No. 72 of 1998)
- Land and Agricultural Development Bank Act, 2002 (Act No. 15 of 2002)

3.5.1 VAT on Sorghum

Sorghum is a commodity on which VAT is levied, with the current VAT rate being 15%. The VAT on is levied on sorghum meal which makes it considerably less competitive than maize meal, wheat flour, basic wheat bread and rice, none of which carry VAT, despite the fact that all them are basic staple foodstuffs. This unfair taxation limits consumers' choice – specifically consumers in the lower income group. Furthermore, imposition of VAT on sorghum meal discourages food processors from developing their range of sorghum foods, which is to the detriment of the consumers and the whole sorghum industry.

The following graph shows the cost (R) per 100 g serving unit of sorghum meal compared to super maize meal, bread and rice. It is again clear that sorghum meal is more expensive compared to the other staple food products due to the VAT on sorghum meal. The graph also illustrates how the price of sorghum meal will compare against the other products in case the VAT on sorghum were to be removed. As can be seen, although removal of VAT on sorghum meal would reduce its price, it would not bring it down to the same price of maize meal or rice. This is because of the high cost of sorghum grain.

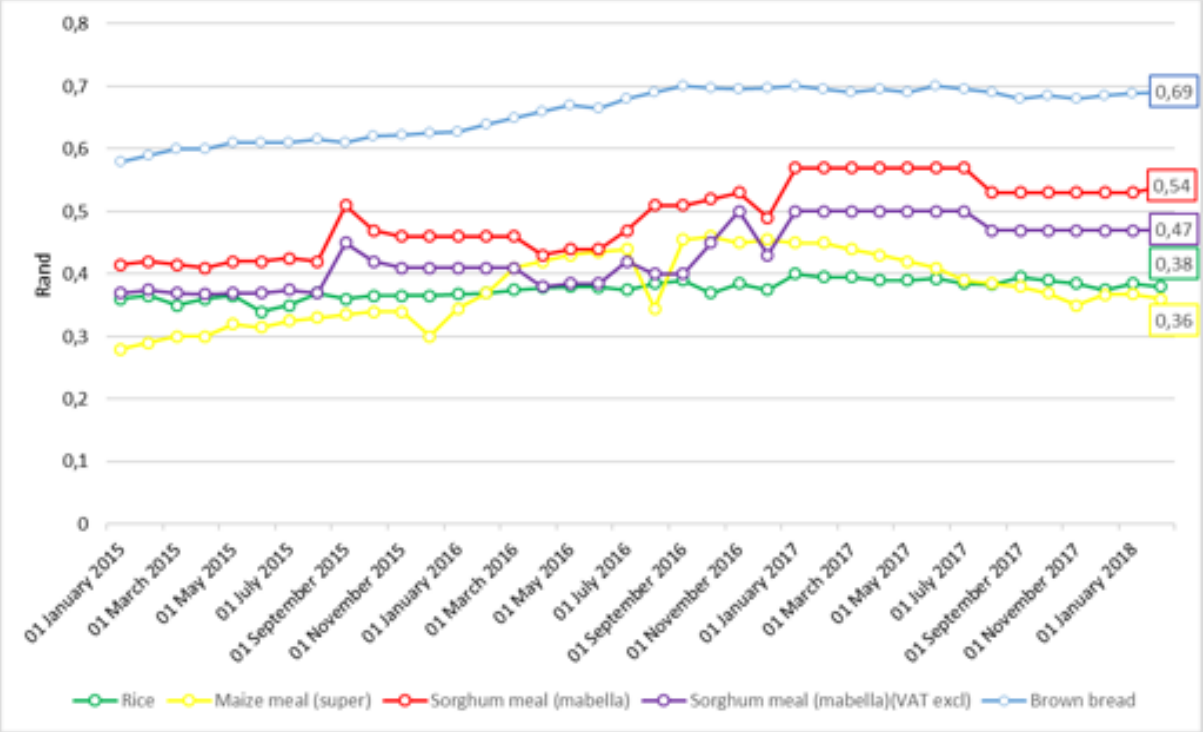


Figure 20: Cost per Single Serving Unit, Maize and Sorghum Comparison

Source: BFAP 2018

3.6 Environment

The most important climate change risk is increased temperature. This affects rainfall and seasonal patterns on a global scale. It also affects plants' phenological growth (phases in the plant's development which require certain thresholds of sunlight, heat and moisture) and physical growth and exposure to pests and diseases. Crops are exposed to higher temperatures which many can endure. But it is the increase in extremely hot days (and warm nights) that can cause the most damage to crops and loss of production yields.

Climate change is expected to have less of an impact on sorghum production than on other grain crops such as maize and wheat. A study done in Queensland, Australia (Queensland Alliance for Agriculture and Food Innovation), proposed that sorghum should be bred for heat stress adoption now, in which event there would not be much change in the current production levels 30 years from now. The study concluded that even with increased heat stress events and reduced summer rainfall, the impact on sorghum yields to 2050 would be offset by the increasing CO_2 in the atmosphere, which would enable the sorghum plant to use water more efficiently for growth. Furthermore, another study on the impact of climate change on selected crops in Africa (*Knox J. et al 2012 Environ. Res*.) concluded that in South Africa maize yields are likely to decline by 11% by 2050 due to the impact of climate change, whereas sorghum and wheat yields would not be affected.

Part 4:
Sorghum Value Chain in South Africa

4 Sorghum Value Chain in South Africa

The following Figure illustrates the sorghum value chain in South Africa, with the section below discussing the major components of the value chain.

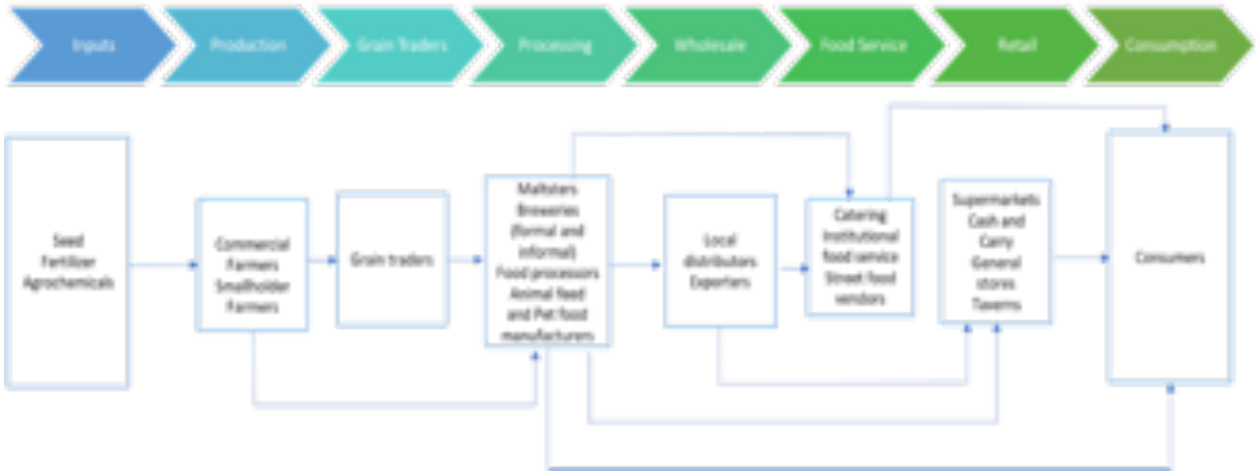
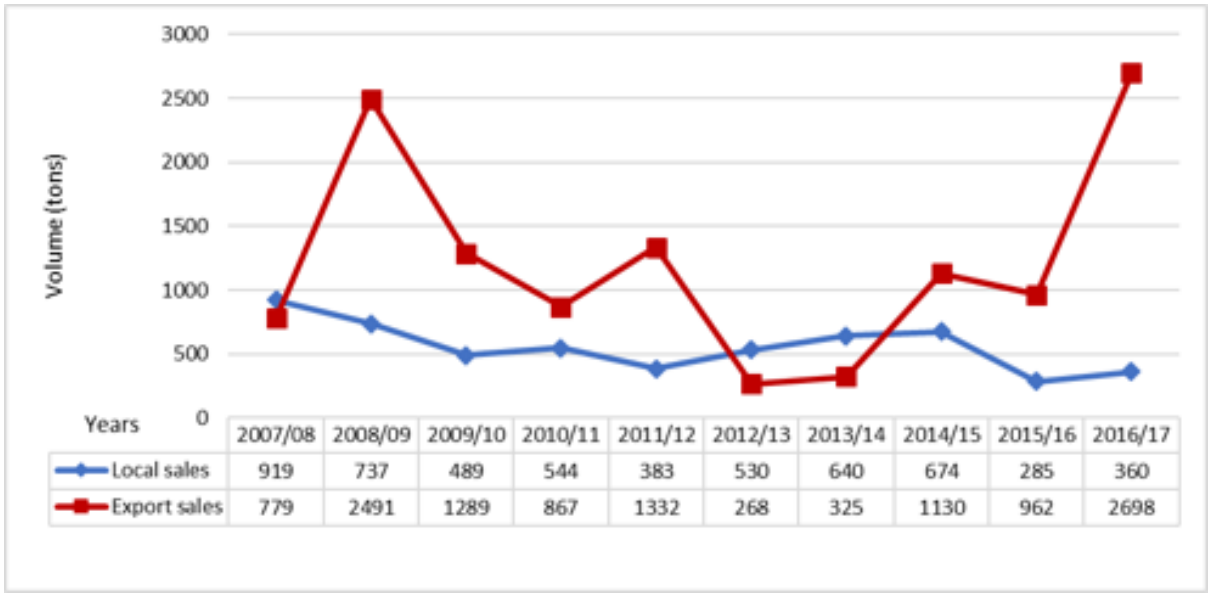


Figure 21: Illustration of the Sorghum Value Chain in South Africa

4.1 Key Components of the Value Chain

4.1.1 Inputs

Grain sorghum seeds make up less than 0.5% of the total market share of agronomic seeds in South Africa. South Africa is currently producing grain sorghum seed for local sales as well as the export market, with the majority of sorghum seed production being exported since 2014/15.



Years	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Local sales	919	737	489	544	383	530	640	674	285	360
Export sales	779	2491	1289	867	1332	268	325	1130	962	2698

Figure 22: Grain Sorghum Local Sales vs. Export Sales 2007/08 – 2016/17

Source: Department of Agriculture, Forestry and Fisheries (DAFF)

However, South Africa imported grain sorghum seed for the first time in a ten-year period in 2012, and imports have been recorded ever since, with imports of approximately 60 000 tons recorded in 2017.

4.1.2 Key Players

The seed industry in South Africa is comparatively more advanced than in other African countries and primarily serves the needs of commercial farmers. The South African seed industry has evolved over more than a century into a mature sector with some 107 seed companies that are members of the South African National Seed Organization (SANSOR).

SANSOR controls the seed certification scheme in South Africa. The production and distribution of quality sorghum seed requires diligent efforts both during field production and post-harvest handling. Field inspections are commonly conducted at different crop development stages to ensure quality. The certified seed crop must be inspected at least three times by inspectors affiliated with SANSOR, i.e. during the vegetative growth stage, at flowering and at maturity.

Other key players in the industry are listed in the table below:

Role	Key Players
Research and Breeding	Agricultural Research Council (ARC), Multinational Corporations (MNC)s, Local Seed Companies and Universities
Variety Registration and Regulation	Department of Agriculture, Land Reform and Rural Development (DALRRD)
Administration of National and International Seed Certification Schemes	SANSOR
Breeders and Foundation Seed Production	ARC, MNCs, Universities and Local Seed Companies
Seed Production	SME Seed Companies, MNCs and ARC
Education, Training, Extension	Seed Companies, NGOs, ARC and the Government
Distribution and Sales	Private Sector Merchants, Agricultural Supply Outlets, Cooperatives and Local Government

Table 7: Key Players in the Agronomic Seed Industry in South Africa

The major companies that produce and sell grain sorghum seed in South Africa include:

- PANNAR (part of the Pioneer DuPont Group, now Corteva);
- AGRICOL; and K^2 (companies within the Zaad Seeds group)
- AGT Foods.

4.1.3 Primary agriculture production

Sorghum production in South Africa has been briefly described in previous sections of the report, and is comprehensively addressed in the first report of the study (the Situational Analysis).

Figure 23: The Declining Trend in Sorghum Production in South Africa

With regard to the sorghum value chain, the ongoing general decline in the area planted and similar but less steep decline in production is very concerning. Furthermore, South African Grains Information Service (SAGIS) data indicate that there was a 14.7% decline in the 'intention to plant' sorghum in the next production season 2019-20, in contrast to all the other crops, except dry beans, where there was increased intention to plant.

CROP	Intentions 2020 (ha)	Area planted 2019 (ha)	Ninth estimate 2019 (tons)	Change %
	as mid-October 2019		as on 24 Oct 2019	
	(A)	(B)	(C)	(A) ÷ (B)
Commercial				
White maize	**1 431 900**	1 298 400	5 538 240	+10,28
Yellow maize	**1 087 400**	1 002 100	5 647 810	+8,51
Maize	**2 519 300**	2 300 500	11 186 050	+9,51
Sunflower	**538 500**	515 350	680 940	+4,49
Soybeans	**745 500**	730 500	1 170 345	+2,05
Groundnuts	**48 000**	20 050	19 455	+139,40
Sorghum	**43 100**	**50 500**	**134 525**	**-14,65**
Dry beans	**52 500**	59 300	66 355	-11,47
TOTAL	**3 946 900**	3 676 200	13 257 670	+7,36

Table 8: Sorghum: Crop Intentions to Plant

4.1.4 Trade

As explained previously, sorghum in South Africa is sold both locally and exported. However, in the past few years South Africa has become a net importer of sorghum. Sorghum imports were expected to increase in the 2019/20 MY on lower domestic production.

In South Africa, sorghum is sold mainly through formal channels, that is processed sorghum products such as meal and cereals being sold in retail stores with very little informal trade. This contrasts sharply with the situation in most African countries, where much of the grain produced is traded informally. Nevertheless, in South Africa, approximately 40% of all informal workers are involved in trading, and of those who are involved in trading, approximately 67% are involved in food trade selling packaged food products and meals cooked on the street side.

In the South African informal to semi-formal market, smallholder farmers are generally prevalent. Small-scale farmers can be divided into those that produce grain for household and marketing purposes, and those that produce grain only for household purposes. The latter group will seldom get involved in the marketing of grain since they would rather feed it to their cattle or sell it to neighbours. The former group are those farmers who are able to produce sorghum in excess of their household needs, i.e. human and livestock consumption. The surplus grain is used to improve their cash flow situation by selling grain to willing buyers that extend the borders of the communal villages. While the informal agricultural channel provides a livelihood for numerous families and contributes to food security, sorghum does not have a significant role in this channel.

Informal trade of sorghum is mostly related to the sale of traditional African beer, brewed in the homes of families in rural areas and townships. Other trade channels for TAB include taverns and local gathering places where the beer is purchased from depots of United National Breweries (the only large-scale TAB brewing company) and then transported to the stores or taverns in either bakkies or their own personal vehicles.

Storage of Sorghum Grain

Commercial storage providers of sorghum operate in the following framework:

- Storage and handling services like cleaning and grading are managed to add value to the products of the owners of the sorghum.
- Effective grain silo services are rendered at market-related costs and on sound business principles and are available to similar users of grain silo facilities on an equal basis.
- Sorghum is classified and graded according to the grading regulations of the Directorate: Food Safety and Quality Assurance of DALRRD
- Any quantity of sorghum that complies with the requirements of the National Department of Health will be handled and stored subject to practical arrangements.
- The quality and quantity of sorghum is guaranteed during storage and agreed arrangements are adhered to.
- The market mechanisms that enhance the trading of sorghum are supported and used, and their requirements adhered to.
- Silo certificates are made available to the owners of sorghum for trading purposes.
- The sorghum specified on a silo certificate will, on presentation of the silo certificate, be supplied to the holder after all relevant costs have been paid.
- Grain silo service tariffs are available at the beginning of a marketing period at head offices and grain silos.

Sorghum is mainly produced on a contract basis, with the majority of large-scale sorghum farmers producing for companies such as Tiger Brands, RCL Foods and Pride Milling.

4.1.5 Processing

Sorghum production in southern Africa is aimed primarily at the market for human consumption (estimated at more than 80% of consumption). Sorghum is used mainly for foods and beverages, such as sorghum meal and malt. Malt is used for manufacturing traditional African beer (sorghum beer). Between 52% and 62% of total domestic demand is for malting/brewing. Sorghum meal, also known as “mabele”, competes directly with maize meal and is consumed as a soft breakfast porridge or as soured porridge “Ting. Sorghum grain is normally more lightly refined than maize, with only 5-10% of the kernel being removed as bran. As sorghum meal competes directly with maize meal, the VAT charged on sorghum contributes to it being more expensive to purchase.

Surplus sorghum is channeled to the stockfeed sector. Price is the main determinant of whether maize or sorghum is used for animal feed. For ruminants, the combination of sorghum with other grain sources and the use of steam flaked sorghum gives a product with a similar nutritional value to maize. Feed manufacturers are, however, sometimes reluctant to use sorghum because locality and season can affect the nutritional value of the sorghum (larger variation in nutrient composition than maize), and because of the possibility of tannins in the sorghum. The combination of problems of grain availability, bin space, cleaning and processing, along with uncertainty regarding consumer demand, place sorghum at a disadvantage relative to maize.

Key Players

Listed in descending order of probable production volumes, key players in the sorghum processing industry are*:

Maltsters

- Tiger Brands
- Isiko Malt
- Dannhauser Malt

Brewers

- United National Breweries (successor company to IDC and SAB sorghum beer brewing companies) – Traditional African beer
- Informal breweries of traditional African beer – micro-enterprises
- Ukhamba Beerworx – Micro-enterprise craft brewer of Western type beers

Food processors

- Tiger Brands – sorghum meal, instant sorghum porridge powder, sorghum beer (traditional African Beer) powder
- RCL Foods – sorghum meal, sorghum flavoured mageu (soured no-alcoholic predominantly maize beverage)
- Pride Milling(AFGRI company) – sorghum meal

- Brenner foods – sorghum meal and malt
- Take 5 - sorghum containing mageu (soured no-alcoholic maize beverage)
- Denmar Estates – sorghum mageu (soured non-alcoholic beverage)
- Small and micro-enterprises – sorghum meal, popped sorghum

*The complete list of sorghum Co-workers (Processors, Traders with and without premises, Commercial silo and harbour silos owners and End consumers) registered with SAGIS is given in the first report of the study (the Situational Analysis). It should be noted the SAGIS list is incomplete as in the above list there are companies that process sorghum that are not registered.

4.1.6 Wholesale and Retail

Sorghum products are sold through both wholesale and retail channels, with the retail channel comprising both a formal and informal sector. However, sales in the informal channel are, the exception of traditional African beer, minimal, with the majority of sales taking place through formal channels.

The retail distribution channel comprises of smaller, more informal shops (Spaza shops, cafes), cash and carry stores as well as large retail stores with numerous franchises countrywide (such as Checkers, Pick n Pay and Spar). While sorghum-based products such as meal and porridges are sold in most retail stores, they are not a major line item in these stores. At present, consumers tend to purchase more maize products, and as such retailers have not put in much effort to promote sorghum products.

4.1.7 Consumption

As explained, in South Africa sorghum is mainly used for human consumption (about 92% of sorghum usage), which includes food (classified under “Meal” in the SAGIS data) and traditional African beer (classified under “Malt in the SAGIS data) consumption. Malt is used in the brewing of traditional African beer, commonly referred to as sorghum beer but in fact sorghum makes up only about 1/3 of the cereal, the majority being maize. In the past 5 years around 37% of total domestic demand was used for malting/brewing. However, sorghum used for malting decreased by 30% the past 10 years to about 60,000 tons.

Sorghum meal, also known as “Mabele”, competes directly with maize meal and is primarily used domestically to make a soft breakfast porridge. It represents a basic staple food, characterized by inelastic demand preferences. In the past 5 years sorghum meal represented around 55% of total domestic demand of sorghum.

It should be noted that the categories meal and malt include other processed products, notably instant porridge powder and “Maltebella” malted sorghum breakfast cereal, respectively.

The animal feed market comprises sorghum processed for pet food, poultry and livestock. The utilization of sorghum in the feed market is inconsistent as price is the main determining factor as to whether maize or sorghum is used for animal feed. Only about 5% or 8 000 tons of sorghum consumption in South Africa end up as animal feed.

Marketing Year	Sorghum Meal	Malt	Total Human Consumption	Animal Feed	Others	Total
			1,000 tons			
2009/10	100.3	82.0	182.3	8.6	13.4	204.3
2010/11	100.9	81.3	182.2	7.1	11.1	200.4
2011/12	88.4	69.4	157.8	5.6	8.5	171.9
2012/13	95.7	69.0	164.7	5.1	8.0	177.8
2013/14	90.3	62.2	152.6	6.8	7.0	166.4
2014/15	88.0	61.4	149.4	10.4	5.2	165.0
2015/16	97.9	62.7	160.6	9.7	1.9	172.2
2016/17	92.7	60.1	152.8	8.6	3.9	165.3
2017/18	95.0	60.0	155.0	8.0	2.0	165.0
2018/19	96.0	59.0	155.0	8.0	2.0	165.0

Table 9: Sorghum Consumption South Africa (SAGIS, Grain SA)

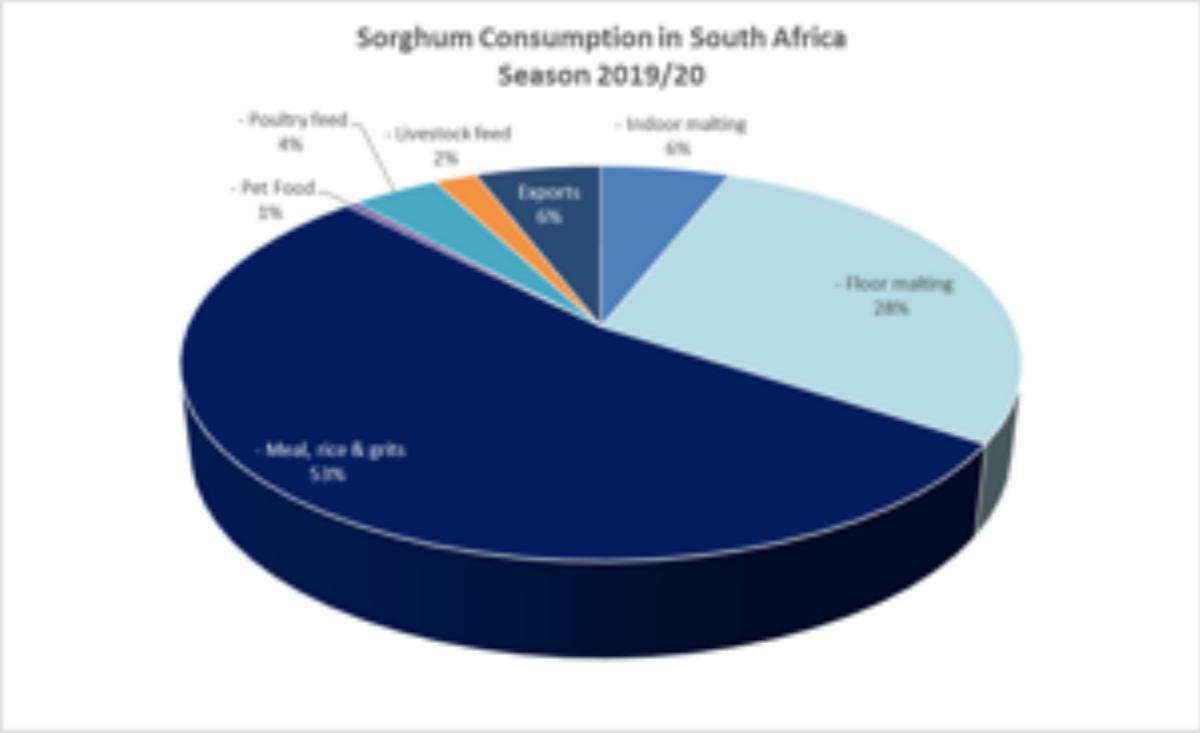


Figure 24: Sorghum Consumption South Africa (SAGIS, Grain SA)

4.2 Competitive position of Sorghum vs. Maize and Other Grains

4.2.1 Maize versus sorghum yields and area planted

Maize is the major grain crop grown and consumed in South Africa and a comparison of the competitive position of sorghum vs. maize reflects the challenges that sorghum faces in the local market.

- Consumer preferences is leaning towards maize products due to their availability in abundance, well-known products and brands as well as competitive pricing.
- Sorghum is the only grain that can be used to produce Traditional African Beers. The market demand is, however, declining.

- Maize is more easily cultivated. For example the husk leaves protect cobs from external threats, such as the quelea birds.
- Research and development of GM herbicide- and insect pest-resistant sorghum maize cultivars have increased yield relative to sorghum.
- Drought-tolerant and higher water use efficiency maize varieties are being developed
    - Bill and Melinda Gates sponsored US$50million for development of drought-tolerant, insect-resistant and higher yielding maize hybrids in Africa https://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2012/10/OPP1019943 African Agriculture technology Foundation.
- Sorghum prices are higher than maize – resulting in end-products being more expensive.
- Farmers prefer maize since it is more profitable. Maize under irrigation is particularly profitable. Sorghum remains predominantly a dry-land crop.
- Maize yields are better and income per hectare as well as profits per hectare for maize are higher than with sorghum.

Although the area planted to maize has decreased, the yield has similarly increased, offsetting the area decline as reflected in the following graph.

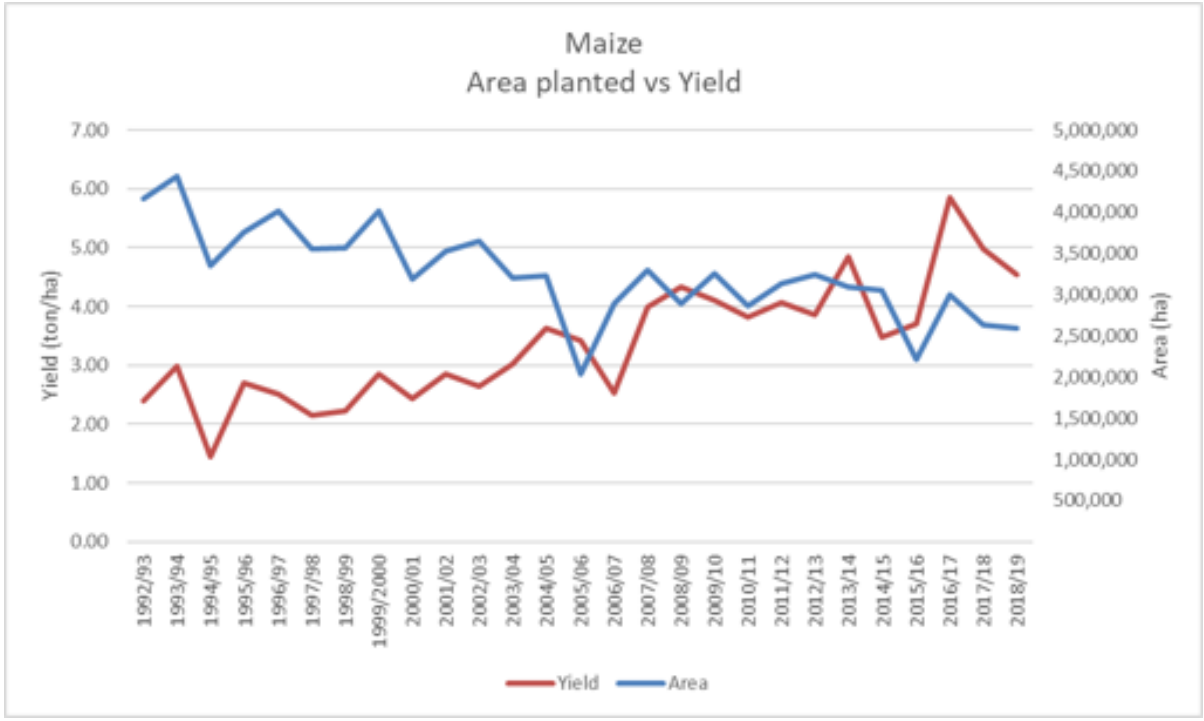


Figure 25: Historic maize production: area planted vs. yield

Sorghum, on the other hand, experienced a decline in area planted while yields have remained essentially the same, albeit with small improvements.

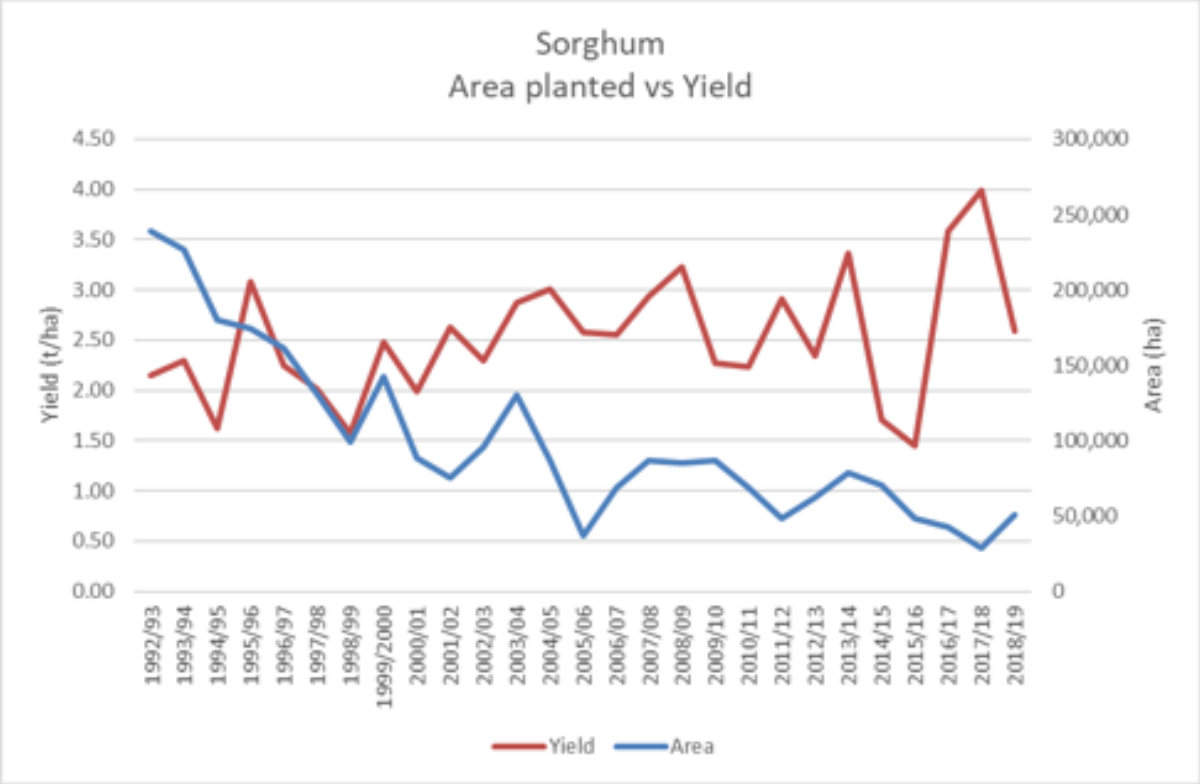


Figure 26: Historic sorghum production – area planted vs. yield

Wheat production in South Africa follows a similar trend to maize of decreasing area dedicated to wheat production, but increased yields per ha.

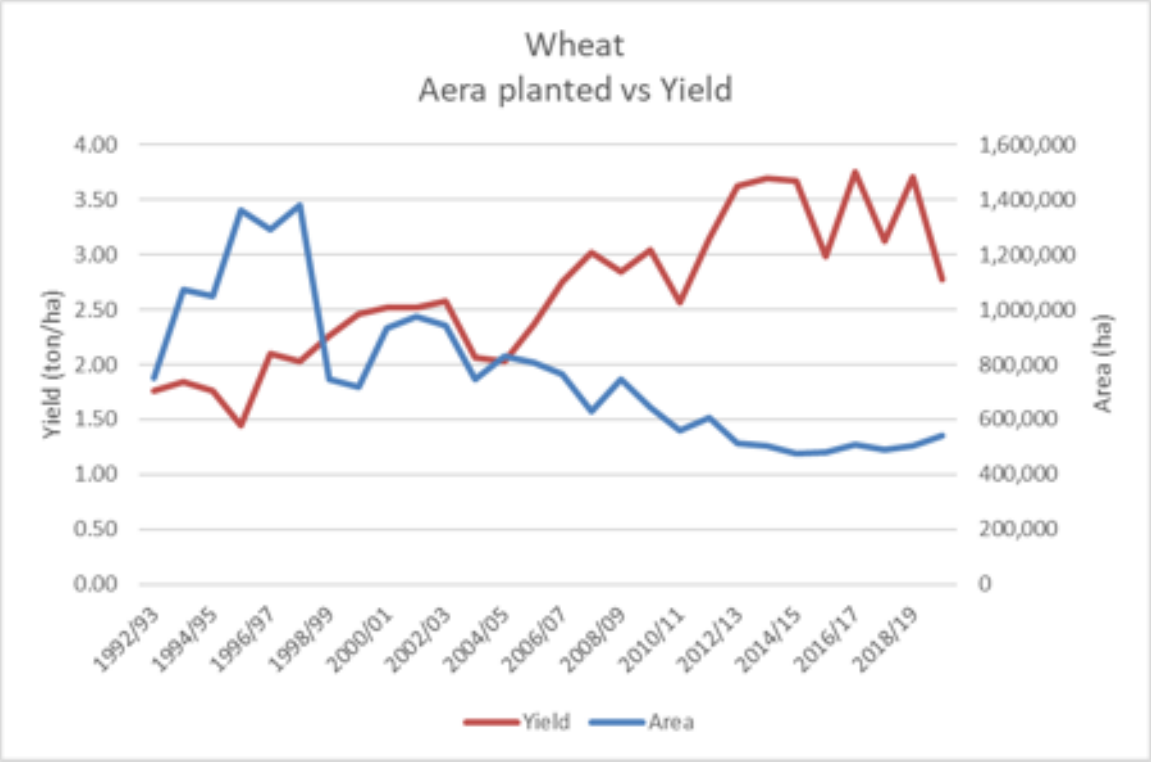


Figure 27: Historic wheat production – area vs. yield

4.2.2 Competitive position of sorghum viz-a-viz other grains:

On the face of it, sorghum could be well positioned versus other grains.

- Comparison of price and input costs reveal that sorghum could be attractive. However, at low yields, sorghum is not as profitable as for example maize and soybeans.
- The higher price of sorghum vs. maize has also contributed to increase in imports, higher end-product prices and a decrease in consumer demand.
- Consumer products are a more relevant consideration for producers' choice of raw materials, e.g. there are some products such as bread, where sorghum will not find a ready market and replace wheat.

South African consumers are amongst the most price conscious in the world and the current economic climate and job-losses contribute towards increased price sensitivity for the consumer. The health benefits of sorghum have not been promoted and therefore do not drive consumer demand. Historic cultural links to sorghum are also not carried over to the youth and increasing urbanisation is contributing to South Africans adopting Western food culture habits and tastes.

4.2.3 South African cereals industry dependency on imports:

Of the major cereals consumed in South Africa, maize is the only one where the country is self-sufficient with regard to production.

- Maize
    - Multiple uses for human consumption and animal feeds.
    - South Africa is a net exporter of maize. Local production in South Africa yields on average about 12 million tons per annum.
    - Human consumption accounts for circa 48% of maize (white & yellow) consumed in South Africa and 89% of white maize.
    - Circa 640,000 tons of yellow maize is imported – mostly from Argentina – accounting for under 9% of local demand. 84% of yellow maize is used for animal feed.
- Wheat
    - Wheat is produced in South Africa for bread and other bakery products and some small quantities for pasta.
    - South Africa consumes circa 3,2 million tons of wheat per annum. 99,9% is destined for human consumption
    - South Africa imports 43% of its wheat demand, with 55% coming from Germany and USA.
    - South Africa also imports circa 26,000 tons of wheat flour per annum.
- Oats (cereals)
    - Used mostly for feeds, human consumption and snacks (cereal bars).

  - South Africa's requirement is estimated at 58,000 tons per annum and local production varies between 30,000 tons and 40,000 tons per annum.
  - Imports to cover shortfall varies between 20,000 and 28,000 tons per annum.
- Barley
  - Barley is mostly used to produce malt for beer brewing, and less than 5% is used for animal feeds.
  - South Africa is self-sufficient in barley supply estimated at circa 330,000 tons per annum. Exports of Barley is minimal.
- Sorghum
  - Sorghum is used for food and beverages for human consumption and feeds for animal consumption.
  - The demand for sorghum in South Africa is estimated at 160,000 ton per annum. The two types of sorghum used in the industry are non-tannin (sweet) (64%) and tannin (bitter) (36%).
  - South Africa is not self-sufficient in the supply of sorghum. Circa 28% of the required demand is imported – mostly sweet sorghum - originating from the USA - accounts for 98% of the imported volume of just over 45,000 tons per annum.
  - Animal feeds take up circa 7% of the sorghum supply.

The following Table and Figure illustrate the competitive position of sorghum vs. other grains in South Africa.

Price comparison		SAGIS	SAFEX	Producer prices	Production costs	Profit
	ton/ha	R/ton	R/ton	R/ton	R/ton	R/ton
White Maize	6	R1,793	R2,836	R2,806	R2,513	R293
Yellow Maize	5	R1,908	R2,830	R2,644	R2,550	R94
Wheat (irr)	8	R3,712	R4,434	R4,112	R3,792	R320
Sorghum	3	R2,998	R3,185	R3,072	R3,033	R39
Barley (irr)	7.5	R3,427	R4,230	R3,777	R3,617	R160

Table 10: Price and cost comparison of major grains in South Africa.

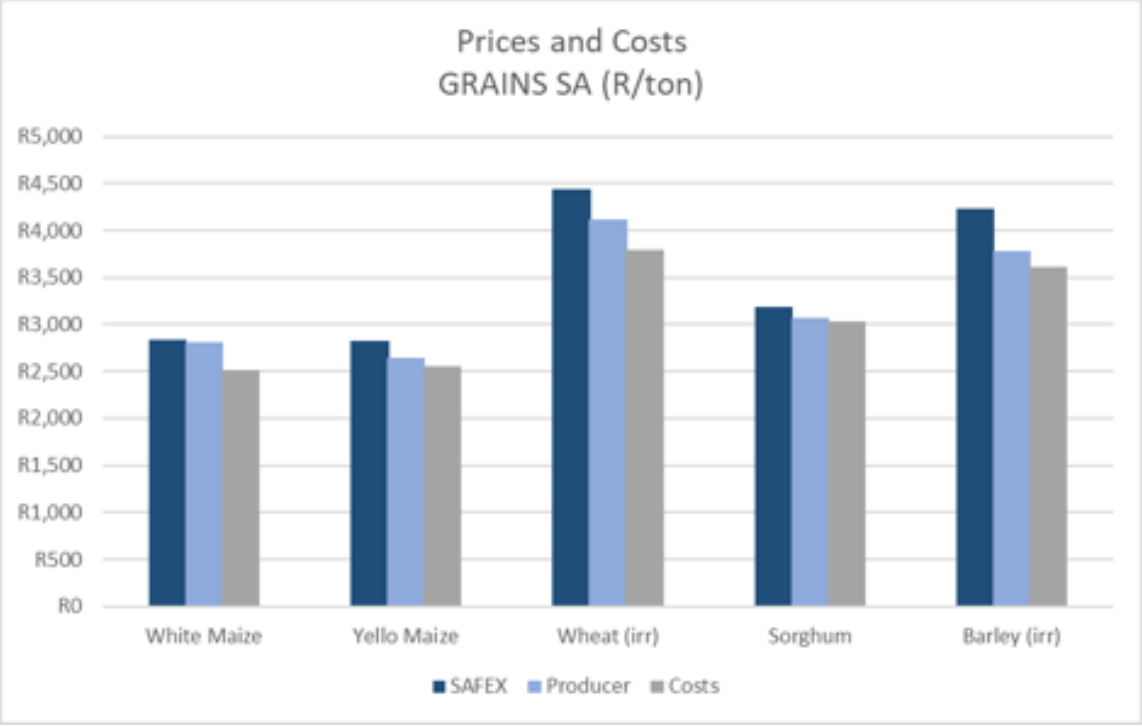


Figure 28: Price and cost comparison of major grains in South Africa

The higher cost of sorghum grain does contribute towards the end-user prices of sorghum products being higher than their maize equivalent: E.g. BOKOMO 1kg: Quick Cook Maltabella = R45.99 vs. Quick Cook Kreemymeal= R39.99. the price difference of 15% is attribute to higher raw material costs and higher processing costs.

4.3 Opportunities for Upgrading the Value Chain

The objective of upgrading the South African sorghum value chain is to support the industry in order for it to be able to successfully target new market opportunities for the industry as a whole. Whereas in the United States and Australia sorghum is used extensively as animal feed, and in the rest of Africa it is consumed by the population as a meal or in the small-scale and industrial production of sorghum-based beers, the use of sorghum in South Africa is essentially limited to the manufacture of traditional African beer and in the form of sorghum meal and porridge flour for sorghum porridge making. In South Africa sorghum also competes directly with maize in the animal feed and human consumption markets, but due to its higher cost of production, it is hardly used in animal feed and only captures about 10% of the meal and flour market. However, it is still the preferred grain for the manufacture of traditional African beer, albeit constituting only 20-33% of the cereal in the beer products.

The high cost of producing sorghum grains is attributed to a combination of high input costs and relatively poor yields, results in sorghum being higher priced than its maize equivalent.

In the event that the cost of sorghum production can be reduced by either optimizing input costs and/or increasing yields, sorghum can command a greater share of the local market,

enhance new product opportunities, and target export markets in the sub-Saharan Africa region. Should the competitiveness of sorghum be improved to match the price of maize, the following opportunities can be pursued:

1. Increased human consumption in the form of meal and porridge powder. Sorghum is widely acknowledged to have higher nutritional quality than its maize counterpart, and in its processing, the loss of material for sorghum at 12% of weight is significantly less than that for maize at 34% of weight. Food processing companies absorb some of the price difference between maize and sorghum by taking a smaller margin in order to keep the retail price of both these products somewhat competitively matched. More competitively priced sorghum will attract consumers and a competitive margin for the food processors will encourage them to promote and market sorghum products more aggressively. The VAT on sorghum meal also renders the product less competitive than maize and therefore impacts on demand and the interests of food processing companies to manufacture these products.
2. The consumption thereof in the manufacture of a pasteurised sorghum beer can contribute to a four or even seven-fold increase in the consumption of sorghum. In order for this to materialize, the price of sorghum should not increase any further than what it is today (ca R3,500 per ton) while a lower price will help support the increase in demand. A key consideration for the success of sorghum-based pasteurised beer is that the customs and excise duty remains the same as for the traditional, fermented beer. This also holds true for the consumption of sorghum beer powder.
3. Shortfalls in the demand for sorghum in sub-Saharan Africa are largely met by importing sorghum from the United States and Argentina. In the event that sorghum can be produced at competitive price in South Africa, these markets should be accessible to local sorghum growers. It is well known that South African produced sorghum is of a better quality than the sorghum exported from the United States. However, this does not significantly impact on the price differential that processors will pay for the product. However, a key challenge to successful export of commodities from South Africa to the Eastern seaboard countries of Africa is the high cost of logistics, even though the shipping lines have a much shorter route to travel than those from the Americas. A cursory assessment of the price differential in logistic costs seems to indicate that the difference can be as much as R500 per tonne.

It is proposed that the competitiveness of the industry be addressed by a cultivar development programme, addressing the transport costs and introducing competitive technologies. The outcome of this should be to replace imports, grow the local market through better priced end-user products and exploit market opportunities to the sub-Saharan African region.

4.4 Value Addition in the Value Chain

The value addition in the sorghum manufacturing processes varies between the sorghum products depending on the amount of value adding and associated processing costs. The key drivers of the value addition that has been taken into consideration, include the raw material costs and the end-user prices. The end-user price is taken from off-the-shelf products in typical supermarkets in Gauteng.

Notably, the smaller and regional milling companies have access to independent distributors or even their own factory shops in the regions and these prices will be different. Raw material costs are input into the model using current prices.

The processing, packaging, transport and distribution costs as well as retail margin (at 23% including up to a 5% rebate) is used as the target end-user price.

Typical costs per value chain component is included herewith for:

- Sorghum malt
- Sorghum malted porridge
- Traditional Africa (sorghum) beer

4.4.1 Methodology

The research team obtained typical cost elements as %'s from a few of the respondents. Notably, the respondents are reluctant to divulge details of their cost structures as these are deemed confidential and a key part of their competitive positioning.

The price build-up, or waterfall, can however be used to illustrate the impact of the sorghum grain price on the profit margins of the processors and manufacturers of sorghum-based food products. These margins are key drivers for the processors and the impact of changes in the sorghum price can be modelled in this way.

4.4.2 Sorghum Malt

The price build-up is based on a typical malt processor's cost. The waterfall contribution of each value chain elements is reflected in the following chart.

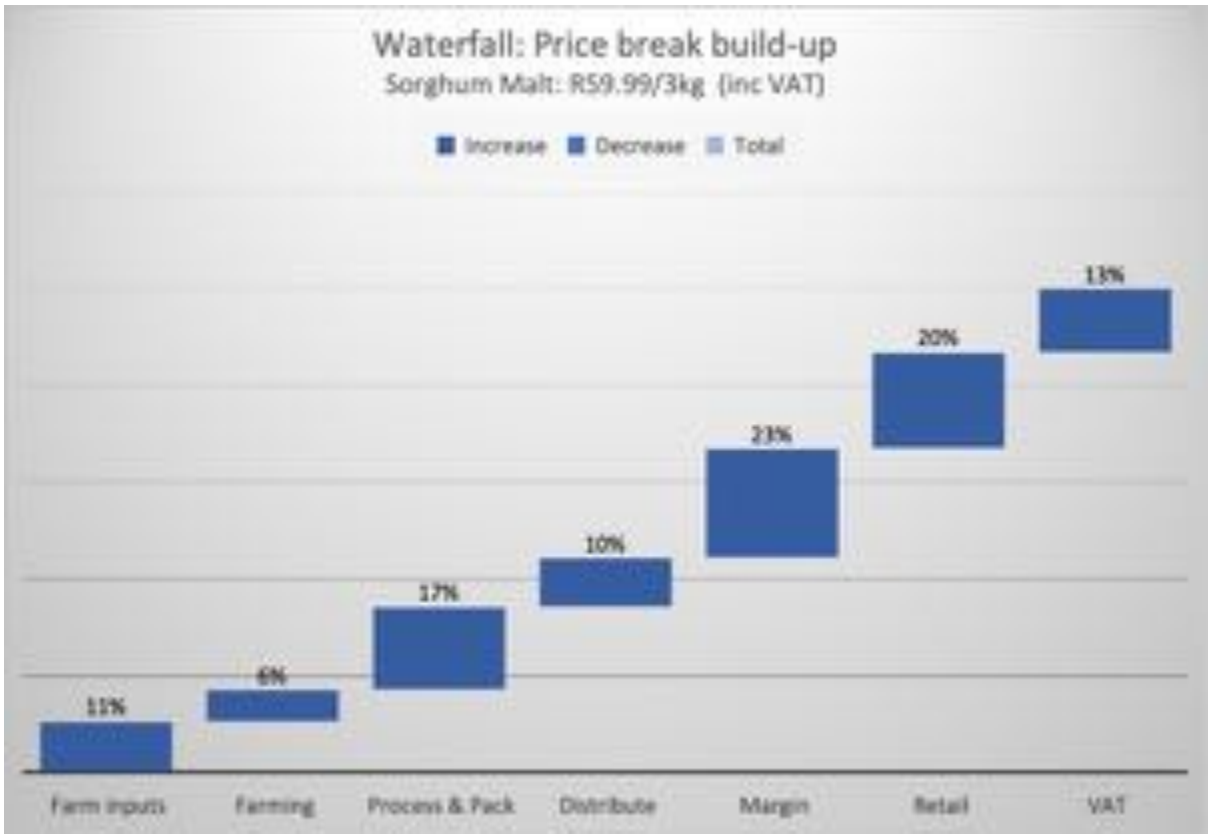


Figure 29: Price Build-Up of Sorghum Malt

The various components that make up the end-consumer price for the sorghum malt is reflected in the following illustration.

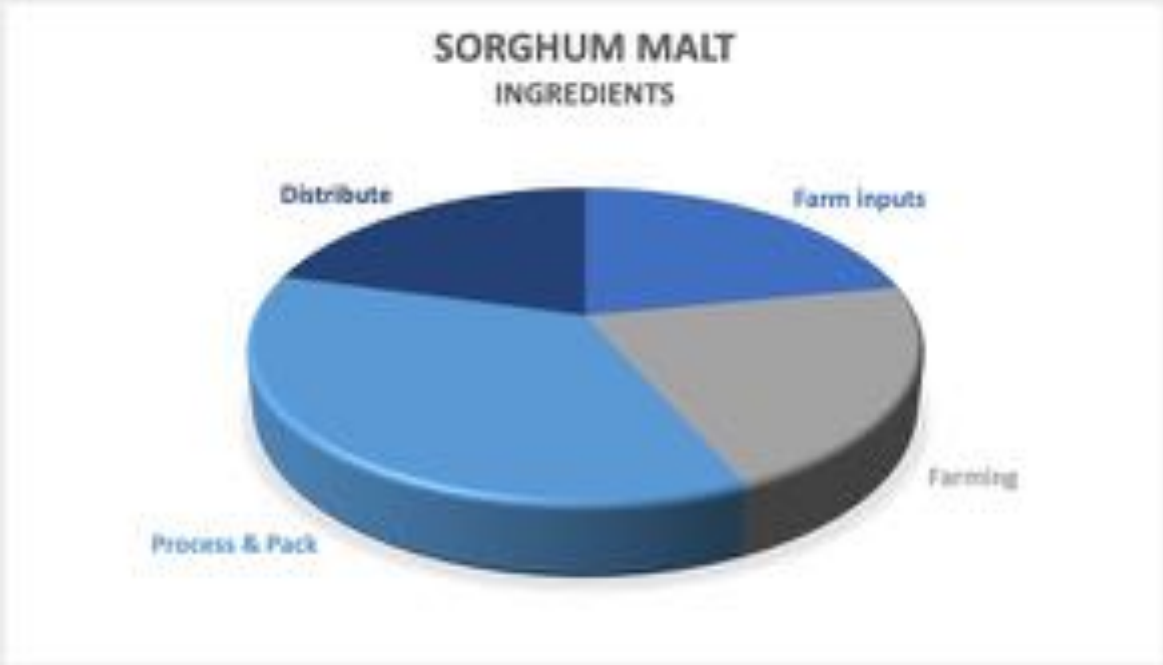


Figure 30: Cost Elements of Sorghum Malt Production

The following waterfall illustrates that R3,400 worth of sorghum is added value by the processors and retailers to contribute R19,924 per ton of end-consumer product.

Figure 31: Sorghum Value-Add in the Malt Value Chain

4.4.3 Traditional African (Sorghum) Beer

The price build-up is based on the traditional Africa beer, Chibuku, is as follows in terms of the waterfall contribution of each value chain element:

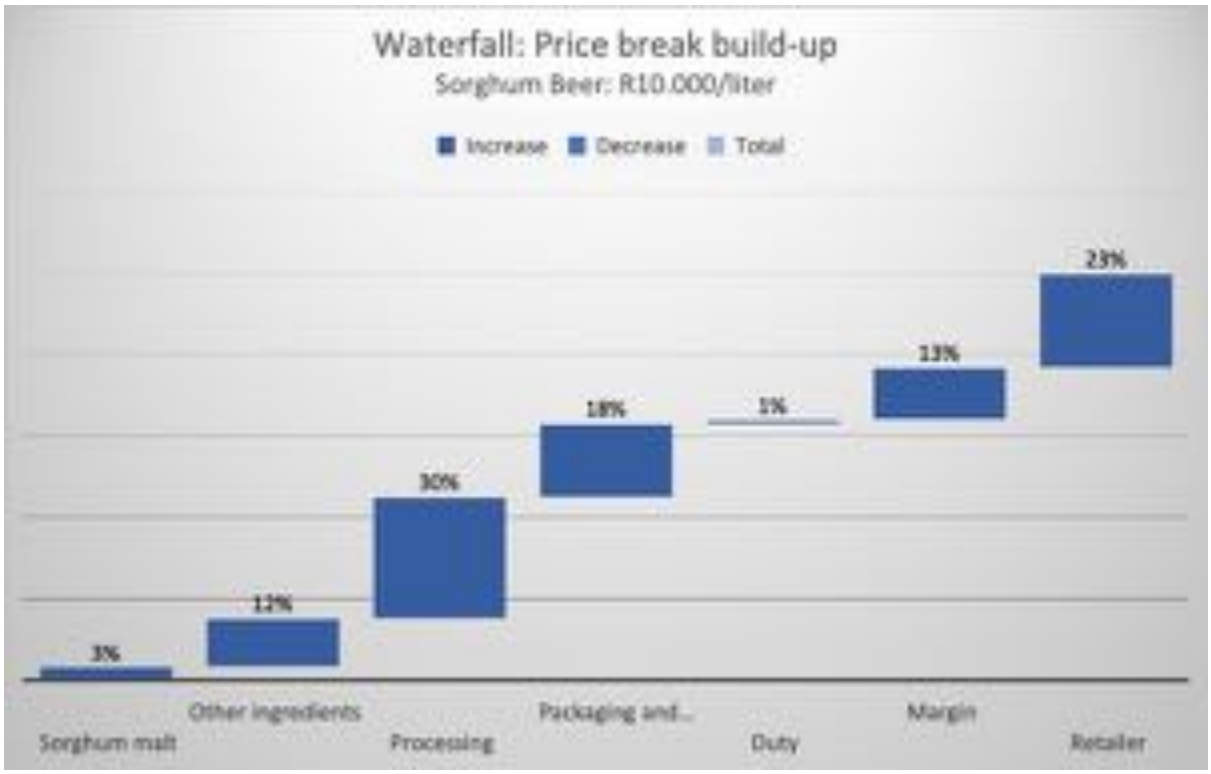


Figure 32: Price Build-Up of Sorghum Traditional African Beer

*Note: VAT has not been included in the above waterfall.

The various components that make up the end-consumer price for the traditional African sorghum beer is reflected in the following illustration.

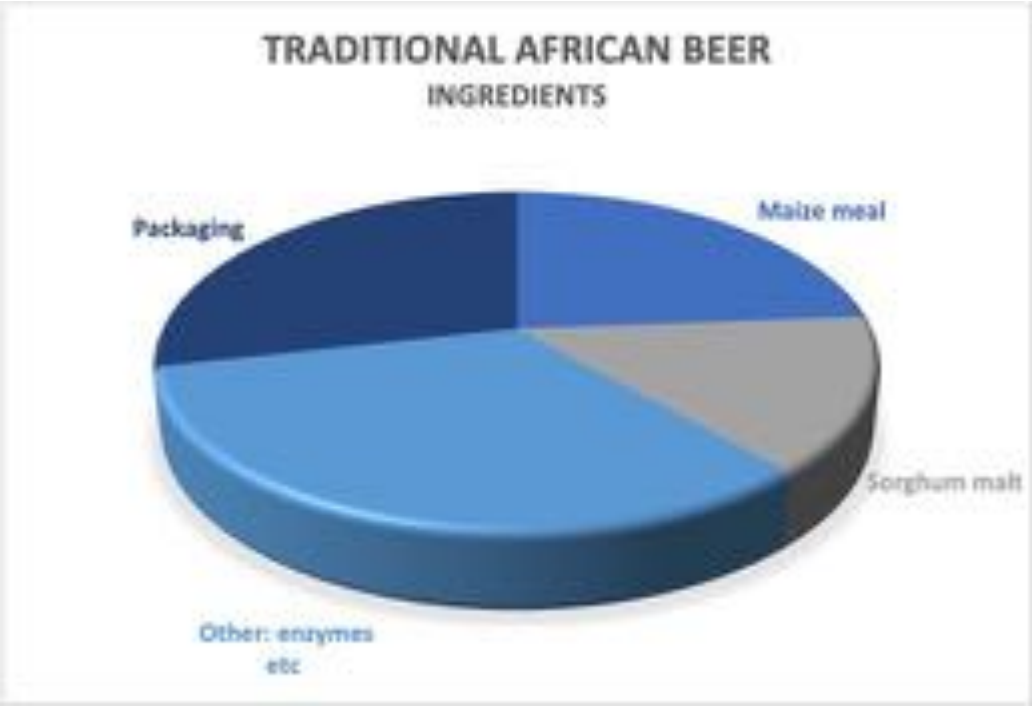


Figure 33: Cost Elements of Sorghum Traditional African Beer

The following waterfall illustrates that R318 worth of sorghum malt is added value by the processors and retailers to contribute R10,000/kl of end-consumer product.

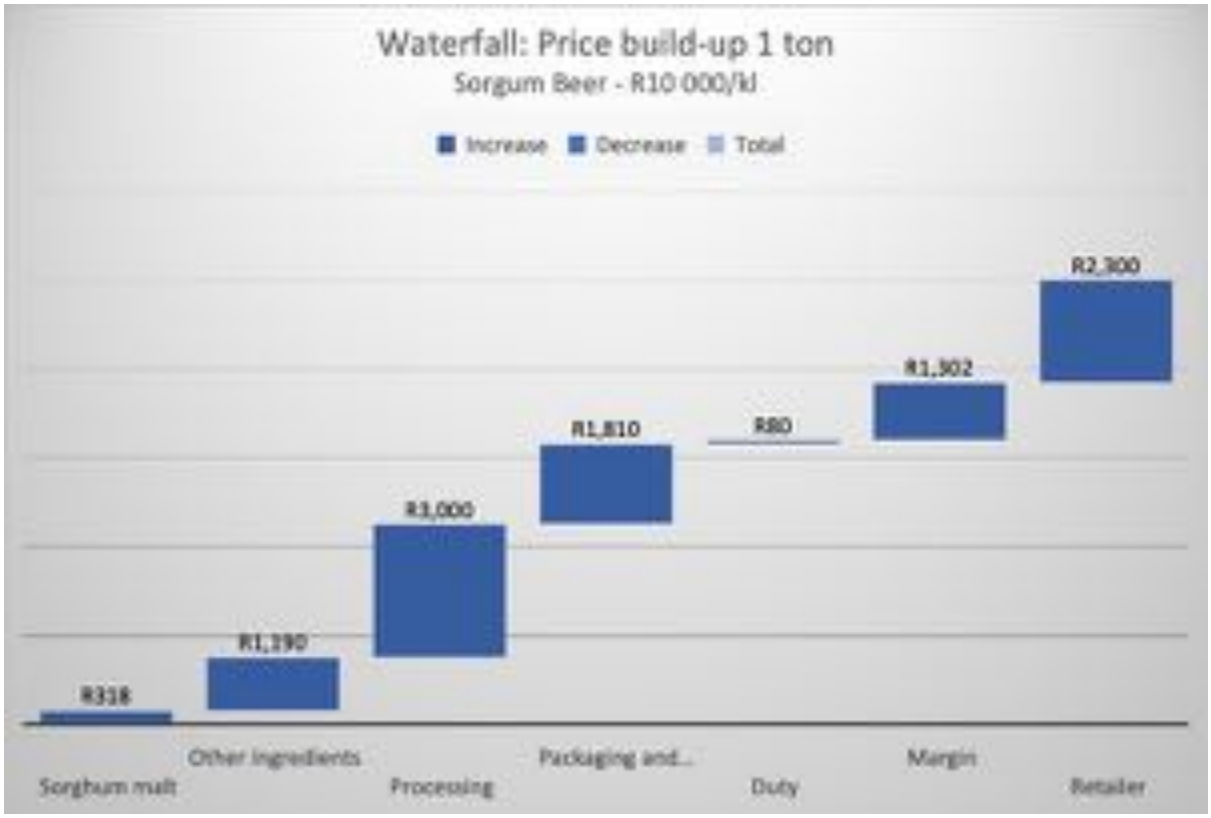


Figure 34: Sorghum Value-Add in the Traditional Sorghum Beer Value Chain

4.4.4 Sorghum Malted Porridge

The price build-up is based on a typical malted porridge processor's cost. The waterfall contribution of each value chain elements is reflected in the following chart.

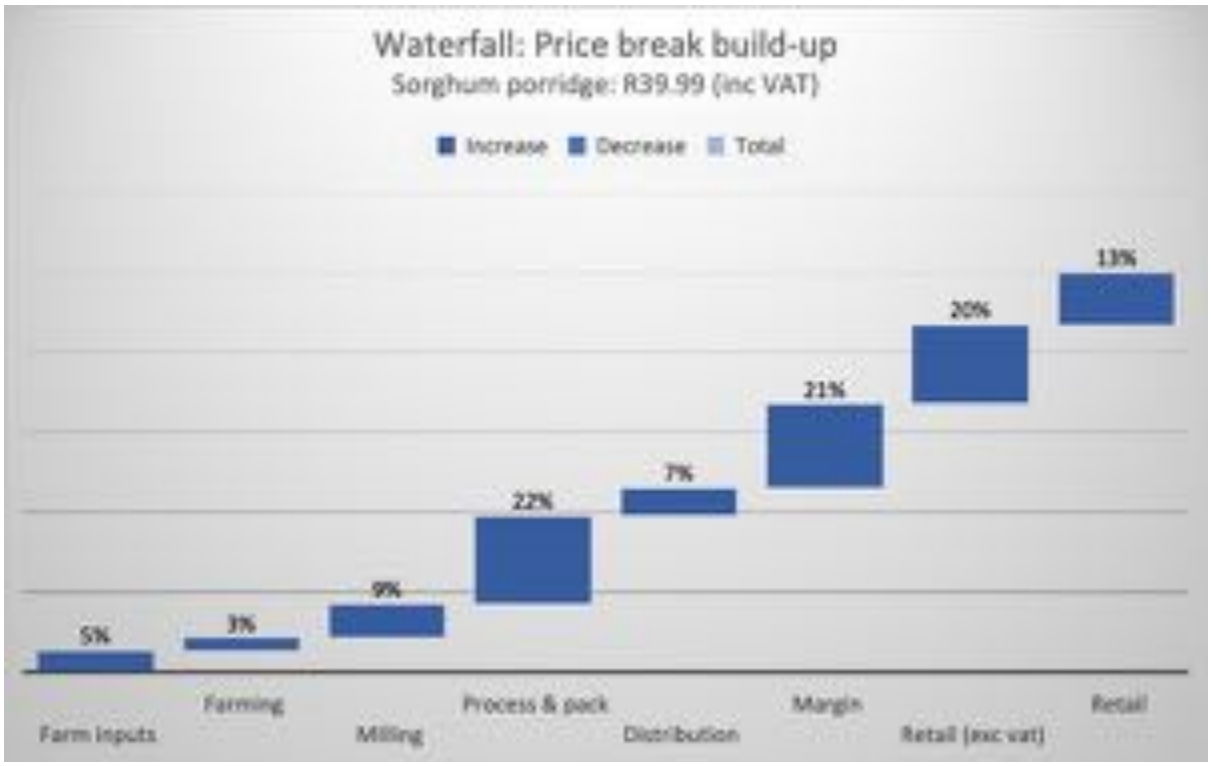


Figure 35: Price Build-Up of Sorghum Malted Porridge

The various components that make up the end-consumer price for the typical malted porridge is reflected in the following illustration.

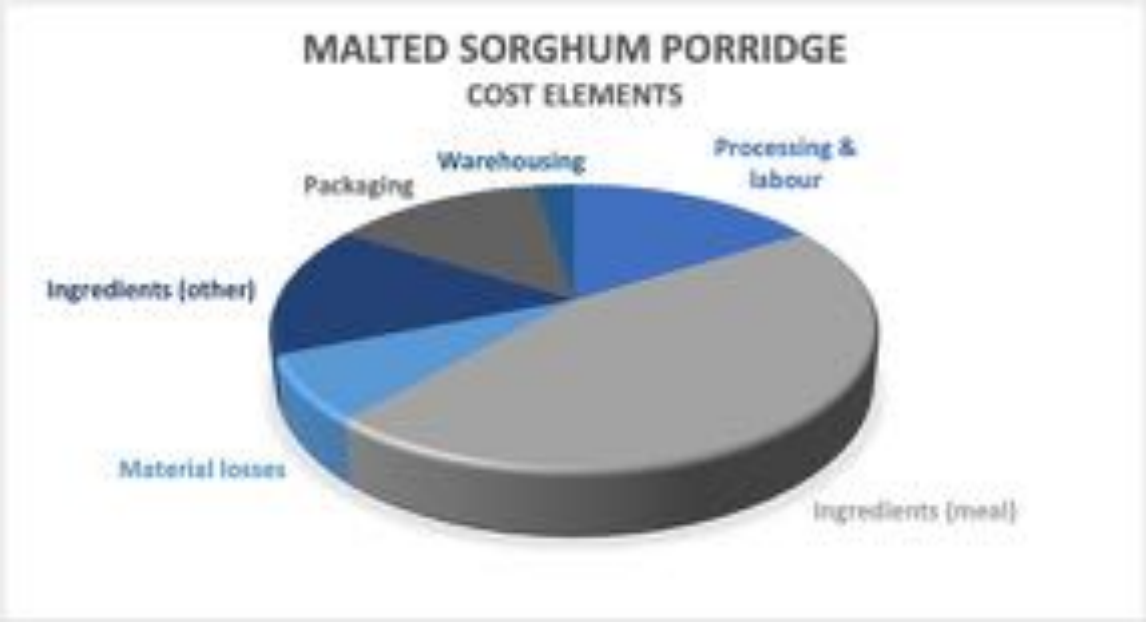


Figure 36: Cost Elements of Sorghum Malted Porridge Production

The following waterfall illustrates that R3,400 worth of sorghum is added value by the processors and retailers to contribute circa R40,000/ton of end-consumer product.

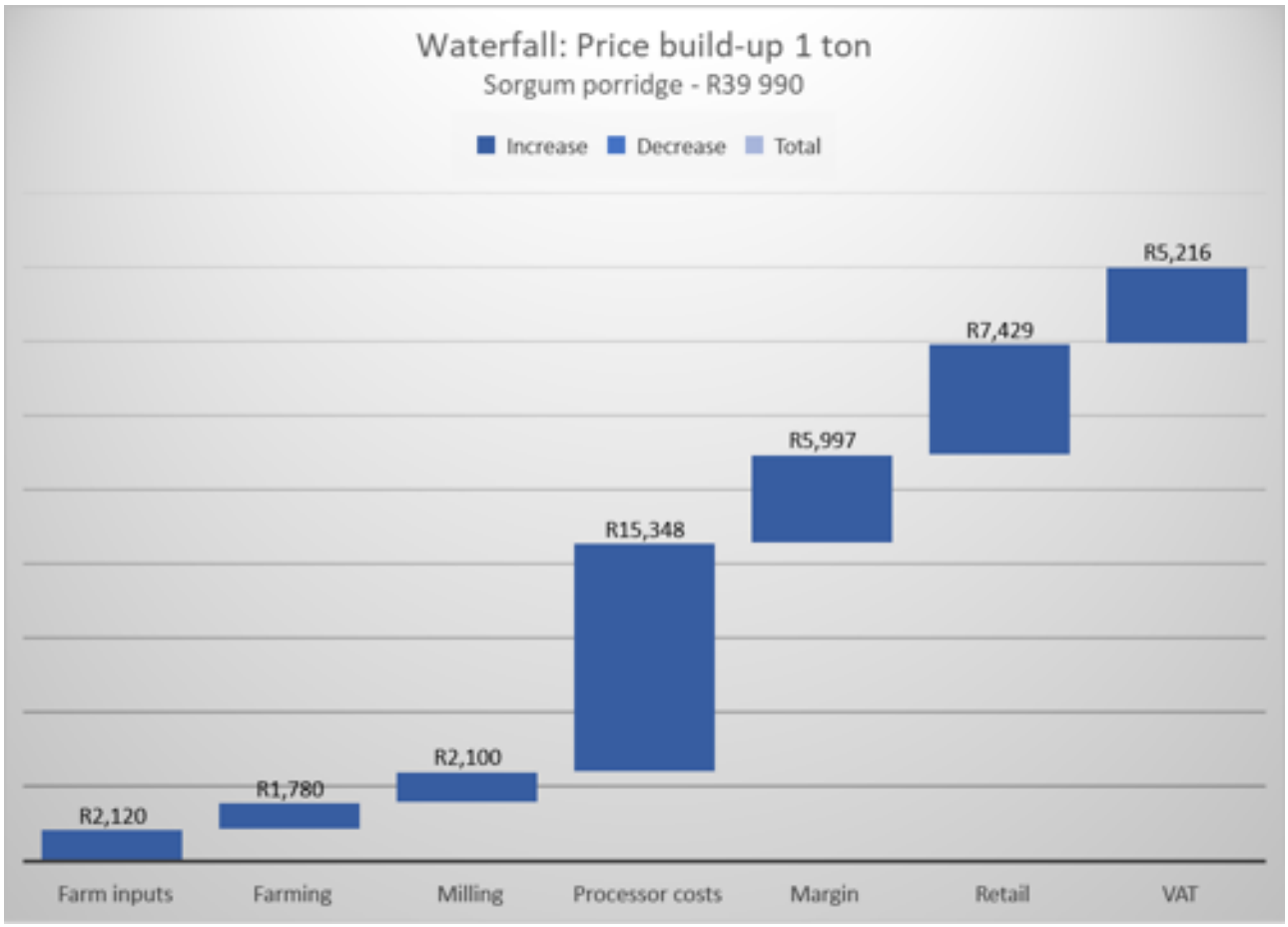


Figure 37: Sorghum Value-Add in the sorghum malted porridge Value Chain

4.4.5 Summary Observations

Manufacturing companies use margin velocity as a measure of assessing their product portfolio. It essentially entails measuring the product's contribution to operating profit margins. This is then used a means of measuring product performance and strategies to grow high-volume, high-profit margin products. Marketing and promotional effort would then be targeted at those products with the most net contribution to operating profit. In the case of sorghum, the consumer demand for sorghum-based products is keeping them on the shelves of the retailers and therefore remains an element of their product mix. However, due to its marginal contribution to operating profits, little effort is spent on marketing and promoting these sorghum-based products. The value chain analysis indicates that a price increase in sorghum raw materials will reduce gross profit contribution since the end-consumer prices, in a competitive environment, will not be able to sympathetically increase pro-rata to accommodate the increase in sorghum price and thereby maintain targeted profit margins. The retailers are also unlikely to relinquish margin on behalf of a single product category. The only place that these prices can reasonably be absorbed therefore, is in the profit margin of the manufacturers.

The value chain model is set-up to illustrate the impact of the increase in sorghum grains for the 3 selected products.

	Sorghum price	Retail price	Manufacturer's margin
Sorghum malt	R3,400	R19.92	13%
African beer		R10.00	18%
Malted sorghum porridge		R39.99	31%

Table 11: Operating Profit Margins for Selected Products

By changing the input price, it is possible to simulate the impact that it has on the manufacturers' operating profit margin.

Product	R2,800	R3,200	R3,600	R4,000	R4,400
Sorghum malt	16%	14%	12%	11%	10%
African beer	18%	18%	18%	18%	18%
Malted sorghum porridge	33%	32%	30%	29%	28%

Table 12: Operating Profit Margins for Selected Products – Different Input Prices

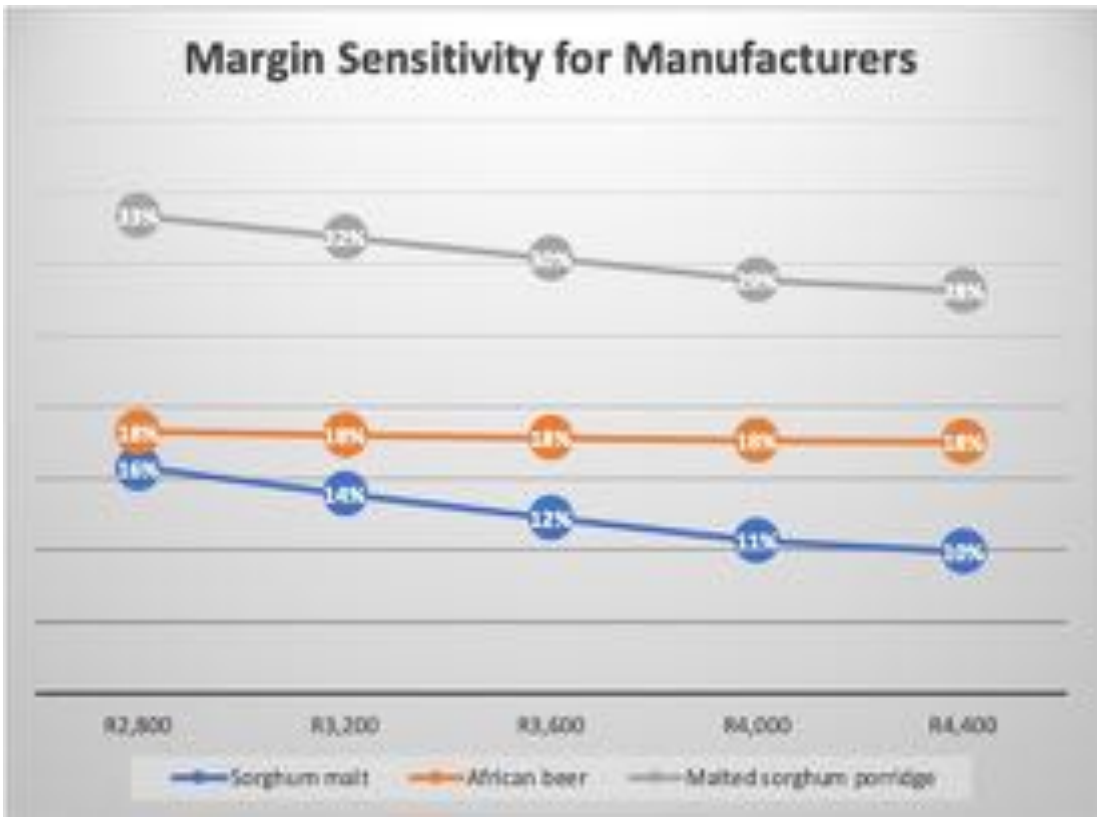


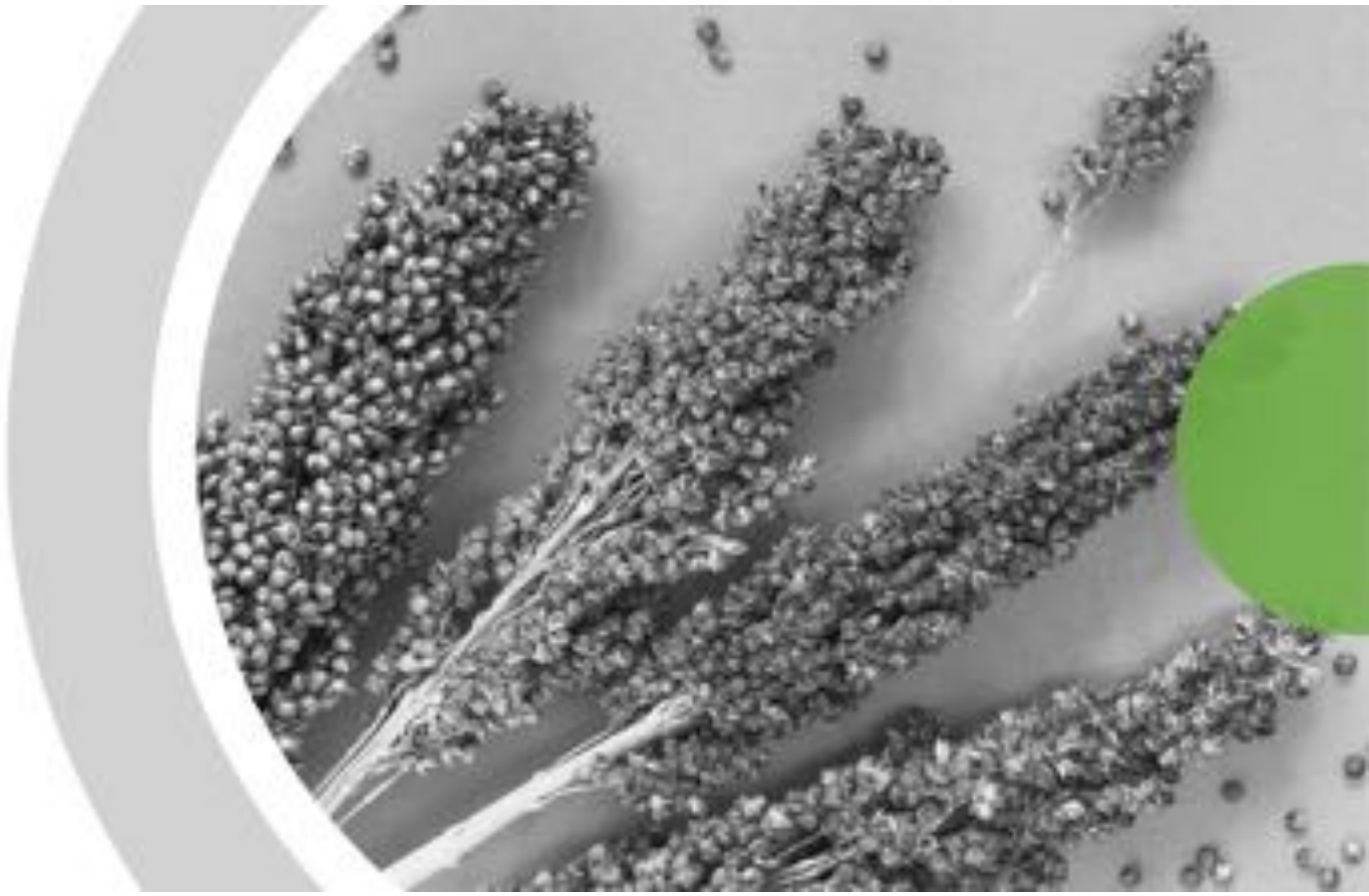
Figure 38: Operating Profit Margin Sensitivity for Manufacturers of Sorghum Products

The impact is most significant in the case of sorghum malt (and the trends would most likely be the same for sorghum flour). It is much less evident in the case of traditional African beer. This is attributed to the fact that maize meal is used in a ratio of 2.3:1 (maize: sorghum) and the relative contribution of sorghum to the total volume and price is therefore circa 3%.

4.4.6 Value Added Tax

Value added tax is added to sorghum meal products and not to meal products of its competitor product - maize. This places the sorghum meal at a considerable disadvantage to maize meal. The price conscious consumer will be directed to buy maize. Sorghum buyers will feel the impact of the price differential. In the processed foods and beverages industry, the VAT can be reclaimed. However, the VAT has to be incurred at the procurement of the raw materials and it will, therefore, have a cash flow impact on the processors. This takes out cash from the business as there will always be a VAT accrual of at least 2 months on a perpetual basis that is funded out of cash flow.

Part 5:
Drivers of Adoption of Primary Production, Value Addition and Market



5 Drivers of Adoption of Primary Production, Value Addition and Market

The sorghum value chain is similar to any other agricultural and food value chain where the consumer demand and other end-user applications such as animal feed, industrial products and commodities such as fuel are the key drivers for primary production and value addition through conversion or a variety of agro-processing techniques.

5.1 Primary Production

There are four key drivers of adoption identified at the primary production phase of the sorghum value chain:

1. Climate Change
2. Price
3. Food Security
4. Cultivars

5.1.1 Climate Change

Climate change is already having a definitive negative impact on agriculture and food supply in terms of productivity and food security. The increase in average temperature and increase in extreme weather events are likely to have an impact considerably on the cultivation areas for particular crops in the future. This will result in increased vulnerability in the agriculture sector over the medium to long term. It is generally accepted that agricultural producers will have to adapt to cope with climate change.

Climate change is occurring primarily as a result of increased carbon dioxide (CO_2) emissions into the atmosphere. This has resulted in extreme weather conditions such as severe floods, extreme heat and droughts. South Africa's temperature is also showing an overall upward trend.

South Africa's climate is also influenced by seasonal synoptic circulations and frontal systems, the El-Niño-Southern Oscillation, the inter-Tropical Convergence Zone, occasional Tropical cyclones, coastal cut-off lows and many more. Jointly, these have provided South Africa not only with summer, winter and all year rainfall regions, but also with one of the world's most variable climates.

Over 80% of the South Africa's land surface may be classified semi-arid to arid, with only 18% being dry sub-humid to sub-humid. The resulting potential for crop production is therefore limited. Only 13% of South Africa's surface are can be used for arable crop production. Only 22% of this available area has high crop production potential, with less than 10% of the total arable land being under irrigation. The most limiting factor in agriculture is water availability, with rainfall generally low and erratic for rain fed agriculture. The relatively small, irrigated sector utilises approximately 60% of the stored water.

Climate change is not yet well understood, especially regarding the extent, timing and impacts thereof. South Africa's is particularly sensitive and vulnerable to geographically-related shifts in climates. Overall, projections for South Africa's winter rainfall region in the southwest of the country suggest future rainfall decreases, while summer rainfall region projections deviate less from present rainfall, with possible increases in rainfall amounts.

The required climate resilient agriculture needs to address issues of strategic national importance, such as food security and its links to availability of water. The agricultural sector as one of the largest consumers of water is vulnerable to reduced water availability, increased water pollution and soil erosion, changes in rainfall patterns, increases in intense rainfall events and increased evapotranspiration.

In comparison with maize, sorghum is generally grown in relatively hotter and drier areas. Sorghum is considered to be more drought resistant and it can better withstand waterlogging. Sorghum is planted between mid-October and mid-December, depending on rainfall in the particular season.

Sorghum can be cultivated in rainfall regimes ranging from 300 – 1 200 mm in the summer growing season, the optimal rainfall being around 600 mm. Sorghum is however killed by frost and is grown ideally where there is a low relative low humidity, below 60%.

Sorghum tolerates a range of temperatures of around 25°C. However, if the mean daily temperature falls below 20°C, the growing period for sorghum increases by 10-20 days for every 0.5°C decrease in the average temperature. Flowering normally takes place 50-70 days after planting. Temperatures below 15°C or above 35°C during the flowering phase causes poor seed production, whilst hot, humid conditions result in disease problems.

The sorghum growing season varies from 120 to 135 day and the harvesting normally takes place from March to May. Sorghum also grows on a variety of soils, but ideally prefers deep and well drained light to medium textures. However, compared with maize, sorghum is cultivated mainly in lower potential soils in, often with a high clay content. The crop can tolerate a range of drainage conditions, including short periods of waterlogging.

In terms of adaptation of grain sorghum production, the breeding of more climate change-tolerant sorghum varieties is an essential strategy for staple food security. As sorghum has already inherited higher tolerance to heat, drought, and salinity than many other crops, it has a better chance being adapted to climate change conditions, but there is still need to improve the genetic potential of sorghum for higher tolerances.

In terms of crop selection, switching from maize to sorghum is potentially an excellent strategy in areas where drier and warmer conditions are expected to manifest as a result of climate change.

5.1.1.1 Potential Impact of Climate Change on Sorghum Yields in South Africa

With the use of the FAO's AQUACROP crop-water production model by applying historic yield and historic and predicted temperature and rainfall data, predictions have been made as to likely changes in sorghum productivity across South Africa by the middle of this century, 2046-2065 (Kunze and Schulze, 2016). Due to higher temperatures, sorghum yields are predicted to increase in South Africa with more than 18% of the country's 5838 quinaries indicating simulated yields in excess of greater than 12 tons/ha. The provinces most suited to future sorghum cultivation are predicted to be the eastern Provinces, i.e. Mpumalanga, KwaZulu-Natal and the Eastern Cape. Specifically, the central region of Mpumalanga and some inland areas of the Eastern Cape may experience yield increases of 4 tons/ha. However, the entire West of the country: Western Cape, Northern Cape, western parts of the Eastern Cape, Northwest, and western Free State will be unsuitable because they will be too dry. Gauteng and parts of Limpopo should remain suitable.

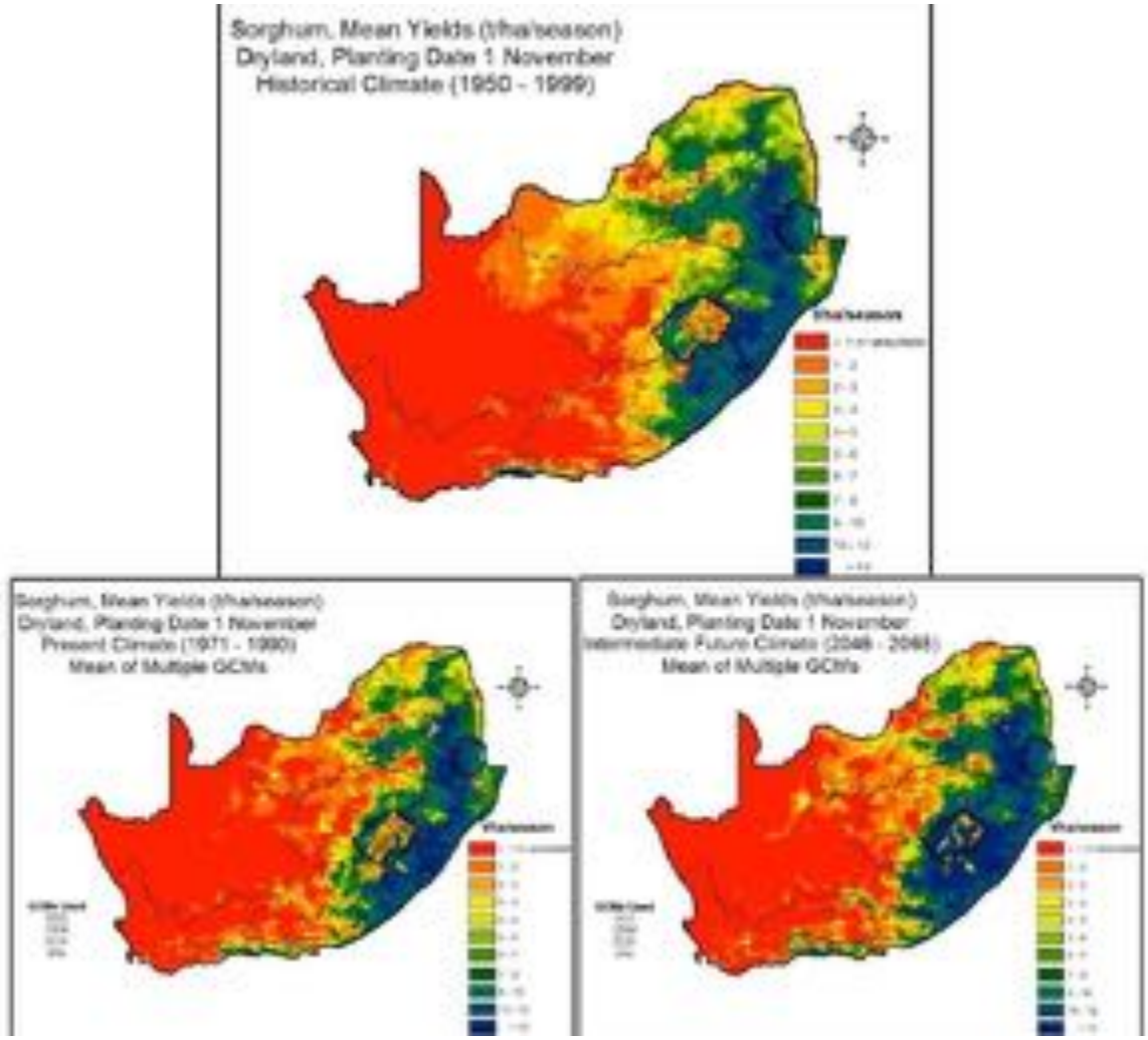


Figure 39: Mean Seasonal Grain Yields (dry tonnes p/ha)

Note: Mean seasonal grain yields (dry t/ha) in South Africa for sorghum planted in November, derived with the AQUACROP model and estimated using historical climate data for the period 1950-1990 (top), and yields estimated using climate inputs from multiple General Circulation Models or Global Climate

Models, for 1971-1990 (bottom left) and intermediate future 2046-2065 (bottom right) scenarios (from Kunze and Schulze, 2016)

The most notable effect of climate change on sorghum productivity is predicted to be that the increasing air temperatures will substantially or even dramatically reduce crop's growing season (crop cycle) by 15-30 days.in the high yielding areas of KwaZulu-Natal and the Eastern Cape and even by as much as 45 days in Mpumalanga. This indicates that short season varieties should be planted in the future. The critical breeding target for sorghum will be heat-stress tolerance. This is notwithstanding the possibility that increasing heat-stress events and reduced summer rainfall may be off-set by the higher carbon dioxide concentrations, which will enable sorghum to utilize the available water more efficiently.

5.1.1.2 Modelling the Effects of Climate Change and Mitigation Strategies on Sorghum Yields

Prof Michael van der Laan and his post-graduate student Mr Simphiwe Maseko of the University of Pretoria's Department of Geography, Geoinformatics and Meteorology were specifically commissioned for the purpose of this study to model the effects of climate change and climate change mitigation strategies on sorghum yields from present to near mid-term future (2020-2080), i.e. a period of 60 years[7].

The crop modeling involved the use of the Agricultural Production Systems sIMulator (APSIM) program, in combination with predicted parameters of future weather data from the WCRP (World Climate Research Programme) Coupled Model Intercomparison Project Phase 5 (CMIP5) weather data models. Historical weather, solar radiation, soil and soil moisture data came from the University of Pretoria's experimental farm cereal field trial in Hatfield, Pretoria, where cereal where highly detailed data exists from 1950 to present. The average rainfall over the 70-year period was 670 mm of which 80% fell between October and March.

For sorghum, the APSIM program uses data for a 1990s US red non-tannin (sweet), medium late sorghum hybrid cultivar, Dekalb-56. The planting rate used was 100 000 plants/ha and fertilization were applied at 100 kg N/ha.

The effects on sorghum yield of two different mitigation strategies in combination were studied:

a. Reduction in greenhouse gas emissions described by Representative Concentration Pathways, according to three levels – Low Radiative Forcing (RCP 2.6), i.e. a high mitigation strategy; Medium Radiative Forcing (RCP 4.5), an intermediate mitigation strategy; High Radiative Forcing (RCP 8.5), low mitigation strategy,
b. Retention of crop residues each season (R1) versus Removal of crop residues each season (R0).

The Figure below shows that model predicts that maximum and minimum temperatures will increase substantially over the coming 60 years. Under the low greenhouse gas mitigation strategy (RCP 8.5),

[7] The full report is available upon request

the average maximum temperature will increase greatly, from the current 27°C to 30°C and the average minimum temperature from the current 13°C to 16.5°C. With the high mitigation strategy (RCP 2.6), the increase will be substantially less, with average maximum and minimum temperatures of 27°C (i.e. no increase) and 14°C (i.e. a 1°C increase), respectively.

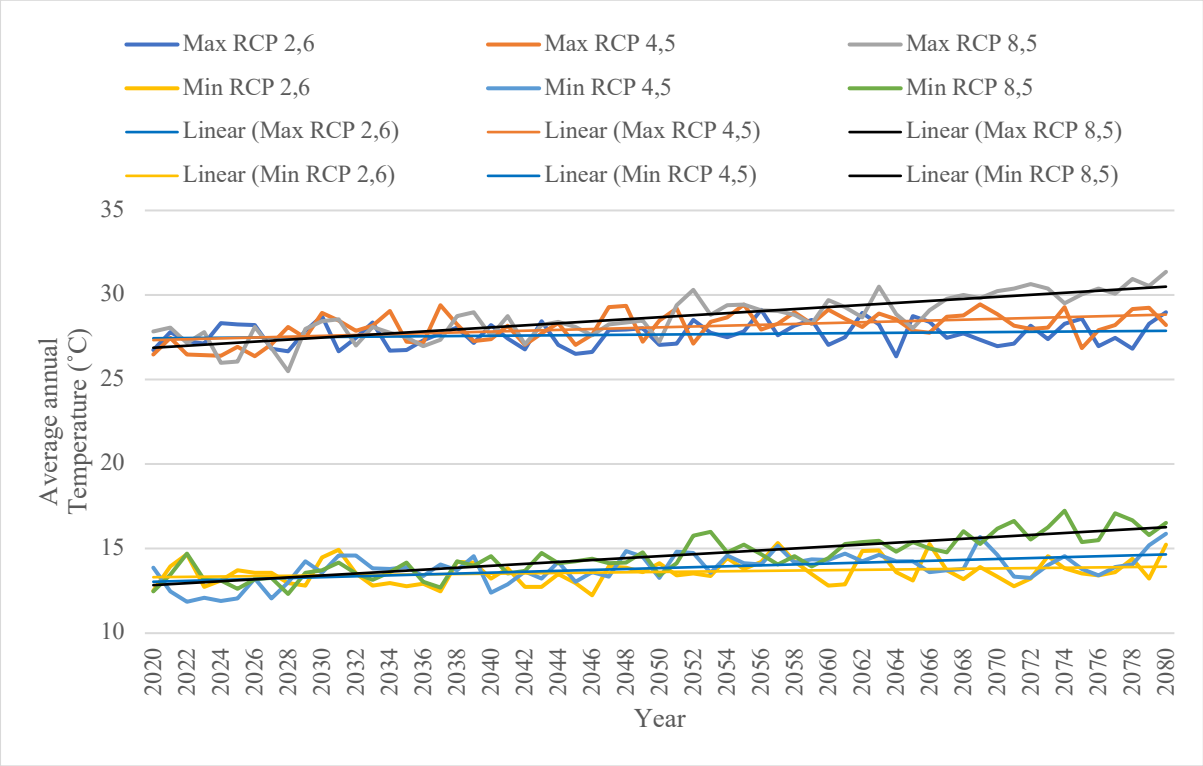


Figure 40: Predicted Average Annual Minimum and Maximum Temperatures (2020-2080)

Note: For the three representative greenhouse gas concentration pathways (RCPs) mitigation strategies: RCP 2.6 (high mitigation strategy), RCP 4.5 (intermediate mitigation) and RCP 8.5 (low mitigation)

The Figures and Table below show that irrespective of the greenhouse gas mitigation strategy, the model predicts that sorghum yields could decline greatly over the next 80 years, from the current predicted yield of 3400 tons/kg down to 1950-2250 kg /ha if crop residues are removed from fields each season. The decline is due to small declines in overall rainfall and changes in rainfall distribution (data not shown) as well as the increasing temperature. Counter intuitively, the lowest predicted yield, 1950 kg/ha is with the high mitigation strategy (RCP 2.6). This would seem to be related to the fact that under this strategy, the number of days of very high rainfall (≥25 mm) is predicted to be the highest, 76 times.

Retention of crop residues appear to be a powerful mitigation strategy with the model predicting that sorghum yields will decline to a considerably lesser extent, with i.e. remaining at 3400 kg/ha under the high greenhouse gas mitigation strategy (RCP 2.6) and declines to 3050 and 2450 kg/ha under the intermediate and low mitigation strategies, respectively. There are likely to be several positive effects of retention of crop residues that are responsible, notably through increasing soil organic matter and

hence improving retention of soil moisture and reducing losses of nutrients by run-off and by provision of additional N and other nutrients.

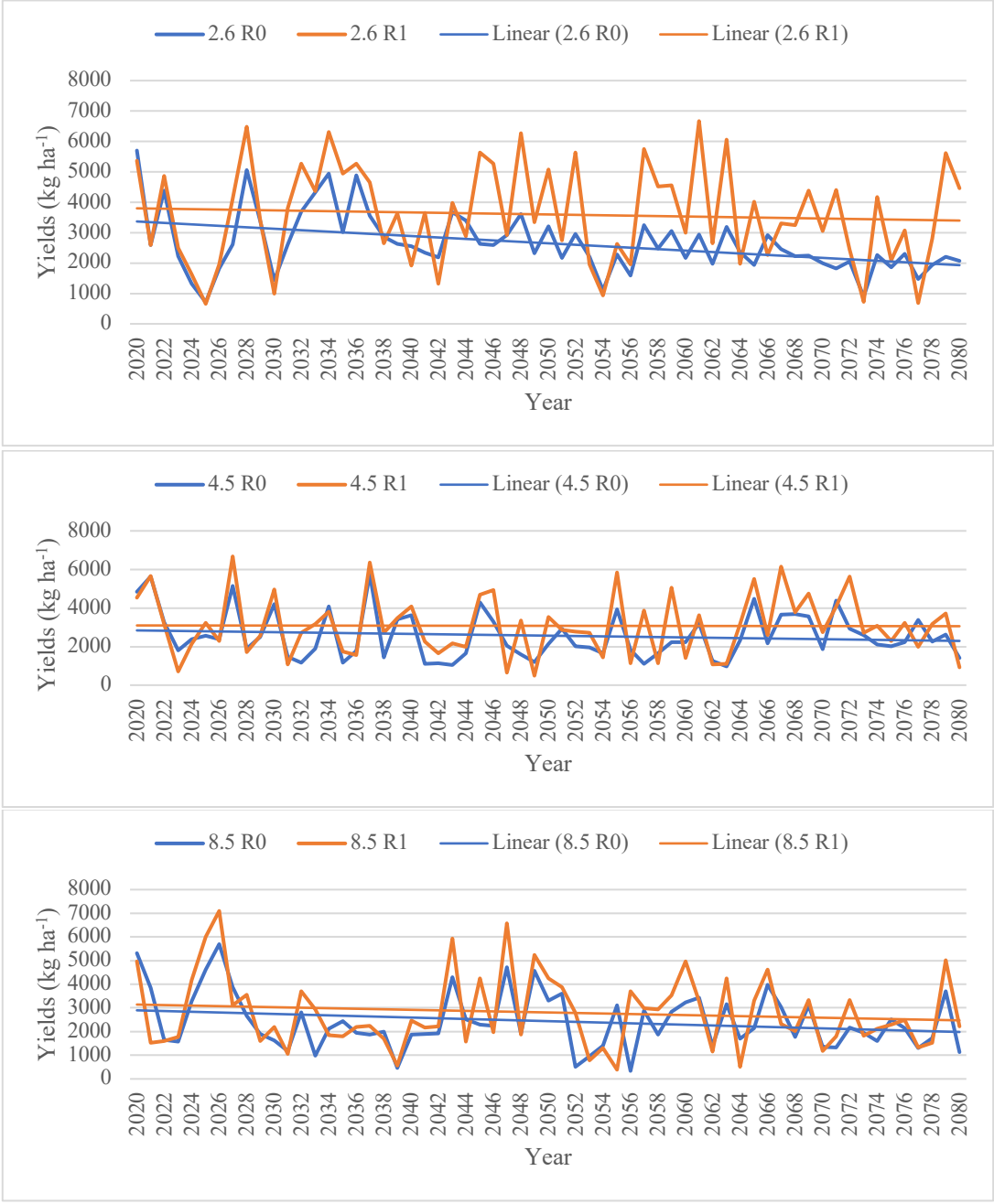


Figure 41: Predicted sorghum yields and yield trends (2020-2080) under the three-greenhouse gas representative concentration pathways (RCPs) mitigation strategies, RCP 2.6

Note: First Figure – High Mitigation; Second Figure- Intermediate Mitigation; Third Figure – Low Mitigation. With Crop Residue Retention (orange) and without Crop Residue Retention (Blue).

Year	RCP 2.6 Crop residues removed	RCP 2.6 Crop residues retained	RCP 4.5 Crop residues removed	RCP 4.5 Crop residues retained	RCP 8.5 Crop residues removed	RCP 8.5 Crop residues retained
Assumed present (2020) baseline	3400	3800				
2020	3400	3800	2900	3050	2950	3100
2080	1950	3400	2250	3050	2000	2450

Table 13: Predicted sorghum yield trends (2020-2080) under the three representative greenhouse gas concentration pathways (RCPs)

Note: RCP 2.6 (high mitigation strategy), RCP 4.5 (intermediate mitigation) and RCP 8.5 (low mitigation) with either crop residues removed or retained, (kg/ha)

Obviously, the predictions of the model may not be applicable to all regions in South Africa and seem to be in contradiction to the substantially increased predicted yield in the wider study of Kunze and Schulze (2016) However, because the modeling utilized detailed historical weather and comprehensive soil data and that the programs used are close to the current state of the art, it is probable that the general predictions with respect to sorghum yields and trends are more broadly applicable than just to the particular location studied. As such, the findings of this study cast some doubt on the discussed earlier work which predicted large increases in sorghum yields in some 18% of the country's agricultural areas, with yields in areas in excess of 12 tons/ha (Kunze and Schulze, 2016). This points to an acute need for more detailed and up to date modeling of the impact of climate change and mitigation strategies on the yields of sorghum and other crops across the country.

5.1.2 Price

During the past few years the local demand for sorghum (particularly non-tannin (sweet) sorghum) has considerably exceeded the local supply and major processors of sorghum-based food products are importing sorghum to meet the end-user demand for sorghum products. The reasons for the shortage of sorghum are complex. Producers find sorghum cultivation to be more expensive and less profitable than cultivation of maize and soybeans. There are also the issues of uncertainty of demand and concern about overproduction as the sorghum market is small. However, the importation of sorghum by processors does not seem to be simply a consequence of farmers being unwilling to cultivate it. Processors are also concerned with issues such as the relative high price of locally produced sorghum and the complexity of contracting numerous local farmers as opposed to simply importing from a single supplier. Processors purchase sorghum predominantly from the United States and Argentina to a lesser extent. The landed cost of circa R3,900 per ton of sorghum, then becomes attractive for local producers to grow and supply sorghum. It is perceived that sorghum producers understand this market dynamic and rather than enter into contracts with the processors they hold their sorghum stock back until such time as the import prices have been confirmed and they are able to sell their produce at import parity prices.

However, this situation is considered to be neither sustainable nor beneficial to the sorghum industry, as it creates tension amongst the processors and primary producers. This situation is not to the benefit of the industry as a whole. The alternative situation that could emerge is where over production of sorghum in South Africa will result in the farmgate price of sorghum being measured against export prices, which at R2,900 per ton, renders the local production of sorghum not profitable and therefore discourages farmers from producing sorghum. A case in point is a large Free State grain farmer that used to grow sorghum on a large scale and was dependent on processor contracts for his production loans. These production loans are granted to farmers using a price of sorghum that is determined at 15% below the SAFEX price of yellow maize and is therefore insufficient to cover the farmer's production costs. This farmer and other farmers who are dependent on production loans for their crop production are therefore unable to achieve profitability with the current sorghum cost structures and therefore exit the sorghum industry.

The high cost of production of sorghum in South Africa needs to be reduced, or alternatively the yield per hectare needs to be increased in order for sorghum production to become attractive again for farmers to invest in the industry.

5.1.3 Food Security

In arid drought-prone areas of the world, the cultivation of sorghum as a staple food is often considered as the only cost-effective way to provide nutrition for the people. Therefore, in the rest of Africa, the driver of adoption for sorghum cultivation by smallholder farmers is most likely food security. International agricultural institutions such as ICRISAT and organisations like SMIL, the USAID Sorghum and Millet Innovation Lab do a lot of research and development work to develop sorghum varieties that can be grown in these harsh climatic conditions to feed people.

In West African countries such as Nigeria and most parts of central and Eastern Africa , they cannot produce barley due to the tropical lowland climatic conditions, and sorghum is used to replace imports of barley for local lager and stout beer and non-alcoholic malt beverage production. In these cases, the local breweries have converted their production to use sorghum and this has created a demand for sorghum in these countries. The breweries have developed a sorghum production regime whereby they provide the small-scale farmers with the ingredients and the seeds to plant and produce the sorghum, and they then pay the farmers a fee when they collect the sorghum. This essentially makes the sorghum production an integral part of the beer brewing companies' business with no intermediate traders in the supply chain.

5.1.4 Cultivars

Cultivar development is aimed at improving certain traits of sorghum that support the key drivers of adoption. The development of cultivars through various techniques such as selective breeding of hybrids is therefore seen as a supporting activity that enhances the sorghum product in terms of its a

Part 6:
Market Opportunities for the South African Sorghum Industry

6 Market Opportunities for the South African Sorghum Industry

6.1 African Market

South Africa sorghum producers used to sell up to 40,000 tons per annum of sorghum to Botswana. Botswana has become self-sufficient in sorghum supply and this market has largely disappeared.

The United Nations projects that the population of the African continent will rise from 1.2 billion to 1.7 billion over the next decade[8]. But, as this demand for food surges, the increasing effects of climate change will make food production on the continent more difficult. Estimates are that rising temperatures and extreme weather events could cause a 10-20% reduction in Africa's overall food production[9]. The African Development Bank expects that Africa's net food imports will triple between now and 2025, reaching over $110 billion[10].

In sub-Saharan countries sorghum is still a major crop for internal consumption and smallholder farmers are used to grow sorghum to meet this demand. The production of sorghum in African countries varies from year-to-year, with climate change having a major impact on the production and yield of sorghum. Climate change and the impact thereof on the entire agricultural sector in Africa is a major crisis facing the continent. Also, across the region, droughts and pests from time-to-time will impact on sorghum supply and these countries are then forced to import sorghum, which comes primarily from USA. South Africa is closer to these East African countries and this regular shortfall should more readily be accessible to South African sorghum growers provided the sorghum can be produced more competitively.

A company such as EABL (East African Breweries Ltd) contracts up to 40,000 smallholder farmers to supply in its demand for sorghum for lager beer brewing in East African countries such as Kenya, Tanzania and Uganda and has developed a comprehensive programme to engage the smallholder farmers. ICRISAT is also involved in the development of sorghum varieties suitable for local sorghum production.

The African market holds numerous export opportunities for South African sorghum farmers. The demand in Africa is mostly driven by the demand for sorghum as a meal for food or for breweries (for lager beer and stout, malta (non-alcoholic malt beverage) and traditional African beer). However, demand fluctuates in these markets, as conditions such as drought, availability of inputs, and other resources impact the ability of farmers to produce sorghum.

[8] United Nations, "Population 2030: Demographic challenges and opportunities for sustainable development planning," 2015
[9] UNEP, "Africa's Adaptation Gap: Climate-change impacts, adaptation challenges and costs for Africa"
[10] AfDB, "Feed Africa Strategy," https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/Feed_Africa-Strategy-En.pdf

Hence, the main opportunities for exports of sorghum from South Africa to other African countries lies in replacing imports from countries such as the USA. As stated, sorghum is used mainly for human consumption in the African market, with some sorghum also being used commercially by the brewing industry. The impact of climate change on other African countries' grain, and specifically sorghum production, presents an opportunity for sorghum exports, if and only if South Africa is able to increase its own local production and yields.

The table below provides a summary overview of sorghum production and trade in selected African countries.

Country	Sorghum Production per year	Imports	Exports	Production Price $/ton	Key Features	Applications
Nigeria	6.9 million tons	0	100,000 tons	USD 296.40	Research and development focused across the entire value chain of sorghum Commercial National breweries funding research and development and supplying free inputs and technical advice to farmers	Essentially 100% of sorghum is used for human consumption in food and beverages.
Sudan	5.1 million tons	110,000 tons	90,000 tons	US$ 397.10	Small holder farmers as well as commercial farmers Decline in production to farmers switching to more remunerative crops	Mainly used for food for human consumption
Kenya	100,000 – 150,000 tons	190,000 tons (average) in 2018/19	re-export circa 70,000 tons.	US$150 – USD230 (imported sorghum)	Low productivity of sorghum associated with low yields and narrow adoption by farmers Increasing production of sorghum	Mainly used for food for human consumption

Country	Sorghum Production per year	Imports	Exports	Production Price $/ton	Key Features	Applications
					by smallholder farmers for lager beer breweries	
Zimbabwe	20,000 tons (2016)	20,000 tons	4,970 tons	n/a	Vast majority of sorghum is cultivated by smallholder farmers in the drier western part of the country	Primarily used for human food consumption Some sorghum produced under contract for industrial traditional beer brewing
Cameroon	400,000 tons	6,000 tons	Less than 100 tons	US$ 330.10	Guinness Cameroon is one of the key drivers for an increase in demand for sorghum – for lager and stout and malt-type non-alcoholic beverages	Primarily used for food and beverages (traditional beer)
Tanzania	1 million tons	2,000 tons	Less than 1,000 tons	n/a	Partnership between Tanzania Breweries and FtMA to support smallholder sorghum farming. Farmers are supported with input materials and market	More than 70% of sorghum produced is used for producing meal for porridge making.

Country	Sorghum Production per year	Imports	Exports	Production Price $/ton	Key Features	Applications
					access for brewing sorghum-based lager beer	
Ethiopia	4.3 million tons	20,000 tons	10,000 tons	US$ 260.61	Sorghum is grown by an estimated 4.8 million smallholder farmers.	75% of sorghum is used for making injera (traditional flat bread), with a further 20% going for animal feed and beer production, and the remainder held for seed.
Botswana	6,000 – 35,000 tons per annum	n/a	n/a	n/a	Large-scale commercial sorghum farming now taking place, leading to imports of sorghum from South Africa reducing significantly	Primarily used for human food consumption

Table 14: Summary of Sorghum Production and Trade in Selected African Countries

In the African market, countries such as South Sudan, Ethiopia, Sudan, Kenya and Zimbabwe are all importers of sorghum when local production is insufficient, with imports in these countries totally on average in excess of 180,000 tons per annum. The imported sorghum in these countries is primarily being supplied by the US and Argentina.

6.1.1 Exported Value Added Products

The following products are exported from South Africa to predominately African countries:
Sorghum malt and flour.

- Sorghum flour to the value of R1,7 million was exported to mainly Eswatini

- Sorghum malt valued at R36 million, representing 5,300 ton was exported in 2018. The statistics are not clear (unclassified) in terms of the target countries

Traditional African beer (instant beer) powder

- Instant beer powder to the value of R33 million and R47 million in 2018 and 2019 respectively was exported primarily to Botswana and Namibia accounting for 55% and 34% respectively. The growth in export sales of the beer powder represents a 40% increase year-on-year.

Traditional African beer exports

- Exports of traditional African beer increased by 98% from R6,6 million in 2018 to R13,2 million in 2019. However, liquid traditional African beer does not travel well due to its short shelf life and will therefore it remain highly unlikely for it to penetrate neighbouring markets.
- However, what represents a growth opportunity is the export of semi-processed sorghum products such as the instant porridge flour, malt and instant beer powder that are traded through the South African based retailers such as Shoprite, which have expanded into numerous other African countries. Shoprite has 2,829 stores in 15 countries across Africa. Linking locally produced sorghum products with retailers such as Shoprite immediately provides export market access for these products. This saves the manufacturer the cost of developing such markets.

6.2 China Market

In 2014/15, China became the world's largest importer of sorghum, which is primarily used for animal feed with some used to produce baijiu liquor. This sudden increase in sorghum imports was driven by demand for lower-priced livestock feed. Maintained by import restrictions with tariff-rate quotas (TRQs) and bans on unapproved genetically modified maize, China's domestic maize prices were up to 1.5 times higher than the international market, despite subsidies to maize producers and, until recently, price supports for farmers.

Approximately 80-90% of China's sorghum imports originate from the US, with the remainder essentially all from Australia. The majority of imported sorghum is destined for southern China where animal production is concentrated, and feed demand is high. Following the January 2020 US-China Phase One Agreement, China waived retaliatory tariffs in March 2020 on numerous agricultural products including sorghum. Sorghum imports into China are not subject to tariff-rate quotas, and US sorghum does not face any known quarantine or biotech (GM) issues that are likely to impede trade.

In China approximately one third of sorghum is used to manufacture alcoholic beverages such as Baijiu, which is China's traditional distilled spirit. A study conducted by the US Grains Council and the US Sorghum Checkoff Program in 2019 found that approximately 50% of the grain used in the manufacture of Baijiu in China is sorghum. It is estimated that the demand for sorghum is in excess of 3 million tons for the production of Baijiu.

The demand from China for imported sorghum is expected to continue to increase, reaching an estimated 4 million tons in 2020/21 to satisfy strong feed demand resulting from livestock (cattle and pig) and poultry restocking. Consumption of sorghum is forecast at 7.7 million tons in 2020/21, an increase of 2.2 million tons from the previous year.

Currently imported US sorghum prices are much lower than domestically produced sorghum and maize in China. US sorghum at the South China ports is 2,050–2,400 Yuan per ton duty paid (with the tariff exclusion now in place), compared to 2,700–2,800 Yuan per ton for local sorghum and 2,130-2,150 Yuan per ton for maize.

6.3 Summary of International Market Opportunities

International market opportunities are identified as those countries that import significant amounts of sorghum. China is the main importing country globally, with African countries such as South Sudan, Ethiopia, Sudan and Kenya also being amongst the top sorghum importers.

South Africa could become competitive in the international trade of sorghum, if sorghum is produced at competitive prices. However, the major opportunity for developing an export market for sorghum is more on African countries, given the fact that South Africa is geographically far away from other

international markets such as China. Therefore, it will be extremely difficult for South Africa to compete in these markets currently supplied by USA and Australia, unless, for example, there was a formal trade agreement with China.

The export opportunities to China and other Asian destinations seems very unlikely due to South Africa's geographic location and distance from these markets, that will increase transportation costs as well as the very competitive nature of competing suppliers in the USA and Australia Therefore the likelihood of these export market opportunities becoming a reality is very low.

6.3.1 Exporting Sorghum to Africa

More than 23 million people are food insecure in eastern and central Africa, with food security conditions worsening in Burundi, Somalia and South Sudan. The US Grain Council and USAID .

USAID Office of Food for Peace (FFP) works to reduce hunger and malnutrition globally – providing nearly 1.4 million metric tons in fiscal year 2018 of U.S. in-kind and locally/regionally procured commodities, in addition to cash transfers and food vouchers. USAID/FFP is the largest donor-to-food assistance program, providing more than $1.7 billion in fiscal year 2018, to meet both chronic and acute food needs globally. USAID/FFP is also a key donor to the World Food Programme (WFP) – the largest humanitarian organization addressing hunger, malnutrition and food security globally.

In fiscal year 2018, USAID/FFP provided more than 415,000 tons of U.S. sorghum globally. The program provided more than $35 million in cash-landed and in-kind food assistance, including more than 55,000 tons of U.S. sorghum, to assist refugees living in Kenya's two refugee camps. South African sorghum producers could make locally grown sorghum available to the USAID/FFP Program should it be possible to supply locally producer sorghum to the region more competitively than from USA. It is also noted that USAID and ICRISAT are working together in Nigeria and other West African countries to bolster sorghum and other grain production to support these countries to become self-sufficient in food supply and improve overall food security. According to SAGIS, sorghum destined for South Africa is sold at a FOB price of USD269/ton or R4,304 per ton at ZAR16 to the USD. Freight and insurance add a further R525/ton to the cost. South African exporters are faced with very high port and freight costs from SA ports to East Africa, and freight charges, including port handling fees exceed ZAR1,055 per ton. The pricing for export from SA is based on a once-of shipment and could be less if an export programme is developed in collaboration with grain traders and shipping companies such as **AFGRI Grain Management**. AFGRI Grain Management is a world leader in the handling and storage of grains and oil seeds. They offer secure storage of agricultural products in an infrastructure of grain silos, bunkers and bagging depots throughout South Africa, Congo-Brazzaville, Uganda, Tanzania, Zimbabwe, Mozambique and Zambia with a capacity of more than 5,0 million tons.

Provided South African sorghum producers can improve the competitiveness of local sorghum production through the cultivar development programme, the local growers should be able to participate in the sub-Saharan African market for grains and sorghum specifically and have access to a target market of circa 100,000 to 200,000 tons of sorghum per annum. Currently, it seems that

South African sorghum growers are largely excluded from participating in this market due to the high cost of locally produced sorghum.

The Figure below gives a high-level overview of US sorghum exports, and also lists selected African countries where US sorghum is exported to:

Figure 42: USA Sorghum Exports

While the African market should be considered the major target market for exporting sorghum, there are a number of developments in the African market that need to be considered when looking at the exports market:

1. The cost of production of sorghum needs to come down significantly in order for it to be competitively priced with that from the US
2. In-country developments in sorghum production capacity are being driven by the desire of African countries' to be self-sufficient in their food and beverage grain supply. This is evidenced by the fact that South African sorghum exports to Botswana have almost ceased, due to the commercial production capacity in Botswana having increased to such an extent that the country has become self-sufficient.

3. In the rest of Africa, institutions such as ICRISAT (the International Crops Research Institute for the Semi-Arid Tropics, the CGIAR organisation responsible for sorghum) has developed, or has contributed to the development of sorghum varieties that are ideally suited to cultivation and the market requirements of a number of African countries. This has thus increased their internal production of sorghum and decreased their need for imported sorghum. It is mostly when droughts occur in these African countries, that they import. In such cases, imports originate mainly from USA and often the sorghum is provided as food aid by agencies such as USAID, the World Food Programme and international NGOs. Targeting the export market to Africa could be risky since the demand could be erratic.

6.4 Natural Growth in the South African Market

The World-Wide Fund for Nature (WWF) estimates that South Africa will have to produce 50% more food by 2050 to feed an estimated population of 73 million people[11]. A population of 73 million people will increase the demand for most agricultural commodities, including grain by more than 50%. Models used by the WWF suggest that significant increases in productivity rates twinned with limited imports can meet local demand.

Figure 43: South Africa's Food Demand in 2050

Source: WWF

Cereal grains (maize, wheat, sorghum, etc.) make up a considerable portion of daily energy intake in Africa, and South Africa in particular. The growing population of South Africa will thus be a key driver of demand for grains, including sorghum.

[11] Agri-Food Systems: Facts and Futures, WWF, 2019

At present, 26% of South Africans are considered food insecure, with up to 27% of children under 5 experiencing stunting in natural growth. Because sorghum has higher nutritional quality maize in particular it can assist in addressing food insecurity and nutrition challenges in South Africa.

However, sorghum and sorghum-based products will have to be competitively priced in order to capture a fair market share of the growing population's demand for food. Sorghum and sorghum-based products will not only be competing with other basic foodstuffs, such as maize meal, but also with highly processed, nutritionally poor but energy-dense food products e.g. hamburgers which are not only readily available but also affordable and socially acceptable. It is estimated that a basket of healthy food can cost up to 67% more than so-called "junk" food[12]. The dominance of junk foods is placing increasing stress on the public healthcare system as the population undergoes a 'nutrient transition' – from traditional diets high in grains and dietary fibre to a diet high in sugars, fats, salt and animal-source proteins.

The negative impact of junk foods is not only limited to the consumers, but also impacts small food producers and informal trade by undermining healthier, more diverse rural and local food networks and their associated shorter value chains. Up to 70% of households in South Africa source food from informal markets, however, with the rising rate of urbanization and increasing availability of 'cheap, processed foods', this figure is declining, putting at risk the livelihoods of small farmers and informal traders.

Importantly, the sorghum industry must place a renewed focus on marketing sorghum, not only to the farming community and food processors, but also directly to consumers, to increase awareness about the nutritional value of the grain, as well as the positive impact of 'buying healthy' on local communities and smallholder farmers and traders.

6.5 Sorghum Beverages

6.5.1 Traditional Sorghum Beer

The traditional sorghum beer market has declined very substantially over the last decade from 91,000 tons sorghum grain for indoor and outdoor malting in 2010/11 to 51,000 tons projected for the 2019/20 season. During the COVID-19 lockdown, powder beer sales increased as home brew of traditional sorghum beer picked up due to ban on alcohol sales. The beer powder market has grown significantly over this period – beer powder enables the consumer to produce a beer at circa R4.50 per litre and on-demand. This negates the need to store the beer and therefore the shelf life of the home brewed beer is not an issue for the consumer.

[12] Agri-Food Systems: Facts and Futures, WWF, 2019

The traditional liquid sorghum beer brewed by UNB only has a 4-7 days shelf life as it is actively fermenting. Because of the gas produced by fermentation (21 litres per litre of beer) the cartons, plastic jugs and drums in which it is packaged have to have vents (slits in the top) to allow the gas to escape. Because of these defects, the beer containers are unhygienic, messy and smelly, unpleasant to stock, expensive to distribute and subject to adulteration. As a result, bottle stores in shopping centres, such as in city suburbs, do not carry any stock of this beer. United National Breweries was recently taken over by Delta Corporation in Zimbabwe and intends to introduce a pasteurised sorghum beer, Chibuku Super, to the South African market. However, this development will only take place if the excise duty leveled on the beer by the South African Revenue Service (SARS) is equitable. This beer will have a 28-day shelf life and bottled in a clear PET bottle. While the fermented sorghum beer sells for R8.50 per litre, the Chibuku Super will sell for just under R10.00 per litre (subject to equitable excise duty). This is considered a key price point that will contribute towards the market for Chibuku Super gaining market share against the fermented beer as well as current beers on the market. UNB predicts that the Chibuku Super will be successful in the local market, based on the packaging, longer shelf life, acceptable taste and the price of under R10.00 per litre. UNB is also currently in the process of starting to produce sorghum (traditional African Beer) beer powder in South Africa under the Chibuku brand name. Chibuku is the most recognised and popular brand of traditional African beer across central and southern Africa and UNB intends to promote the brand in South Africa.

A key driver for Chibuku Super success lies in the current excise duty regime for traditional beers. UNB is currently engaging the Department of Trade and Industry, the House of Traditional Leaders and the Department of Agriculture to secure support for maintaining the current excise duties as part of supporting traditional African beer.

The benefits of switching to the Chibuku Super pasteurised beer include:

- A significant increase in demand for sorghum to meet the increased demand expected from consumers. UNB projects a 4- to 7-fold increase in its sorghum demand, i.e. growing from its current requirement of circa 14,000 tons per annum to 56,000 tons per annum and eventually to just under 100,000 tons per annum. UNB currently sources its sorghum from Free State (Koppies area), which accounts for almost 75% of its annual requirement. Under the its previous ownership by Diageo, UNB also attempted to source sorghum from farmers in the Eastern Cape. Due to poor yields and poor reliability of supply, the engagement with the farmers unfortunately had to be terminated. However, now UNB intends to engage commercial farmers in the region.

- Packaging the beer in more environmentally friendly container – waxed cardboard for the current packaging is difficulty to recycle whereas the empty PET container used to bottle the Chibuku Super can enter the existing recycle network for PET materials and bottles used for carbonated and other beverages.
- Dramatically reduced distribution costs - Currently TAB has to be transported almost daily to all parts of the country from UNB's only operational brewery, which is in Tshwane.

- Forex saving. The waxed cardboard used to manufacture the sorghum beer containers are imported and are not manufactured in South Africa, whereas PET materials are manufactured in South Africa.
- Health and safety. As explained the current TAB packaging (cartons, milk type plastic jugs and drums) are not hygienic and the beer is subject to adulteration. Also, farmers, some processors and consumers continue to produce their own sorghum malt by allowing the sorghum grain to germinate on open ground. This exposes the sorghum to contamination from bird excrement, insects and vermin, this rendering the malt unsafe for human consumption.

The popularity of sorghum beer powder has also necessitated that UNB develop its own brand of beer powder. The beer powder will also be destined for export markets. Beer powder will be manufactured at the UNB Tlokwe plant in Potchefstroom and Chibuku Super at the Isithebe malting plant in northern KZN as well as at the Pelindaba brewery in Tshwane.

UNB will encourage and support a sorghum cultivar development programme to increase competitiveness of the local sorghum industry as well as focus on cultivar development that meets the taste requirements of the local consumer.

6.5.2 Non-Alcoholic Sorghum Beverages

The local soured, non-alcoholic cereal beverage (mageu-type) market is currently around 150 million litres per annum. There is evidence from the success of novel products like multigrain-dairy beverages such as Danone's DanUP and Mabele variants produced by several companies that sorghum-based mageu products are capturing a rapidly increasing share of this market.

Several drivers of this trend can be identified: The health food connation of ancient grains; The gut health connation of lactic bacteria fermented foods, Demand for "On the Go" preparation-free breakfast foods among young consumers, Demand for convenient versions of traditional African sorghum foods like soured ting porridge.

To produce the 150 million litres of mageu, the industry requires approximately 10,500 tons of maize.

If sorghum variants were to capture 20% of the current market, this translates to a demand of 2,100 tons of sorghum per annum.

6.6 Biofuels

South Africa recently published the Biofuels Regulatory Framework (BRF) (gazetted on 7 February 2020) in line with the objective of developing a national biofuels industry and introducing renewable resources at scale into the national transport fuel mix.

The purpose of the Bio-Fuels Feedstock Protocol is to provide a framework for sustainable production and procurement of feedstock crops in support of a prosperous and sustainable biofuels industry in South Africa.

The Biofuels Industrial Strategy (BIS) is, amongst others, premised on the creation of jobs in the agricultural sector and envisages the large-scale use of first-generation biofuels in the initial implementation. First generation feedstocks for ethanol include maize, wheat, grain sorghum, sugarcane, cassava, sugar beet and sweet (sweet stalked) sorghum. Market assessments conducted indicates that grain sorghum, sugar beet, sugarcane and soybeans are the most likely feedstocks for biofuels production in South Africa.

While sorghum has been identified as a potential key crop for the production of biofuels in South Africa, in the current environment this is not a feasible opportunity due primarily to the current depressed price of fossil fuels. Biofuel has to compete in this market as a replacement or supplement and it has to match the competitive price of fossil fuel which renders the conversion of sorghum to ethanol unfeasible, unless it is heavily subsidised by the government. At this stage the subsidy from government has not been clarified and therefore it should not be considered in the current sorghum industry scope of market opportunities. It is, however, necessary for the sorghum industry to remain abreast of developments of the policy framework through the Central Energy Fund and the Department of Minerals and Energy.

Apart from the above-mentioned, the Framework has been criticized as falling short in terms of delivering on socio-economic benefits and limiting the risks to biodiversity and food security[13].

The Biofuels Industrial Strategy's (BIS), the implementation of which is the main purpose of the BRF, rightly identifies as its primary objective's poverty alleviation and economic development, and acknowledges the role of biofuels in contributing towards the achievement of the country's renewable energy goals, energy security and the reduction of greenhouse gas (GHG) emissions. The BIS thus sets the stage for a national biofuels programme where socio-economic and environmental objectives are in synergy, but adequate regulations are needed to achieve this double dividend.

In its current form, however, the BRF fails to provide the adequate regulatory setting for an industry that is able to deliver on these multiple objectives. As it stands, it offers little incentives or safeguards to ensure the potential benefits are maximised while the risks are minimised.

The Feedstock Protocol, a key component of the BRF which aims to mitigate the risk of the biofuels programme to food security and to biodiversity, explicitly excludes staple crops such as maize and alien crops such as jatropha as potential biofuel feedstocks. It also prioritises multi-purpose crops, rain-fed crops and crops grown on fallow land.

[13] WWF, https://www.wwf.org.za/our_news/news/?30981/New-biofuels-regulatory-framework-falls-short

While this is sensible, it is not sufficient to ensure biofuel production does not affect maize prices, as competition for land where maize could be grown remains. It is also not sufficient to ensure preservation of biodiversity, as conversion of virgin land for the production of biofuel feedstock with local crops can be just as damaging to biodiversity.

6.7 Summary of Opportunities

On their own, each opportunity has merit and worthwhile pursuing. Combined, these sorghum market opportunities identified herewith, amounts to 348,000 tons per annum on the upside and 169,000 ton per annum conservatively.

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement	40,000	70,000
East Africa export	100,000	220,000
Beer	20,000	40,000
Consumer food	9,000	18,000
TOTAL potential	**169,000**	**348,000**

Table 15: Quantification of Market Opportunities

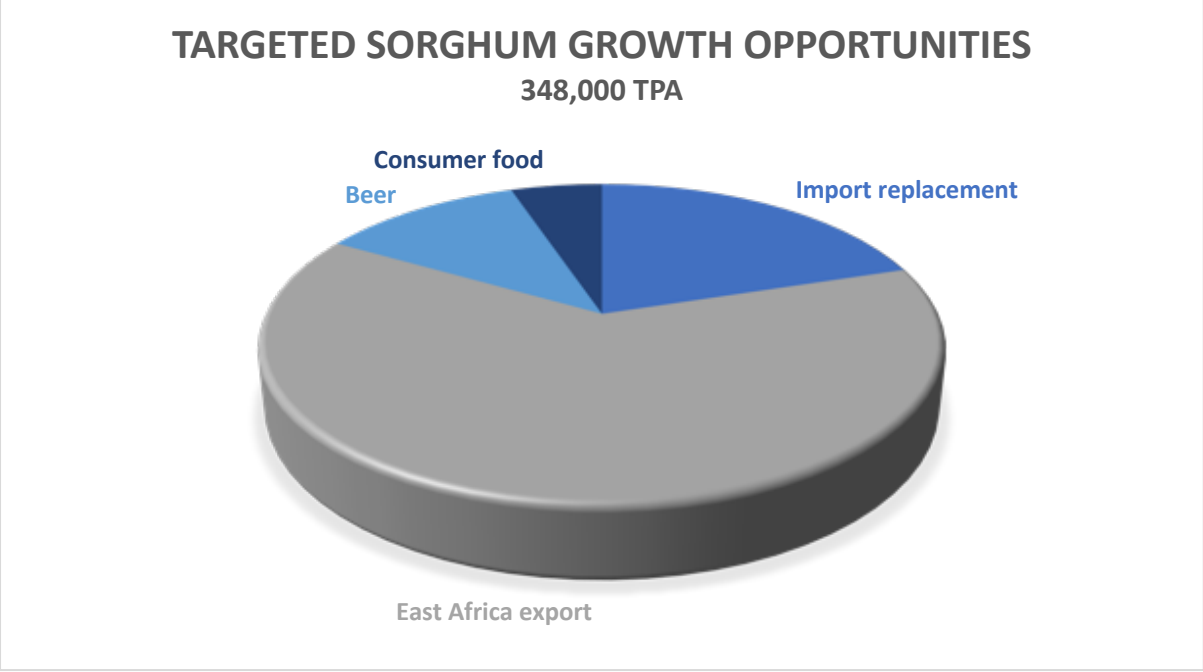


Figure 44: Targeted Sorghum Opportunities

6.8 Cost Benefit Analysis of Market Opportunities

In order to capitalize on the identified market opportunities, sorghum has to be competitively priced

The following assumptions were made to conduct the cost-benefit analysis:

1. The replacement of imported sorghum at approximately 50,000 tonnes per annum;
2. The development of the export market, which is conservatively estimated at 100,000 tonnes per annum, but could be as much as 220,000 tonnes per annum;
3. An increase in local sorghum consumption as a result of developments by beer and beverage companies such as United National Breweries and Denmar Estates, as well as development of the local market by food processors such as Tiger Brands and Pride Milling:
    a. United National Breweries (UNB) indicated that the market potential for Super Chibuku (pasteurised sorghum-based traditional African beer) could lead to a demand for sorghum of as much as 40,000-70,000 tonnes per annum.
    b. Food processing companies indicated that should the sorghum price be more competitive to that of maize, and the VAT on sorghum meal removed, they should be able to increase sorghum-based meal and porridge sales by 15% per annum.

As per the summary of market opportunities identified in the previous paragraph, and repeated here for ease of reference, the cost-benefit analysis is based on a middle road between the conservative and optimistic estimates reflected below, amounting to 250,000 tonnes per annum.

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement	40,000	70,000
East Africa export	100,000	220,000
Beer	20,000	40,000
Consumer food	9,000	18,000
TOTAL potential	**169,000**	**348,000**

Table 16: Summary of Market Opportunities

This opportunity would require an additional 32,000 hectares of sorghum to be planted (based on a yield of 5 tonnes per hectare). Approximately 2 workers are required for every 5 hectares planted, indicating that the job creation potential would be in excess of 12,000 new employment opportunities.

The import replacement opportunity is valued at an estimated R192 million in forex savings, and the export opportunity translates into approximately R250 million in forex earnings per annum.

Part 8:
Global Best Practices

7 Global Best Practice Overview

7.1 International Research and Development Programs

The yield and quality of sorghum is affected by a wide array of biotic (insect and other animal pests and primarily fungal diseases) and abiotic stresses (adverse weather and problematic soils). These are shoot fly (India and Eastern Africa), stem borer (India and Africa), midge (Eastern Africa and Australia) and head bug [India and West and Central Africa (WCA)] among pests; grain mould (all regions), smut (South Africa) anthracnose (WCA and Northern India) among diseases and *Striga* (parasitic weed) (all regions in Africa); drought (all regions) and problematic soils – saline (some parts of India and Middle-East countries) and acidic (Latin America) – which together (except saline and acidic soils) cause large yield losses.

Sorghum has not received sufficiently wide attention in the scientific community, especially in Africa and Asia due to the fact that it is not so commercially important as maize and wheat and that much of its production is at subsistence level. Increased pressures of population growth on food supplies, enhanced food and feed utilization and depleting fossil-fuel reserves have driven attention towards utilizing the full potential of this crop as food, feed, fodder and fuel. Genetic improvement is the cost-effective means of enhancing sorghum productivity for different end-uses. Depending on the production environment and constraints and end-product utilization, the objectives of sorghum improvement programmes have been different in different parts of the world.

The following section contains some of the most recent research and development programmes undertaken in the sorghum industry in various countries across the world.

7.1.1 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

The ICRISAT is the CGIAR (Consultative Group on International Agricultural Research) institute responsible for scientific research for development on sorghum, millets and some legumes. The approach of ICRISAT is to utilize partnerships with national and regional agricultural organizations and the private sector to promote inclusive, market orientated development.

The following gives an overview of research programmes that ICRISAT are involved in specifically related to sorghum.

a. Asia

- The ICRISAT Research Programme in Asia adopts an integrated and value chain approach to achieve the best possible impacts on farmers' fields through building partnerships.

- The programme is organized into six themes: Crop Improvement, Integrated crop management, Policies and impacts, ICRISAT Development Centre, Plant Quarantine Unit, and Farm and Engineering Services. Its main objectives are to develop high-yielding stress-tolerant cultivars of six mandate crops (chickpea, groundnut, pigeon pea, sorghum, pearl millet and finger millet) and make them available to different stakeholders.

b. West and Central Africa

- ICRISAT's Regional Research Programme in West and Central Africa has Country offices in Mali (Regional hub), Niger and Nigeria. Together with research and development institutions in the region, it conducts research to develop improved technologies to enhance the agricultural productivity of sorghum, pearl millet and groundnut.

- The Research Programme comprises four major themes – Crop improvement, Integrated crop management, Systems analysis, and Policy and impact. The theme on crop improvement aims to understand crop biodiversity by studying and exploiting phenotypic diversity, intra-varietal diversity and geographic differentiation. The focus is on improving farmer-preferred and market-oriented cultivars of pearl millet, sorghum and groundnut.

c. Eastern and Southern Africa

- ICRISAT's research programme in ESA works to address these challenges in its Country offices based in five countries — Kenya (Regional hub), Malawi, Ethiopia, Zimbabwe and Mozambique — as well as in Tanzania, Uganda, Sudan and Eritrea. The programme seeks to strengthen the value chain of its climate-smart crops (sorghum, finger and pearl millets, groundnut, chickpea and pigeonpea) to improve livelihoods of smallholder farmers. Currently, the region works in four thematic areas: Crop improvement and seed systems; Integrated crop management; Systems analysis; and Adoption, markets and impact.

7.1.2 India

In India, unlike in most other countries, sorghum is cultivated in two seasons - kharif (rainy) season (June/July-September/October) and rabi (postrainy) season (October- December/January). The rabi crop is almost entirely used for human consumption whereas the kharif crop is not very popular for human consumption and largely is used for animal feed, starch and alcohol industries. Only 5% of the area under sorghum in India is irrigated. Over 48% of the area under sorghum cultivation in the country is in States of Maharashtra and Karnataka.

The Institute of Millets Research in India is also a key research institute that is focused on basic and strategic research on sorghum and other millets under the Indian Council for Agricultural Research.

7.1.3 China

Modern sorghum breeding in China began in the 1920s, and has progressed through three stages: (a) collection, classification and pedigree selection within the best local varieties; (b) cross breeding, using crosses between local varieties or local-exotic for variety production and (c) exploitation of heterosis through the development of single-cross hybrids from inbred parents. China's national agricultural research system is the largest publicly funded and administered research system in the world. About 60,000 researchers and technicians work in approximately 400 research institutes and 70 agricultural universities throughout China. Plant breeding is mainly performed by the several institutes of the public sector within which the Chinese Academy of Agricultural Sciences (CAAS) is the leading agency. All agricultural universities in China have agricultural institutes/sections responsible for plant breeding and bio-technology. There are also many seed companies at both public and private levels.

In general, the breeding objectives include high yielding capacity, good resistance and tolerance to biotic and abiotic stresses and excellent quality.

7.1.4 East and Central Africa

Sorghum is a very important food crop in east and central Africa, however, despite its relative importance in the regional food system, relatively little sorghum is commercially processed. In 2019, a group of agricultural scientists and other value chain actors, such as processors and seed business houses working with sorghum and millets, came together to create a platform – a Crop Network Group (CNG) – to stimulate crop product design, development, testing and delivery in Eastern and Southern Africa.

The CNG Steering Committee – with members from AGRA (Alliance for Green Revolution in Africa), ICRISAT, Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA) project, Syngenta Foundation for Sustainable Agriculture (SFSA), NARS (National Agricultural Research Systems) and the CGIAR CRP-GLDC (Collaborative Research Programme in Grain Legumes and Dryland Cereals) will be responsible for raising resources for the network. An Implementation Team – represented by AGRA, ICRISAT, NARS coordinators from each country, AVISA, SFSA, food processors and seed companies – implement the activities of organizing and coordinating testing, exchange of improved germplasm, capacity building and Community of Practices (CoPs).

7.1.5 Australia

Australian Research Council (ARC)

The ARC Centre of Excellence for Translational Photosynthesis seeks to develop and harness advances in photosynthesis research, crop bioengineering, plant phenomics and computational tools to realise increased and sustainable crop yields, opening new routes to achieving the next revolution in plant productivity. It aims to deliver improved yield by undertaking a continuum of fundamental and applied photosynthesis research and targeting projects with a high probability of producing increased yield. The programme started in 2014, and is due to end in 2021.

The University of Queensland

The University of Queensland in Australia has played a significant part to increase the rate of productivity gain for sorghum in Australia through a sorghum pre-breeding public research program funded. The program is run by the Queensland Alliance for Agriculture and Food Innovation (QAAFI), with sorghum genetic improvement being the key focus of the program (which is run in collaboration with the Department of Agriculture and Fisheries and the Grain Research and Development Corporation). The program draws upon a range of scientific disciplines such as plant physiology, crop modelling, molecular biology, pathology and entomology.

UQ's development of elite germplasm (otherwise known as parent lines) for licensing to the global sorghum hybrid seed industry has generated both positive economic and environmental impacts. At the same time that sorghum yields have increased, growers have also benefited from decreased production costs due to higher insect resistance and reduced need for chemicals.

OZ Sorghum

OZ Sorghum is an alliance of Australian sorghum researchers. The organization is globally recognized as leaders in conducting integrated multi-disciplinary research with industry impact. The research is focused on linking upstream industry science to industry problems and opportunities.

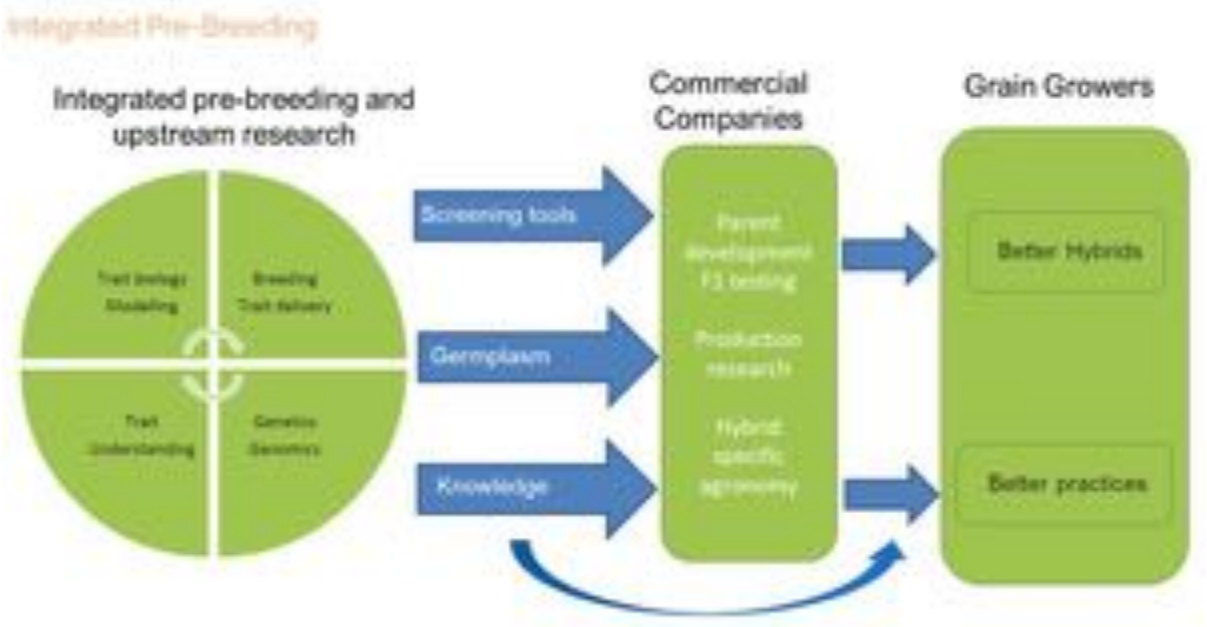


Figure 45: OZ Sorghum Integrated Pre-Breeding Approach

7.1.6 USA

The United States is home to some of the largest sorghum seed producers in the world, with comprehensive research and development programmes focused on developing the sorghum industry's productivity and profit potential. The section below lists some of the main sorghum seed companies in the country.

Corteva (formerly Du Pont Pioneer)

Corteva inherited from the Pioneer HiBred company a comprehensive sorghum research programme, with ongoing investment into research and development to drive genetic gains an incorporate new traits and technologies to improve the productivity and profit potential for sorghum producers. The company has six breeding programmes worldwide – three in the United States, two in Mexico and one in Australia, plus the PANNAR (which itself was taken over by Pioneer) programme in South Africa – producing more than 200 new parent lines every year.

Since the takeover of Pioneer by Corteva, the future of these sorghum breeding programmes is uncertain. However, a majorly important consequence for South Africa is that PANNAR's sorghum breeding programme was terminated. The PANNAR sorghum breeding programme was the only significant sorghum breeding activity in South Africa.

S&W Seed Company

S&W Seed Company focuses on agricultural breeding, production and processing for the alfalfa, sunflower, sorghum species, and stevia industries. The company has 6 research and development facilities, 2 of which are in Australia. The company works extensively in research and development of forage and grain sorghum, and in 2017 commenced with commercial scale production of its hybrid grain sorghum and hybrid forage sorghum operations.

Other

- **Advanta**:
  - Advanta US is a private company which also owns Pacific Seeds in Australia– one of the largest producers of sorghum seeds. Advanta Seeds has a number of sorghum breeding programmes in the US, Argentina and Australia.
- **Nuseed**:
  - Nuseed is a wholly-owned subsidiary of Nufarm Limited and produces canola, sorghum and sunflower hybrid seeds.
- **Hancock Farm and Seed Company**:
  - Hancock Seed Company produces sterile sorghum seed and four types of sorghum Sudan grass seeds.

7.1.7 Europe

In France, scientific research on the genetic improvement of sorghum is particularly active. Spain has also been increasingly focusing on sorghum production for animal feed, as recurring droughts have led to irrigation restrictions being implemented in the country.

Star-Sorghum

Star-sorghum refers to the range of sorghum hybrids offered by European seed companies. There are over 300 varieties of sorghum registered by seed producers in EU countries, and approximately 300 varieties registered in non-EU countries. In the past 30 years, European sorghum has been tannin free. A tannin content of <0.3% is required to register any new variety in Europe.

7.1.8 Namibia

Namibia's Ministry of Agriculture, Water and Forestry, through and IAEA (International Atomic Energy Agency) technical cooperation project which began in 2009, has enhanced existing varieties of cowpea and sorghum in its first ever plant breeding programme. New varieties of cowpea and sorghum were released in 2018 and facilitated seed multiplication in 2019. To generate the initial batch of seeds, scientists at the Joint FAO-IAEA laboratories in Seibersdorf, Austria, used gamma irradiation on the local seed varieties to induce desired changes in the plants' DNA. By using radiation to mimic the natural process of spontaneous mutation, scientists can generate varieties with new and useful traits.

One of the key challenges in Namibia is the poor soil fertility, which requires farmers to use expensive nitrogen fertilizers. Experts from the research and development programme used a stable isotope of nitrogen to evaluate cowpea varieties for their nitrogen fixing ability. Cowpea is known to add nitrogen to soil, reducing the need for industrial nitrogen fertilizers and therefore boost soil fertility and provide a more sustainable crop yield. . By initiating crop rotations with cowpea, sorghum yields have increased by approximately 30% and farmers make estimated savings of at least 30% of fertilizer costs.

7.1.9 Research Drivers and Objectives of Sorghum Development

Global sorghum production is estimated at approximately 60 million tonnes per annum, with just over 40% of this production being destined for human consumption, primarily in Africa and Asia. Animal feed consumption accounts for another 40-45% of production.

Sorghum is a crop which offers both an opportunity for diversification for farmers, as well as an agronomic response to climate change challenges. Some of the key drivers and objectives of research and development programmes in the sorghum industry include the following:

- Developing germplasm that responds positively to the effects of climate change;
- Harnessing sorghum's potential to enhance food security; and
- Optimizing the crop in line with its diverse nature.

Developing a germplasm that responds positively to the effects of climate change

Approximately 95% of all plants are classified as C3 species, including the so-called temperate cereal species: wheat, rice, rye, barley and oats. However, the so-called tropical cereals, maize, sorghum and the millets are C4 plant species. This means that they have greater photosynthetic capacity to utilise the higher solar energy in tropical latitudes. The C4 photosynthesis system is an additional pathway to the C3 Calvin photosynthetic cycle. In fact, currently, maize is one of the most photosynthetic-efficient crops. However, sweet sorghum (sweet-stemmed sorghum), is emerging as an alternative, given that it shows some advantages over maize. Sorghum possesses high tolerance to various abiotic stresses and high-water use efficiency, and thus is more often grown in semi-arid areas, and is expanding into those regions where fresh water is declining.

In general, sorghum has narrower and deeper root morphology than maize, a beneficial leaf canopy and capability to capture sunlight especially well in low rainfall environments and minimize water transpiration losses. Hence, it also uses water more efficiently; conserving water and can still photosynthesise while its stomata are closed.

There is research indicating that climate change can decrease yields worldwide of commodity crops including wheat, cocoa and maize. Because sorghum has better water use efficiency and natural heat tolerance, as increased CO_2 levels occur with climate change it will become potentially more sustainable as it will not require increasing inputs, especially water. Other studies have shown that barley, wheat, potatoes and rice have 6 to 15% lower concentrations of protein when grown at increased levels of carbon dioxide, however the protein content of sorghum did not decline significantly.

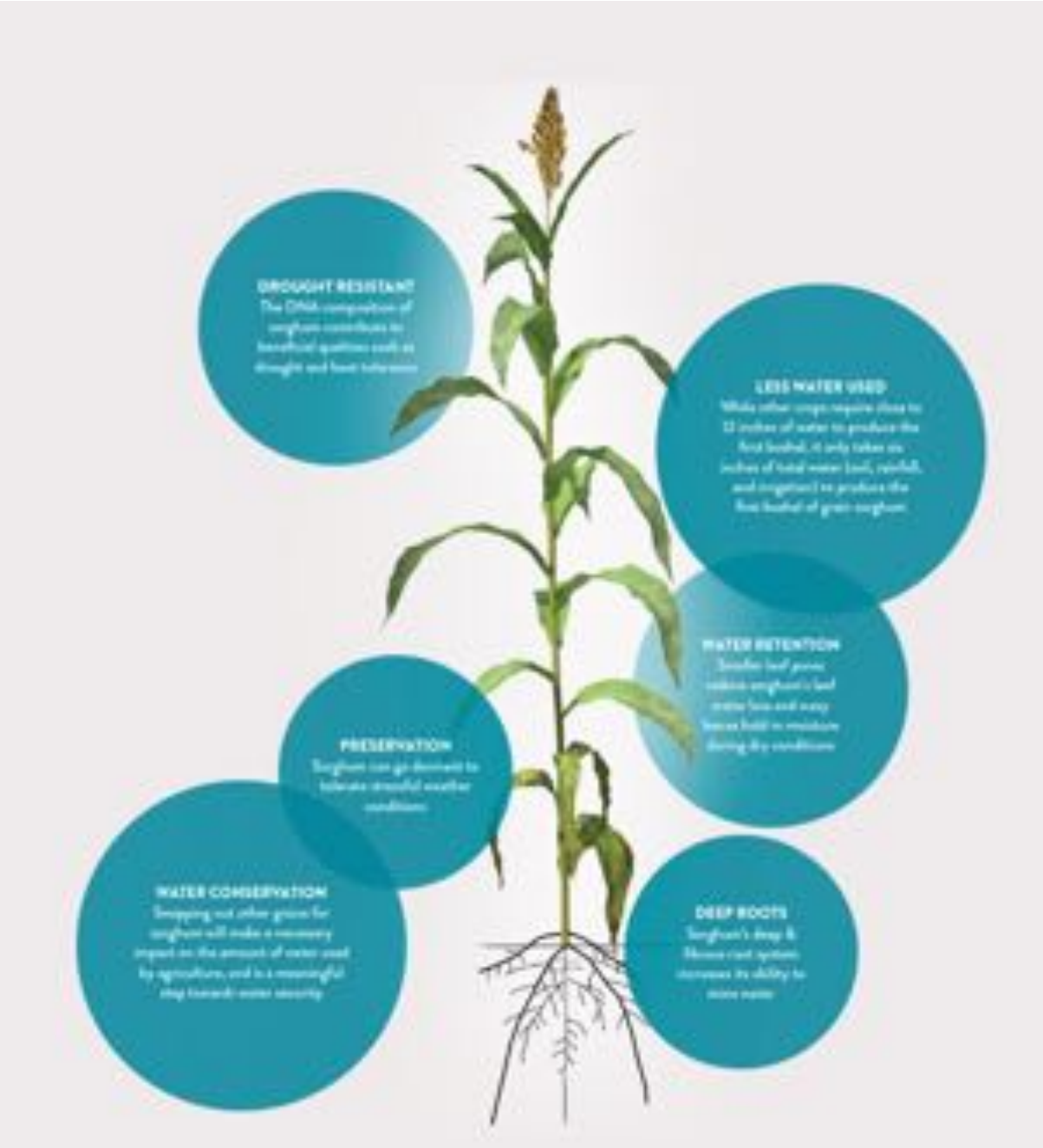


Figure 46: Key Features of Sorghum as a Sustainable Crop

Sorghum's potential to enhance food security

Sorghum as a climate-friendly crop that can be grown and used as a food-security grain, has gained increased attention world-wide. The crop is particularly important in regions that rely on subsistence agriculture with little adaptive capacity to climate change.

In various countries across the world, research and development in sorghum varieties has been focused on producing high-yielding crops with better tolerance to physical and biological stresses. The newly released sorghum varieties in Namibia, referred to above, are expected to benefit over 8,000 farmers in the first season. In Tanzania, farmers have also been encouraged to adopt sorghum as a

drought-tolerant crop. However, the sorghum seed market is not well-developed in Tanzania, and this discourages farmers from investing in sorghum, which is currently largely grown for household consumption. Tanzania is currently a net importer of seeds, however, the recent accreditation from International Union for the Protection of New Varieties of Plants (UPOV), Organization for Economic Co-operation and Development (OECD) and International Seed Testing Association (ISTA) will enable seed companies to increase production.

Optimizing sorghum in line with its diverse nature

Sorghum presents numerous opportunities as a grain crop for human consumption and animal feed, as a fodder crop, source of sugar for food and fuel, and cellulosic biomass as feedstock for the future bio-based economy.

With regard to sorghum as a good grain for today's urban consumers, breeding efforts must be directed at improving the traits that make sorghum more functional in bakery-type food products (e.g. breads, cakes and biscuits) to ensure consumer-acceptable product quality and sustained consumer interest.

With the growing importance of renewable energy, the introduction of new crop sources without compromising or sacrificing the food grains is a key requirement. Dual-purpose sweet (sweet-stemmed) and grain sorghum can potentially meet both applications. Although the grain and the sweet sorghum types have the same genome, they differ in the specific traits and require specific breeding programmes for the traits.

The demand for animal feed products continues to increase as world economies grow. In line with this growth, the demand for forage and grain feed sorghum is expanding. Grain traits such as starch and its composition and digestibility, protein content and its essential amino acid composition and digestibility, and the presence and content of tannins and other antinutrients must be considered to ensure that feed efficiency of sorghum remains competitive. The emerging trend of premium foods for companion and sports animals can potentially be met by ensuring sorghum and its components provide superior nutritional attributes.

7.2 Regional and Global Best Practices: Cultivars and Agronomic Practices

This section provides an analysis of regional and global best practices targeted at potential cultivars and agronomic practices that may lend itself to the South African climatic condition, including the required technology transfer and extension support.

7.2.1 Botswana

Large-scale commercial farmers in Botswana cultivate red non-tannin (sweet) hybrid cultivars, mainly MR Buster for milling to produce meal for porridge. These commercial farming operations are centered around Pandamatenga, some 950 kms north of Gaborone where sorghum and dry beans are the major crops. This is an area with around 600 mm of rainfall but also subject to droughts and

flooding. The venture started more than 30 years when the Botswana government sold land to 54 commercial farmers. It has been highly successful and as a result, in recent years Botswana has become self-sufficient in these crops and even exports dry beans to China.

Best Practice Identified

There are two key best practices that can be identified:

- Government provision of infrastructure in the Pandamatenga region including tar roads and especially water control and land drainage systems. This was achieved with financial support from the African Development Bank. The infrastructure project is now completed and serves more than 250 farms and an area of 25,000 ha of farmland.
- There is not a free market system for grain. Grain produced in Botswana is purchased by the Botswana Agricultural Marketing Board (BAMB) either on availability or through contract farming. The BAMB prices are very attractive by South African standards. For example: The current (September 2020) purchasing price for sorghum and for white maize is Pula 2500 (equivalent to R3,676) per ton. Concerning contract farming prices, for the 2018-2019 season the contract price for sorghum was Pula 2650 (then equivalent to R3,586) per ton and white maize Pula 2500 (then equivalent to R3,383) per ton.

7.2.2 Zimbabwe

Sorghum is a traditionally important crop in Zimbabwe that can be grown in marginal areas where maize may not thrive. Sorghum is predominantly cultivated in the drier western part of the country. Today, the vast majority of sorghum is cultivated by small-holder farmers for home consumption. The table below shows common sorghum varieties in Zimbabwe.

Variety	Seed Colour	Unique characteristics	Days to maturity	Yield potential
SV1	Creamy white grain	-Open pollinated -Semi dwarf, 1.25 to 1.8m tall -Semi compact medium sized head -Very hard grain with excellent milling quality -Produces 2-3 tillers per plant	115 to 125 days	3 to 6t/ha
SV2	Pearl white grain	-Semi dwarf with an average plant height of 1.4 to 1.6m -Open pollinated -Thin stemmed -Produces 1-2 tillers per plant	110 to 115 days	3 to 6t/ha
SV3	Creamy white grain	-Semi dwarf -Plant height 1.14 to 1.59m -Open pollinated -Semi loose heads -Generally does not tiller	112 to 124 days	3.8 to 8t/ha
SV4	White grain	-Semi dwarf, open pollinated variety -Average height of 1.3m -Generally does not tiller	Medium maturity, 113 to 127 days to maturity	3.4 to 9.0t/ha
NS5511	Red seed	-Hybrid (cannot be used as retained seed) -Early maturing Bird damage resistant	110 to 120 days to maturity	4 to 6 t/ha
Macia	Creamy white seed	-Open pollinated variety Height of 1.2 to 1.5m -Excellent milling quality	120-125 days to maturity	
DC75	Red seeded	-Open pollinated -Normally used for brewing	120-125 days to maturity	3 to 6 t/ha

Table 17: Common Sorghum Varieties in Zimbabwe

*Note: *NS5511 and DC75 are both tannin (bitter) hybrid-type sorghum varieties. SV1-4 and Macia are all white tan-plant improved open pollinated varieties.*

Delta Corporation, Zimbabwe's major opaque beer (sorghum beer) and monopoly lager beer brewing company, contracts small-holder farmers to cultivate a red tannin (bitter) sorghum hybrid, NS5511, for indoor malting to produce sorghum malt for industrial opaque beer brewing. The company also purchases white tanplant, non-tannin (sweet) open-pollinated sorghum, mainly the Macia variety, from small-holder farmers for sorghum lager beer (Eagle Lager) brewing.

Best Practice Identified

Three best practices can be identified:

- As tannin (bitter) sorghum is not a popular human food, has poor feed nutritional value for monogastric animals and in southern Africa is essentially only used for indoor industrial malting, contract farming makes good sense. This is because the purchaser is guaranteed a supply and the farmer has little temptation to break the contract and sell elsewhere as there is essentially only one market.
- Delta Corporation provides extension support to the farmers. It also provides financial support to the small holder farmers by providing them with seeds and fertilizer and once ready for harvest, Delta Corporation arranges for the collection of the grain.
- Delta Corporation is also supporting the local development of new sorghum cultivars to replace NS5511. This development is also particularly important in the South Africa context.

Here NS5511 is similarly widely cultivated for malting. However, an increasing problem with NS5511 cultivation is it is susceptible to smut fungal infection.

7.2.3 Australia

Australia essentially only cultivates red non-tannin (sweet) hybrid sorghum cultivars. The market for sorghum is almost entirely for the local and international animal feed market, mainly China. A very small amount is used for human food, for gluten-free flour and gluten-free breakfast cereals. There is also a very small production of white tan-plant (sweet) hybrid cultivars for gluten-free foods. In contrast to South Africa, sorghum and not maize is the major summer rainfall region cereal crop. This is on account of the fact that in the tropical and sub-tropical areas (Queensland and northern New South Wales) where sorghum is cultivated it yields more reliably than maize, primarily due to the region's very high temperatures and unpredictable rainfall. The Australian sorghum industry is highly successful and globally competitive.

Best Practices Identified

Several best practices can be identified:

- Australian sorghum farmers and seed breeding companies receive massive and well-focused agronomic and scientific support, notably from the Queensland Department of Primary Industries and the University of Queensland, under the umbrella of the Australian Sorghum Alliance (OZ Sorghum). Activities of OZ Sorghum include: 1. Integrated Pre-breeding and Upstream Research - genetics and genomics, trait understanding and modeling, breeding trait delivery, and 2. Applied R&D in partnership with commercial seed companies – hybrid parent and F1 hybrid testing, hybrid specific agronomy and production research.
- The marketing of sorghum for export receives directed support from the Australian Export Grains Innovation Centre (AEGIC). Examples include: 1. For the Chinese market, AEGIC has supported research into the pig-feeding value of Australian sorghum relative to other cereal grains, and 2. AEGIC through a local university has been working on better understanding the Chinese sorghum quality requirements for Baijiu production, the Chinese sorghum liquor.
- Ongoing development and application of crop modeling and precision agriculture to sorghum cultivation. The focus is on crop design (plant density which affects root architecture and leaf canopy area which affects moisture transpiration rates) to optimise the available soil moisture at planting and the predicted seasonal rainfall, and taking into account predicted seasonal temperatures (Rodriquez et al., 2018). This precision agriculture-type crop design means that plant distances and row widths will differ even across a single field according to a particular area's soil fertility and available moisture. Good results are also achieved with simpler systems based on crop water availability at time of planting to inform optimum crop design to increase yields and improve yield stability (Rotili et al., 2020). According to Prof David Jordan, head of the Australian sorghum pre-breeding research programme, Australian sorghum yields have increased by an average of 4% per annum over the past two decades. Half the increase is due to improved genetics and half due to improved agronomic practices, primarily by ever more efficient use of the available soil moisture.

- Sequencing the genome of many sorghum types, both cultivated and wild (Mace et al., 2013) with the aim of identifying genes coding for useful traits that can be introgressed into parental lines in breeding programmes.
- Applying genome editing (CRISPR/Cas9) to sorghum for trait improvement, for example to give it herbicide resistance by down-regulating the enzyme phytoene desaturase, which is involved in carotenoid synthesis and is a target for certain herbicides that function by bleaching (Liu et al., 2019).
- Non-GM, Imidazolinone-type herbicide resistant cultivars are now being trialed in Australia (See Table - Sentinel IG cultivar). This trait enables more efficient and economic weed control post seed post-emergence. In practice, what this trait means is that the sorghum fields can be sprayed with an Imidazolinone-type herbicide to kill the weeds without killing the sorghum plants. This is a very promising technology equivalent to the GM Round Up ready technology used for maize.
- Farmer application of the glyphosate-type herbicide to the sorghum plant at seed maturity to rapidly dry the plant and the grains down to a safe moisture content for grain storage. This reduces the risk of crop damage by late rains and potentially allows cultivation of a winter season crop in the same field.
- End Point Royalties (EPR) - Australia and other countries are starting to replace traditional royalties paid to seed breeders to recover their return on investment. Traditional royalties are incorporated into cost of the seed. EPR, in contrast, is levied on the grain production achieved by the farmer. Hence, with EPR if a farmer achieves a higher yield when using a new cultivar both the farmer and seed breeder share the benefits.

7.2.4 USA

The USA also essentially only cultivates red non-tannin (sweet) sorghum hybrids. The primary markets are for the local feed industry and some to grain bioethanol production but also to the international feed market, mainly China and Mexico and recently Spain. The USA, like Australia is a major sorghum exporter with China being a very important customer. Some of this type of sorghum is exported to Africa (mainly Sudan and Kenya) for food. There is also small but rapidly expanding cultivation of white tan-plant (sweet), black non-tannin and red tannin (bitter) cultivars for the gluten-free and health food and beverage markets. White tan-plant sorghum grain is exported to Japan. Food applications for sorghum in the USA now account for some 5% (approx. 350 000 tons) of total production. In the USA, like South Africa, maize is by far the predominant tropical cereal crop. The US sorghum production of approx. 7 million tons is just 2% of the maize production of 360 million tons. However, sorghum farming is profit-competitive with maize in a few areas where either the rainfall is low and unpredictable, e.g. in parts of Kansas and/or where there are major mold and mycotoxin problems with maize cultivation, e.g. in parts of Texas. The US sorghum industry is highly geared to export.

Best Practices Identified:

Several best practices can be identified:

- Reasonably well-funded public sorghum breeding programmes have existed for many decades in the USA at three Land Grant universities: Kansas State, Purdue and Texas A&M. These programmes have been responsible for most of the major developments that have resulted in increased sorghum varietal yields globally, notably the development of photoperiod (day length) insensitive lines and of hybrid cultivars. A fundamental difference between agricultural research at US and South African universities is that in the US each Land Grant university is a formal part a State's department of agriculture and as such receives funding from the State and has to undertake statutory R&D work for agricultural sector in that State. Moreover, many university agricultural faculty members (academic staff members) have a compulsory extension work component as part of their appointment. This system has much to recommend it in comparison to the totally laissez-faire situation in South Africa.
- Additionally, a dedicated industry-supported organization, the United Sorghum Checkoff Program (simplysorghum.com) has been in existence since 2008 to support farmers to market sorghum locally and internationally and to provide directed R&D support. As examples: 1. Supporting a university to develop tall grass herbicide-resistance traits in sorghum using mutagenesis, and 2. Supporting a marketing company to inform the food community and chefs about sorghum with the aim of increasing marketplace knowledge and sorghum food sales.
- Marketing support for the export of sorghum is provided by the US Grains Council.
- Concerning genome editing, according to Prof Bill Rooney - sorghum breeder at Texas A&M University, this technology has some potential for trait improvement sorghum, for example with traits such herbicide resistance, time to plant maturity and waxy (high amylopectin starch i.e. high starch digestibility) endosperm types. However, since this is essentially a gene function inactivation technology, it is necessary to know the gene(s) that are responsible for a trait and their chromosome location.
- The ability to rapidly and inexpensively sequence the genomes of sorghum and other crops and the associated identification of specific genes is contributing to bringing about a revolution in breeding efficiency through the application of Multi Trait-Assisted Genomic Selection (Multi Trait GS) (Fernandes et al., 2018). This technology enables a limited number of genetic markers to cover the whole plant genome so that all the selected QTLs (Quantitative Trait Locis) are linked to at a least one marker. For example, in a yield trial of the type currently being conducted by Grain SA for sorghum, performance data from lines in the trial can be used to inform and accurately predict the performance of related lines which were not themselves trialed with respect to a range of traits. In practical terms, this can mean that trialing just 20 lines will enable the performance of 400 lines to be accurately predicted.
- In the USA, as in Australia, trials of non-GM herbicide-resistant sorghum cultivars are currently taking place. According to Prof Bill Rooney, herbicide-resistant sorghum is potentially a game-changer with respect to reducing the yield gap in the USA between sorghum and GM maize. Also, according to Prof Rooney, commercial production of herbicide-resistant sorghum cultivars is apparently already taking place in Argentina.

7.3 Comparison of Main Sorghum Producing Countries and South Africa

The main sorghum farming areas in South Africa are Limpopo, Mpumalanga and the Free State. As has been previously stated, the area of sorghum planted has decreased significantly in the past few years, and yields have only increased marginally. At the same time, imports have also increased and exports declined.

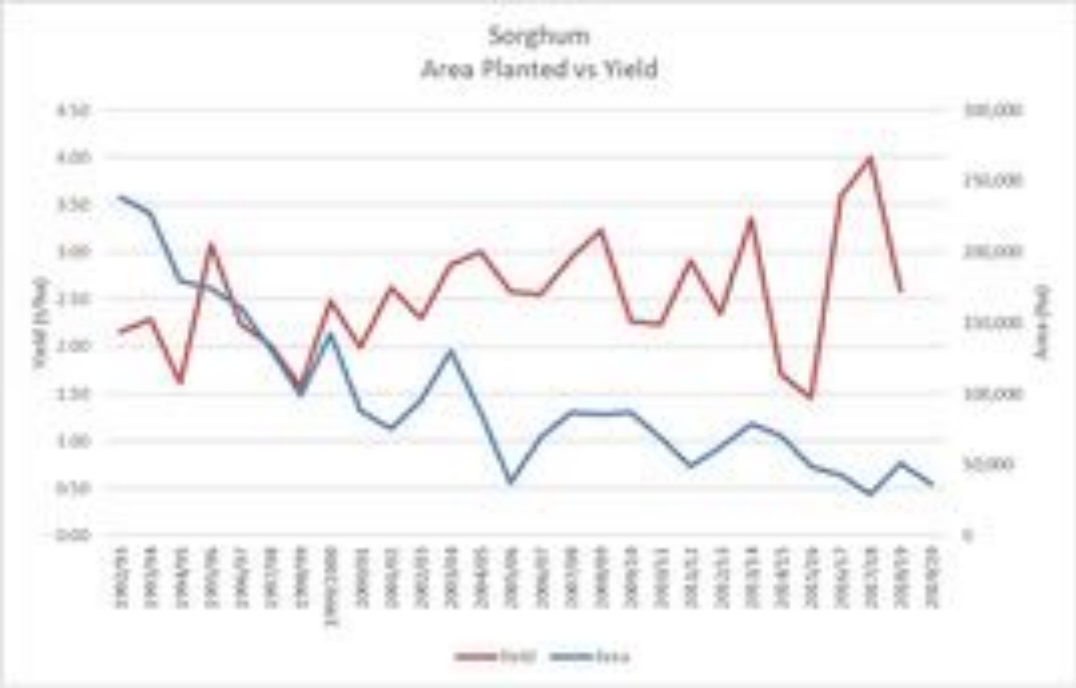


Figure 47: Sorghum Area Planted versus Yield, South Africa

Figure 48: Sorghum Imports and Exports South Africa

In the USA, sorghum is traditionally grown in the Sorghum Belt, which runs from South Dakota to Southern Texas, primarily on dryland acres. Farmers planted 5.7 million acres (2.3 million ha) and harvested 365 million bushels (9.3 million tons) in 2018. Sorghum farmers had another strong year, harvesting an average of 72.1 bushels per acre (4.6 ton/ha). Kansas and Texas are the main growing areas. In the USA, sorghum sells at a lower price than maize, thus increasing the competitiveness of the crop.

Figure 49: USA Sorghum versus Maize Prices

In Australia sorghum is one of the most significant summer grain crops, in terms of area sown and quantity of grain produced. It is a key feed grain for the beef, dairy, pig and poultry industries. Grain sorghum is generally produced on large agricultural enterprises (several hundred or thousands of hectares), as a dryland or irrigated crop, and it is grown in rotation with winter and summer crops (cereals, oilseeds and grain legumes) depending on climate and availability of soil moisture/irrigation. As is the case in the USA, sorghum prices in Australia are consistently lower than maize prices.

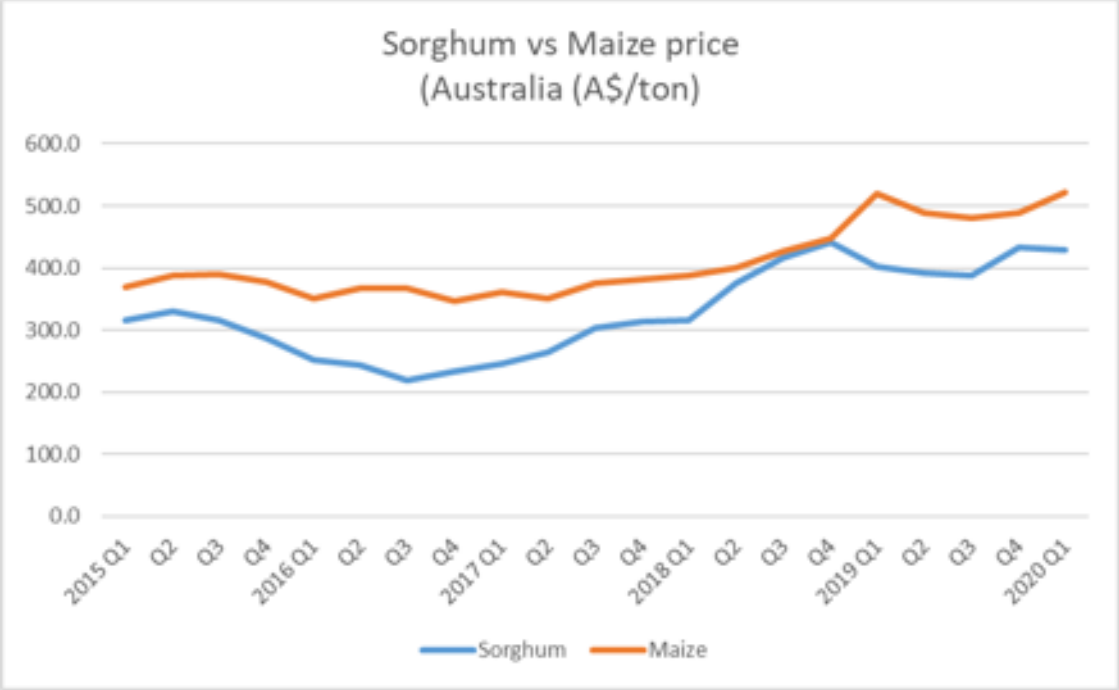


Figure 50: Australia Sorghum versus Maize Prices

The analysis of the sorghum industry in Australia and the United States, and the comparison thereof with sorghum production in South Africa indicates that there should be an opportunity to reduce the cost of sorghum production in South Africa to bring the sorghum price in South Africa to a level where it can compete more effectively with maize. Since price is one of the key drivers of adoption for both the farmers and the food processors, achieving this objective will greatly enhance the adoption of sorghum in the South African food value chain.

		NW Fee State	NW Fee State		East highland	NW Fee State		USA	Aus
Crop		IRR Maize	RR Maize		Sorghum	Sorghum		sorghum	Sorghum
Costs									
seed	R/ha	4,198.00	1,251.73		688.00	473.00		234.00	637.00
fertiliser	R/ha	9,930.00	3,538.15		3,235.00	2,833.00		1,275.00	1,844.00
Other	R/ha	15,661.56	4,855.93		5,497.89	3,935.93		5,743.00	3,552.64
	R/ha	29,789.56	9,645.81		9,420.89	7,241.93		7,252.00	6,033.64
Yield	t/ha	18.00	7.00		6.00	4.00		4.65	4.50
Variable costs	R/ton	1,654.98	1,377.97		1,570.15	1,810.48		1,559.57	1,340.81
Fixed costs		266.00	360.14		418.33	643.50		981.00	636.00
		1,920.98	1,738.12		1,988.48	2,453.98		2,540.57	1,976.81
Marketing costs		280.00	280.00		63.00	63.00			80.00
		2,200.98	2,018.12		2,051.48	2,516.98		2,540.57	2,056.81
Price		2,700.00	2,700.00		3,200.00	3,200.00		2,975.00	2,750.00
Profit		499.02	681.88		1,148.52	683.02		434.43	693.19
300ha	yield	5,400.00	2,100.00		1,800.00	1,200.00		1,395.00	1,350.00
		2,694,731.47	**1,431,956.42**		**2,067,332.75**	**819,621.54**		**606,030.00**	**935,809.28**

Figure 51: Comparison of Sorghum Cost of Production in RSA, USA and Australia

If a farm of 300ha is assumed, South Africa compares well with the USA and Australia in terms of the cost of production of sorghum.

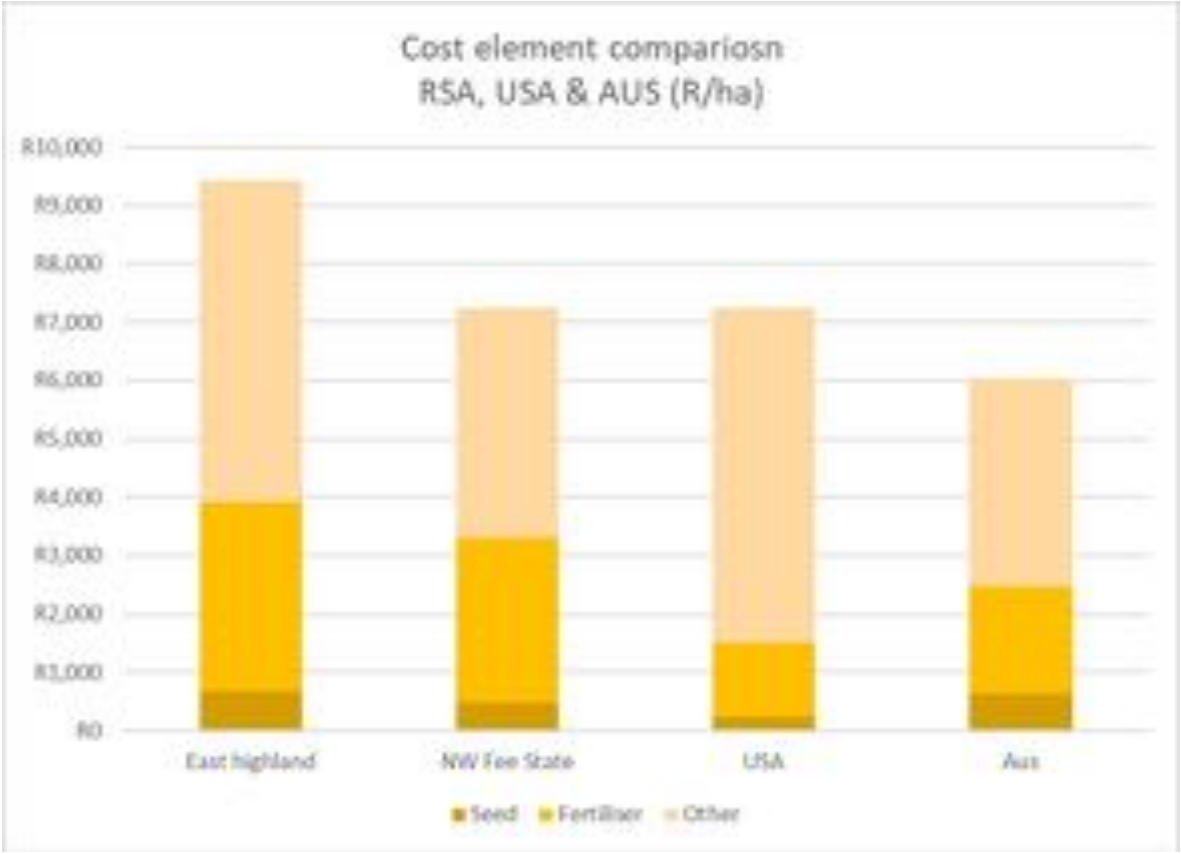


Figure 52: Production Cost Element Comparison – USA, Aus and RSA

Data for the analysis was extracted from various reports and crop budgets such as: 'Crop budgets' for USA developed by Justin Benavidez, Assistant Professor, Texas A&M AgriLife (USA) and 'Farm Enterprise budgets' from the Department of Primary Industries, NSW Government. (Australia)

7.4 Sorghum cultivars

The Table below lists essentially all current locally released red non-tannin (sweet) sorghum cultivars and their particular agronomic and end-use quality traits, plus selected US and Australian cultivars that have not been released locally but have potentially useful agronomic and end-use quality traits.
The survey of sorghum cultivars was restricted to red non-tannin (sweet-type) hybrid cultivars because: 1) Red non-tannin types have far greater end-use for both human food and animal feed than the red tannin (bitter) types (the end-uses for the latter are restricted to ruminant animal feed and indoor malting for industrial traditional African beer brewing), and 2) Hybrid cultivars consistently give higher yield than open pollinated varieties and are essential if sorghum is to be economically competitive with maize.

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
Early – Medium Maturing	**PAN 8950** (Available) **Enforcer** (Released) **Arrow** (Not Available **MR Buster** (Released) **MR Taurus** (Not available) **ADVG 3247** (Not available) **AG 1201** (Not available)	PANNAR (Corteva) AGRICOL, NuSeed (Australia) S&W Seeds (USA/Australia) K2, Pacific Seeds -Avanta Seeds (Australia) Pacific Seeds - Avanta Seeds (Australia) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)	Large kernel size	**PAN 8950** (Released) **PAN 8816** (Released) **Sentinel IG** (Not available)	PANNAR (Corteva) PANNAR (Corteva) Pacific Seeds - Avanta Seeds-(Australia)
Late-Medium Maturing	**PAN 8816** (Released) **NS 5655** (Released) **Arrow** (Not available) **AG 1203** (Not available)	PANNAR (Corteva) AGT Foods AGT Foods, S&W Seeds (USA/Australia) Alta Seeds-Avanta Seeds (USA)	Milling quality (kernel hardness or high test weight)	**AG 1201** (Not available)	Alta Seeds (USA)
Full season	**Enforcer** (Released) **Sentinel IG** (Not available)	AGRICOL, NuSeed (Australia) Pacific Seeds - Avanta Seeds (Australia)			
Suitability for dry conditions	**MR Buster** (Released)	K2, Pacific Seeds -Avanta			

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
and/or Drought tolerance	**AG 1203** (Not available) **AG 1201** (Not available**)**	Seeds (Australia) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)			
Cold tolerance	**PAN 8950** (Released) **Sentinel IG** (Not available)	PANNAR (Corteva) Pacific Seeds - Avanta Seeds (Australia)			
Leaf disease tolerance	**PAN 8816** (Released)	PANNAR (Corteva)			
Midge resistance	**MR Buster** (Released) **MR Taurus** (Not available)	K2, Pacific Seeds -Avanta Seeds Australia) K2, Avanta Seeds-Pacific Seeds (Australia)			
Sugarcane aphid resistance	**ADV 3247** (Not available) **AG 1203** (Not available) **AG 1201** (Not available)	Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)			
Smut and Fusarium tolerance	**PAN 8950** (Released) **PAN 8816** (Released)	PANNAR (Corteva) PANNAR (Corteva)			

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
General disease resistance	**Arrow** (Not available)	AGT Foods, S&W Seeds USA/Australia)			
Bird resistance	**MR Taurus** (some indication from Grain SA trials – Not available)	K2, Pacific Seeds -Avanta Seeds (Australia)			
High yield potential and yield stability	**PAN 8816** (Released) **Arrow** (Not available)	PANNAR (Corteva) AGT Foods, S&W Seeds (USA/Australia)			
Herbicide tolerance	**MR Buster** (N.B. Poor tolerance to Organophosphate type herbicides - Released) **Sentinel IG** (Tolerance/resistant to imidazolinone herbicides (non-GM trait- Not available)	K2 (Pacific Seeds -Avanta Seeds (Australia) Pacific Seeds - Avanta Seeds (Australia)			

Table 18: Desirable Sorghum Cultivar Agronomic and End-Use Quality Traits for Non-Tannin Red Hybrid Types

The South African developed cultivars, which are solely from PANNAR, are characterized by having smut and fusarium mold resistance. Additionally, attention has been given to their food processing (milling) characteristics, i.e. large kernel size and hard kernels. As noted above, in Australia and USA sorghum is primarily grown for animal feed where milling quality is not a quality criterion.

Currently essentially all the other locally available cultivars are from Australia. In terms of agronomic characteristics, perhaps the most useful is that of early maturing. Such cultivars, for example MR Buster, yield better in the drier production areas like the Springbok Flats in Limpopo than later maturing cultivars. Two potentially valuable agronomic traits were identified: 1) non-GM trait herbicide resistance (as discussed above) and 2) sugarcane aphid resistance. Examples are given of

sorghum cultivars with these traits from Australia and the USA, both being from subsidiaries of the Advanta Seed company, Pacific Seeds and Alta Seeds, respectively.

7.5 Marketing and Promotion of Sorghum

In countries such as the USA, EU and Australia, sorghum and the use of sorghum in various applications is actively promoted by industry organisations such as Sorghum CheckOff (America), SorghumID (Europe) and the Grain Sorghum Marketing Board (Australia). In South Africa, the Sorghum Forum is the main organisation that promotes the crop and the use thereof in various applications with the objective of developing the industry. However, the Forum's main industry support activities are funding of agronomic research and development and statistical production data.

7.5.1 Sorghum Checkoff

In the USA, agricultural Checkoff programs collect funds from producers of a particular agricultural commodity and then use these funds to promote and do R&D pertaining to the commodity. Checkoff programs attempt to promote the position of their commodity by expanding market opportunities, increasing demand and developing new uses. The United States Department of Agriculture is responsible for overseeing the formation of Checkoff organizations.

The United Sorghum Checkoff Program commenced in 2008 and has contributed enormously to the growth and development of the industry, with the program currently being managed by National Sorghum Producers organization.

Figure 53: Core Values of the Sorghum Checkoff Program, USA

The Sorghum Checkoff Program has a website (www.sorghumcheckoff.com) with a wealth of information to support producers, processors and buyers of sorghum. The program also hosts regular events where sorghum producers as well as sorghum product manufacturers can market their products, and where industry stakeholders can engage.

Figure 54: Sorghum Checkoff Program Website

While the use of sorghum for human consumption in the USA is currently only a small percentage of the total market, there are numerous sorghum products being manufactured in the USA. The image below shows some of the products currently being manufactured using sorghum.

Figure 55: Sorghum Based Food Products Manufactured in the USA

7.5.2 Sorghum ID

Sorghum stakeholders in Europe recently unanimously supported the creation of an organisation to promote of the interests of its sorghum industry and improve sorghum hybrid genetics for several end-uses (grain sorghum for food and feed, silage sorghum, sorghum for energy and other non-food uses). To this end, a European inter-branch sorghum organisation is being set up.

Sorghum ID (Sorghum – International Development) is the name of this association, whose constitutive assembly was held on 26 September 2017 in Brussels in the Copa-Cogeca building, and whose headquarters are also located in Brussels.

This Assembly brought together various organisations and companies along the sorghum value chain from many European countries (the European Union as well as eastern Europe) in order to develop European production of sorghum (grain – silage – energy) and its hybrid genetics with an action plan based on:

- Representing and promoting the interests of sorghum vis-à-vis national and European institutions, consistently with the other main crops;
- Implementing promotion actions that demonstrate the technical and economic assets of sorghum in terms of production;
- Promoting the potential uses and outlets of sorghum for human food, animal feed and non-food outlets;

- Bringing together and mobilising potential stakeholders to build synergies and gather momentum in the long term.

The Sorghum ID website (www.sorghumID.com) contains large volumes of information on the sorghum industry, including up to date news on developments in the industry, as well as opportunities for sorghum producers.

Figure 56: Sorghum ID Website

Part 7:
Upgrade of the Value Chain

8 Upgrade of the Value Chain

8.1 Introduction

The key challenge that the sorghum industry faces is that its traditional African beer market in South Africa is declining and rapidly being substituted by western style lagers and other alcoholic beverages. The currently available, short shelf life-type traditional African beer only remains a regular beverage amongst middle aged and elderly males in the lowest LSM groups and more widely only during celebratory events such as weddings and funerals or other social events and gatherings. It is fast losing its attractiveness amongst the younger and more affluent population. The fact that it has a short shelf-life and is sold in a fermenting state are major deterrents to its distribution and stock holding by retail outlets.

Positive developments include the formulation of a pasteurised alternative such as the Chibuku Super and other pasteurised clear beer derivatives, both which have a similar shelf-life to lager beer and other alcoholic beverages and should find a ready market in South Africa. These developments are being pursued by UNB as a subsidiary of Delta Corporation in Zimbabwe.

Another positive development with respect to expanding consumption of sorghum foods is the increasing scientific evidence of sorghum's health-promoting attributes and its gluten-free and GMO-free nature. Health-conscious consumers will be attracted to these attributes. A number of new products continue to appear on the market and while the demand in relative terms is small, it appears to be growing in regions such as the USA and Europe at a rate that considerably exceeds the GDP growth.

The upgrade of the sorghum value chain needs to be aligned to the sorghum industry opportunities and address the industry challenges that are preventing it from capitalising on these opportunities.

8.1.1 Opportunities

As stated, the opportunities that have been identified include:

- **Import replacement**. Immediate replacement of imported sorghum, which amounts to 40,000-70,000 tpa depending on seasonal local production and availability. This will support the establishment of new productive capacity and lead to creating employment opportunities in the agriculture sector. It also will create new value add and not substitute any other locally produced grain.

- **Targeting the export market.** It is evident that the USA and Argentina are exporting large amounts of sorghum to the African continent. The USA exported a total of US$80 million worth of sorghum or 370,000 tons, to the African continent in 2018/19 season. Kenya is the leading importer of sorghum in East Africa and is a readily accessible market for South African sorghum growers. The value of sorghum imports increased from US$31million in 2018 to

US$39million in 2019. On the other hand, Kenya also exports sorghum to its neighbouring countries and exports represent circa 50% of the imports. Although it is not confirmed, it appears that Kenya imports sorghum for re-export to countries such as South Sudan (63%) and Uganda (35%). Uganda is a landlocked country and dependent for its imported products via Mombasa in Kenya. Logistically, the South Sudan region is closer to Mombasa than the Port of Sudan in the north. The projected prices for sorghum in 2020 ranges from R2550 to R3910 per ton. It therefore makes sense to consider export of sorghum to the region as it represents an estimated 200,000 ton per annum market opportunity. South African exporters will have a distinct geographical advantage over the USA and Argentina exporters in terms of transport costs.

The export of sorghum to Kenya can be investigated together with other export opportunities such as soybeans or maize to benefit from established trade relationships and trade experiences. The finalisation of the Africa Free Trade Agreement could also benefit exports of South African products to East Africa. Uganda is part of East Africa Community and enjoys beneficial trade relations with Kenya for throughfare of products and commodities imported via Mombasa.

- **Exporting value added products**. The most valuable sorghum product exported to African countries is traditional African beer powder representing a market of 5,300 tons per annum in 2019. Growing this market by 10% per annum, however, will add a mere 530 to 600 tons per annum. Although this market should not be neglected, it is not considered one of the key drivers of potentially re-stimulating the sorghum industry in South Africa.

- **Growing the consumer market.** The total consumer demand for sorghum products in South Africa (both malt for brewing and meals and flours) requires currently an annual production of 180,000 tons of sorghum per annum. Educating the market through product promotions, advertisements and consumer education in respect of the nutritional and health-promoting properties of sorghum products could stimulate demand. The development and introduction of new products, such as breakfast cereals and snacks could also support market growth. Achieving a 5% annual growth in demand would be considered a good achievement and will add circa 9,000 to 10,000 tons per annum to the national sorghum production. In all likelihood, the sorghum products will replace other home-grown and produced products resulting in a relatively small net gain in benefit for the country.

  The development of sorghum as a staple food for rural communities is, however, worthwhile considering as part of a growth plan for sorghum.

- **Replacement of maize in animal feeds**. In order to achieve this, the challenge would be to produce sorghum at prices that are up to 15% below that of yellow maize. Yellow maize for animal feed is imported into Cape Town routinely at a large scale as it is cheaper than moving it from inland. In 2019/20, yellow maize imports into Cape Town amounted to 510,000 tonnes with 460,000 tonnes originating from Argentina and 50,000 tonnes from Brazil. The imports

of yellow maize are, however, erratic and mostly driven by seasonal fluctuations in local production to supplement local production to meet animal feed demand. This is therefore not considered an immediate a sustainable market opportunity. The substitution of maize with sorghum will not necessarily add value to the local economy and there is not a compelling argument for the feed industry to consider such as substitution at this stage. A dramatic reduction in cost of sorghum production or commensurate increase in sorghum yields would be required to drive this conversion. It would then most likely be that existing farmers will allocate more farmland to sorghum to meet this demand. Overall, it is not seen to be creating new productive capacity with the associated required increase in employment and social impact that is sought from a sorghum growth strategy. Long term climate change and loss of grain producing areas in South Africa would indicate that these developments need to be monitored in the event that the country is forced to find a suitable alternative to maize.

- **New beers.** As stated, UNB indicated that it intends to launch new sorghum-based beer products in the foreseeable future. The market success in South Africa of Corona brand beer from Mexico over the last 3 years is a case in point of what can be achieved with the introduction of a new beer brand.
    - Imported beer from Mexico accounted for 94% of all malt (clear-type) beer imported into South Africa in 2019
    - The imported beer grew from nothing in 2017, to R50million in 2018 and a whopping R480 million in 2019.
    - Volumes grew from 2,187 kl in 2018 to 20,593 kl in 2019.
    - Average landed price is R23 per litre.

The success of sorghum-based lager beer in East African countries has been due to it being cheaper than barley lager. With the high unemployment levels in South Africa, the opportunity is for a cheaper bottled beer as many people are currently trading down. The above-mentioned example of Corona beer serves merely as an illustration of what can be achieved with aggressive marketing and promotion, and it should be noted that the aim is not to compare sorghum lager, which is a cheaper beer, with a premium beer such as Corona.

Notably there may also be an opportunity to target this market with a high value-added local beer and why can it not be a sorghum-beer? It would require a detailed study though and UNB might already be well advanced with their new clear beer brands that could target this market.

The projected impact of a successful new beer in the local market based on sorghum could be as much as 20,000 to 40,000 ton per annum. It remains pure speculation at this juncture but worth some further investigation.

Such a project could also lead to the introduction of sorghum in the Eastern Cape and the engagement of emerging commercial farmers in an out-grower programme whereby the farmers are empowered and contracted to grow sorghum for a local brewery in the Eastern Cape. In such event, it is also proposed that the brewery engage the farmers and provide them with the seed and fertiliser requirements and extension support – the cost of which is only deducted from the purchase price once harvested and collected by the brewery. Extension services provided by the provincial Department of Rural Development and Agrarian Reform should be included in the support provided to these farmers.

In fact, The Eastern Cape sorghum farmers have received support previously from Diageo and the Coca Cola Foundation.

8.1.2 Summary

On their own, each opportunity has merit and worthwhile pursuing. Combined, these sorghum market opportunities identified herewith, amounts to 348,000 tons per annum on the upside and 219,000 ton per annum conservatively.

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement	40,000	70,000
East Africa export	150,000	220,000
Beer	20,000	40,000
Consumer food	9,000	18,000
TOTAL potential	**219,000**	**348,000**

Table 19: Quantification of Market Opportunities

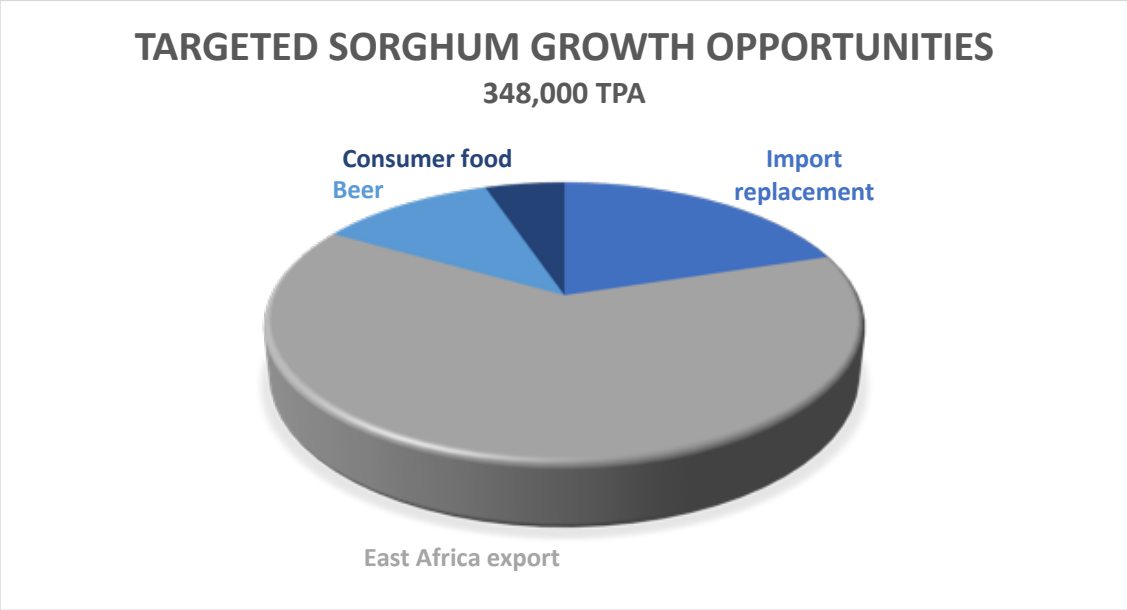


Figure 57: Targeted Sorghum Opportunities

8.2 Actions to Upgrade the value chain

For the sorghum industry to achieve its potential in the local market and potentially target the more challenging market opportunities identified above, it has to take serious steps to reposition itself to produce and compete effectively in both these markets.

Upgrading the value chain requires the following actions:

- **Competitive position of sorghum in the grains industry**. Increase the competitive position of sorghum in the local and international grain and sorghum industry specifically. The current local production costs and yields of sorghum do not support sorghum's competitive position in the market. Cultivar development programmes are needed to develop new germplasm that can improve yield and drive down production costs, such as pest resistance and better adaptation to climate change. The target price for sorghum should be in the region of R2,500 per ton.

    - Support of the local cultivar development programmes should be developed as part of the implementation plan and include players such as the seed companies, the ARC and institutions such as GrainSA and SAGL, and Universities such as UKZN and UFS.
    - The comparisons with the USA and Australia position of sorghum relative to maize in these countries points to the possibility that in South Africa, this should be achievable.

- **Industry structure.** The local market for sorghum is dominated by a single manufacturer of a range of sorghum-based products. The market dynamics associated with this monopolistic structure of the industry impacts on the local producers and affects the ability of smaller manufacturer to effectively compete for local supply of sorghum. These smaller manufacturers also do not have the luxury of readily importing sorghum from USA or Argentina or stockpiling the sorghum at the end of the harvest season. The introduction of a pricing mechanism will assist the local farmers and contribute towards the smaller manufacturers also having a fair opportunity to source sorghum at competitive prices and gain access to production loans.

- **Market related price fixing mechanism.** Establishing a market related price finding mechanism such as SAFEX. Due to the very low volume of sorghum traded on the open market, the SAFEX mechanism does not function optimally. Prices are either too high (based recent trends) at the end of a season or at the beginning of the season too low. Both these extreme prices have a negative effect on the industry. Due to these fluctuations, the benchmark price used is 15% below the SAFEX price of yellow maize. Using this price places the smaller farmers at a disadvantage as they need to raise production loans for the growing season. Production loans based on this price are insufficient to cover the production costs that the farmer has to incur. The result is that smaller farmers are not able to enter the market.

- **Food product development.** Research institution (e.g. CSIR) and university food scientists and the food manufacturers in South Africa should be encouraged to work in partnership develop and promote new food applications for sorghum to maximise the health benefits of sorghum-based foods. Key drivers for adopting sorghum by the food manufacturers, is in the first instance the consumer demand/pull. The US Sorghum Checkoff Program's promotion of sorghum is a good example of more aggressive promotion that could be implemented on the South African Sorghum Trust website to promote and encourage increased use of sorghum in the consumer food basket. The competitive position of sorghum products will be enhanced if the food manufacturers are able to meet their targeted profit margins. This would require that the price of sorghum be more competitive and this links to the first requirement of upgrading the sorghum value chain.

Figure 58: Range of Sorghum Based Snacks Produced in USA

Figure 59: Range of Sorghum Based Cereals from the USA

- Other activities that can contribute towards upgrading the sorghum value chain include the development of applications and food recipes using modern processing technologies. The development of extrusion cooking processes enables the production of pre-cooked and processed grain products at much reduced costs by directly processing the milled grain through an extruder to produce a pre-cooked porridge flour, breakfast cereal or snack, cutting out the wet cooking step. The twin-screw extruder technology developed by CFAM in Potchefstroom is a case in point.

Figure 60: Sorghum Products Produced by Twin Screw Extrusion Technology

- The application of this technology enables small production facilities to be located within the communities that produce the raw materials. This will support the establishment of sustainable businesses and farmers in smaller communities. The RED Hubs in the Eastern Cape can be used as a possible hub for the establishment of a 30tper day processing plant that can support the production of circa 7,000 ton of sorghum per annum from 3,330 ha of farmland.

8.3 Downstream and Upstream Linkages and Potential End-users

The information in this section is primarily from the numerous interviews with persons operating at all the stages of the sorghum value in South Africa and internationally, from breeders to farmers to processors to influencers of consumer purchasing behaviour.

The market opportunities for South African sorghum can be divided into export (Africa and international) and local. The status of the linkages between farmers and these market opportunities are detailed in Figure 61 and Figure 62, respectively.

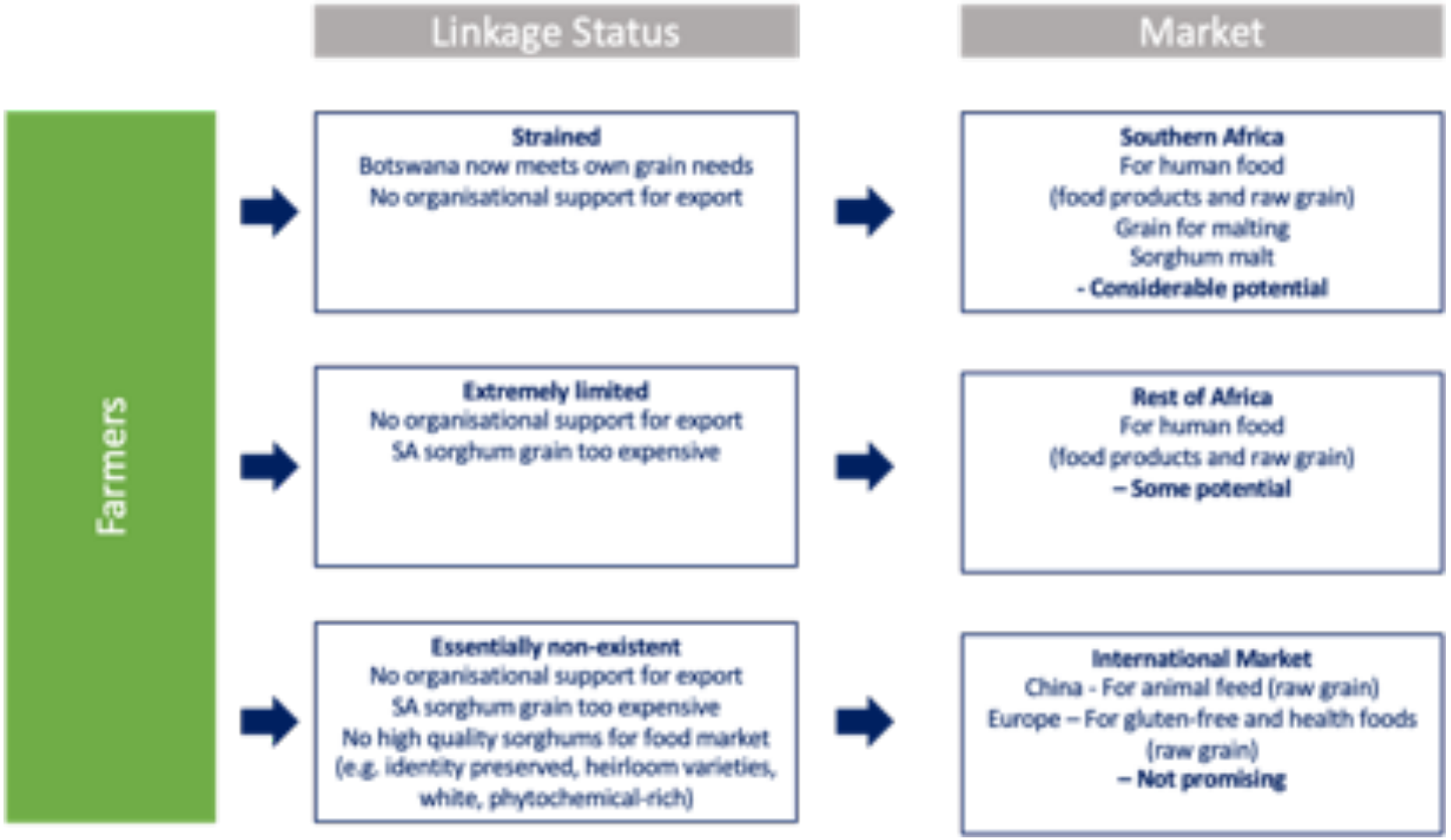


Figure 61: Downstream Linkages for South African Sorghum Exports

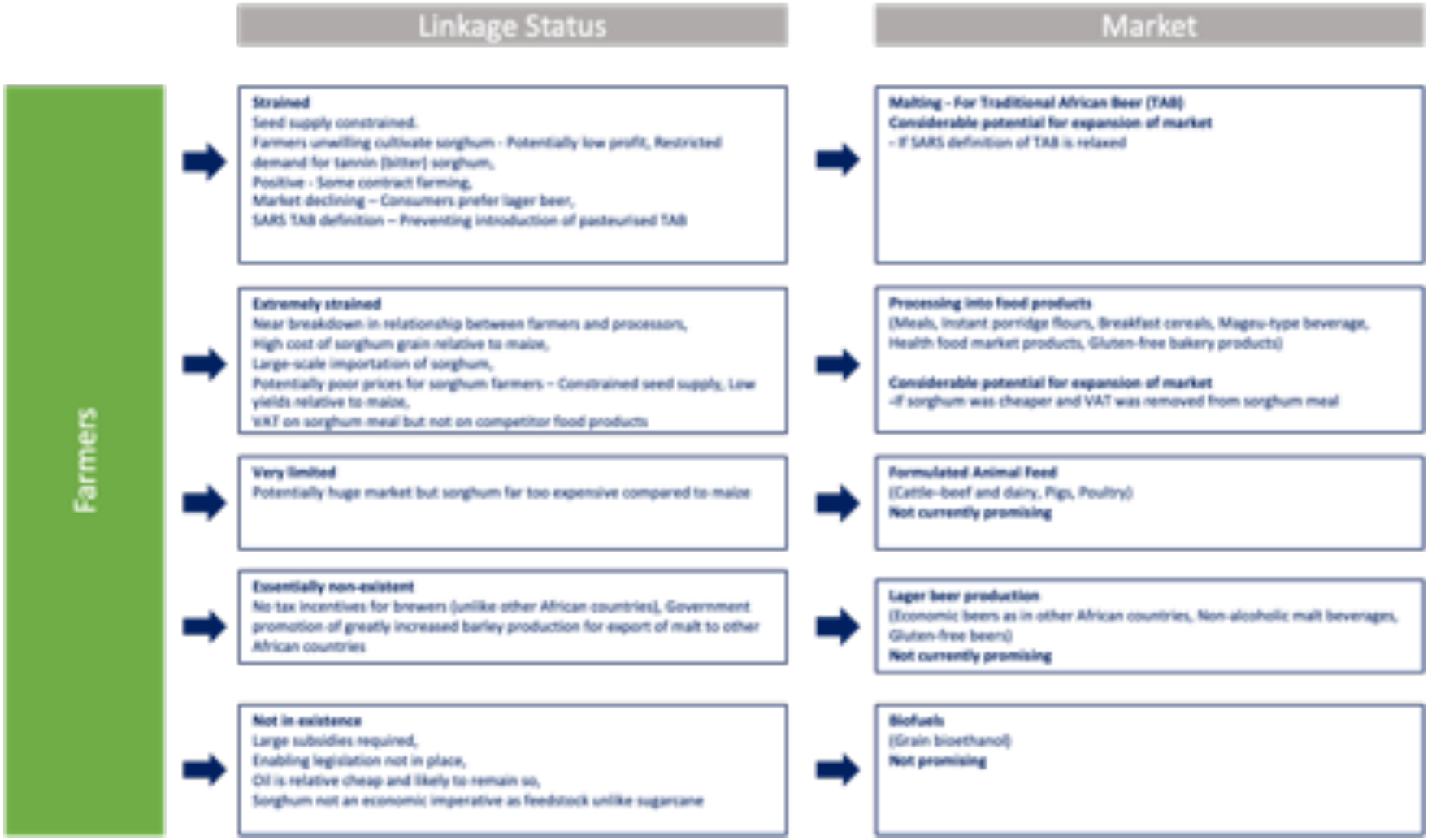


Figure 62: Downstream Linkages for Local Sorghum Markets

Globally, the largest international export opportunities for sorghum are to China for animal feed and to Europe for human food. However, as can be seen, neither is at all promising for South African producers. This is because South African sorghum cannot compete in terms of price with sorghum from the USA and Australia, nor does South Africa does not produce specialty food-type sorghums and because the USA and Australia have organisations like the Sorghum Checkoff Program (USA) and AEGIC (Australia) that actively promote grain export. They do this by providing financial services and technical support that make the linkages that enables them to export grain to particular markets.

The African market can be divided into Southern Africa and the rest of Africa (Figure 61). Here there is much more potential but, as set out in the status of the linkages, the constraints are the high cost of South African sorghum grain (compared to that from the USA) and also of finished food products and also again the lack of a support organisation.

The local market for sorghum, although potentially very large and diverse (Figure 62) is currently severely limited as set in the status of the linkages. This is due to two general problems:

1. The intrinsically high cost of locally produced sorghum grain relative to maize, which makes sorghum food products more expensive than similar maize products and essentially completely prevents sorghum from being used as an animal feed grain. This is totally different from the situation in other countries like USA, Australia, Argentina, Brazil and France where sorghum is competitively price relative to other feed grains. Moreover, the high cost of locally produced sorghum and problems with supply have contributed to food processors to now importing around 40% of their sorghum grain requirements. At the same time, many farmers consider that the prices being offered by processors are simply not adequate to make sorghum farming profitable. This has resulted in farmers turning to other more profitable crops, notably maize and soybeans, further limiting supply. Unfortunately, these issues have resulted in a near breakdown in the relationship between producers and major food processors, which has further exacerbated the problem.
2. Unfair and restrictive taxation. Sorghum grain and sorghum meal carry 15% VAT whereas competitor products like maize meal, wheat flour, rice and standard brown and white bread are zero rated. Traditional African beer (TAB) which is produced with sorghum malt is subject to minimal excise duty unlike lager beer. However, technological improvement of TAB product to make it more attractive to consumers by producing it as pasteurised long-life beer is prevented by the restrictive SARS definition of TAB.

Of the two issues, the intrinsically high cost of sorghum produced in South Africa is the by far the more serious and intractable. To understand why South African sorghum grain is relatively very expensive, the weaknesses in the upstream linkages need to be understood (see Figure 63).

Figure 63: Upstream Linkages in the South African Sorghum Value Chain

Two issues will be highlighted.
The National Agricultural Research System, with the exception of Universities, is very under resourced with respect to sorghum. Critical activities like breeding for improved agronomic traits resistance to locally important sorghum diseases such as aphids and fungal smut is essentially not taking place and the system of bird pest control is no longer functioning effectively. In contrast, university training of sorghum agricultural scientists by the University of KwaZulu-Natal's Africa Centre for Crop Improvement (ACCI) and the University of the Free State are notable success stories. However, one area of weakness is that training in molecular breeding and sorghum genomics is not generally state of the art.

Primarily, because the sorghum market in South Africa has become so small relative to the maize and soybean markets, the local seed companies have ceased to develop new hybrid cultivars. The country is now increasingly reliant on old local cultivars and newer cultivars from Australia. These old cultivars do not have the required yield potential and the imported cultivars often do not have the required resistance to locally important diseases and are not well adapted to some South African environments, for example where cold tolerance is required.

In combination, all the factors set out in Figure 63 are contributing to sorghum produced in South Africa being increasingly more expensive than locally produced maize and compared to sorghum produced by major grain countries, the USA, Australia, Argentina and Brazil and smaller producers such as the Ukraine.

8.4 Production Systems and Varieties

Three general production systems can be distinguished: Traditional small-holder farming, Intensive limited mechanization farming and Intensive highly mechanized farming (Taylor, 2019). In traditional small-holder farmer systems, animal traction and manual labour are used. Open pollinated varieties (OPVs) are cultivated, which enable the farmer to keep the seed for replanting. Today, improved varieties with better yield potential and disease resistance are rapidly replacing the local landraces. However, fertilizer use is generally very low and pesticide and herbicide use is minimal. Hence, yields remain chronically low (Table 20), with average yields of around 1 ton/h. This type of agriculture is still the norm for sorghum agriculture in India and across Africa, with the exception of South Africa and some sorghum cultivation in Botswana and elsewhere, for example Sudan.

Country	Sorghum yield (tons/ha)	General production system
South Africa	2.82	Fully mechanised agriculture, rainfed, hybrids, high inputs
Argentina	4.37	Fully mechanised agriculture, rainfed, hybrids, high inputs

Country	Sorghum yield (tons/ha)	General production system
Australia	2.86	Fully mechanised agriculture, rainfed, hybrids, high inputs
Brazil	2.71	Fully mechanised agriculture, rainfed, hybrids, high inputs
USA	4.59	Fully mechanised agriculture, rainfed, hybrids, high inputs
Kenya	0.82	Traditional manual agriculture, rainfed, mainly landraces, low inputs
India	0.86	Traditional manual agriculture, rainfed, improved OPVs, low inputs
Nigeria	1.17	Traditional manual agriculture, rainfed, mainly landraces, low inputs
Sudan	0.65	Traditional manual agriculture, rainfed, improved OPVs, low inputs
Zambia	0.69	Traditional manual agriculture, rainfed, mainly landraces, low inputs
China	4.65	Intensive limited mechanisation agriculture, rainfed, improved OPVs, high organic fertilizer inputs

Table 20: Sorghum Yields in Tons per Hectare in Various Countries

Note: Average over 5 years, 2014-2018, using different agricultural production systems (FAOSTAT data).

In intensive limited mechanization farming, tractors are used for ploughing and mechanical threshing and winnowing is widely used. However, much manual labour is still utilized, especially for weeding. Improved OPVs are also the norm. There is also some use of hybrid sorghum cultivars. Most importantly, fertilizer use is high, capitalizing on the higher yield potential of these improved varieties. Hence, sorghum yields are much higher than with traditional small-holder agriculture. Intensive limited mechanization farming is the norm for sorghum and millets in Eastern Asian countries, notably China (Table 20), accounting for its exceptionally high yield, >4 tons/ha.

In intensive highly mechanized farming, virtually all the farming operations are mechanized including combine harvesting. With sorghum, hybrid cultivars are the norm. This farming system is generally

characterized by high use of inorganic fertilizer and integrated use of herbicides and pesticides. Sorghum yields are much higher than with manual farming systems, on average 2.5-4.5 tons/ha (Table 20), depending on soil and climatic conditions (chiefly rainfall) which affect planting density, cultivars and inputs. Intensive highly mechanized sorghum is essentially universal in countries such as the USA, Argentina, Brazil, Australia, Italy and France and in commercial farming in South Africa.

From the above, it is clear that emerging commercial farmers in South Africa who wish to cultivate sorghum will need to use the highly mechanized-type production system in order to be competitive and have a viable business. Where such farmers only have small land holdings, groups of farmers will have to combine their adjacent holdings together to obtain land areas large enough to enable, for example, combine harvesting. This type of development is already starting to take place in the Eastern Cape.

Regarding sorghum varieties, it is also clear from the above that hybrid sorghum cultivars must be used in order to be competitive. The current problems with availability of suitable cultivars in South Africa are described in 8.3 above.

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
Early – Medium Maturing	**PAN 8950** (Available) **Enforcer** (Released) **Arrow** (Not Available **MR Buster** (Released) **MR Taurus** (Not available) **ADVG 3247** (Not available) **AG 1201** (Not available)	PANNAR (Corteva) AGRICOL, NuSeed (Australia) S&W Seeds (USA/Australia) K2, Pacific Seeds -Avanta Seeds (Australia) Pacific Seeds - Avanta Seeds (Australia) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)	Large kernel size	**PAN 8950** (Released) **PAN 8816** (Released) **Sentinel IG** (Not available)	PANNAR (Corteva) PANNAR (Corteva) Pacific Seeds - Avanta Seeds- (Australia)

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
Late-Medium Maturing	**PAN 8816** (Released) **NS 5655** (Released) **Arrow** (Not available) **AG 1203** (Not available)	PANNAR (Corteva) AGT Foods AGT Foods, S&W Seeds (USA/Australia) Alta Seeds-Avanta Seeds (USA)	Milling quality (kernel hardness or high test weight)	**AG 1201** (Not available)	Alta Seeds (USA)
Full season	**Enforcer** (Released) **Sentinel IG** (Not available)	AGRICOL, NuSeed (Australia) Pacific Seeds - Avanta Seeds (Australia)			
Suitability for dry conditions and/or Drought tolerance	**MR Buster** (Released) **AG 1203** (Not available) **AG 1201** (Not available**)**	K2, Pacific Seeds -Avanta Seeds (Australia) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)			
Cold tolerance	**PAN 8950** (Released) **Sentinel IG** (Not available)	PANNAR (Corteva) Pacific Seeds - Avanta Seeds (Australia)			
Leaf disease tolerance	**PAN 8816** (Released)	PANNAR (Corteva)			
Midge resistance	**MR Buster** (Released) **MR Taurus** (Not available)	K2, Pacific Seeds -Avanta Seeds Australia)			

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	**Seed company**		**Cultivar**	**Seed company**
		K2, Avanta Seeds-Pacific Seeds (Australia)			
Sugarcane aphid resistance	**ADV 3247** (Not available) **AG 1203** (Not available) **AG 1201** (Not available)	Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA) Alta Seeds-Avanta Seeds (USA)			
Smut and Fusarium tolerance	**PAN 8950** (Released) **PAN 8816** (Released)	PANNAR (Corteva) PANNAR (Corteva)			
General disease resistance	**Arrow** (Not available)	AGT Foods, S&W Seeds USA/Australia)			
Bird resistance	**MR Taurus** (some indication from Grain SA trials – Not available)	K2, Pacific Seeds -Avanta Seeds (Australia)			
High yield potential and yield stability	**PAN 8816** (Released) **Arrow** (Not available)	PANNAR (Corteva) AGT Foods, S&W Seeds (USA/Australia)			
Herbicide tolerance	**MR Buster** (N.B. Poor tolerance to Organophosphate type herbicides	K2 (Pacific Seeds -Avanta Seeds (Australia)			

AGRONOMIC TRAITS			END-USE QUALITY TRAITS		
	Cultivar	Seed company		Cultivar	Seed company
	- Released) **Sentinel IG** (Tolerance/resistant to imidazolinone herbicides (non-GM trait- Not available)	Pacific Seeds - Avanta Seeds (Australia)			

Table 21: List of Examples of Red-Non-Tannin (Sweet) |Hybrid Sorghum Cultivars

Note: The list contains red non-tannin (sweet) hybrid sorghum cultivars currently released in South Africa setting out their useful agronomic and end-use quality traits and of selected cultivars that are not currently available that have potentially useful agronomic and end-use quality traits.

8.5 Cost Benefit Analysis

As explained, in order to capitalize on market opportunities that were identified in the chapter on Market Opportunities, the cost of production of sorghum needs to come down to the level where the sorghum grain can be sold at competitive prices to maize. It is therefore necessary to clearly identify the programmes, steps and investments needed to achieve the targeted yield and/or cost reduction for sorghum farmers to encourage these farmers to remain in the market and produce.

The benefit of this investment will be quantified in terms of the following parameters:

1. **Socio economic benefit**
   - It is envisaged that the revival and growth of the sorghum industry will include an element of smallholder farmer engagement, such that their livelihood and food security can be addressed in a meaningful way. Such a programme can include for example, the establishment of a sorghum brewery in the Eastern Cape and engaging numerous smallholder farmers in the area in an out-grower programme. The cost-benefits of a commercial farming operation versus outgrowing operations using smallholder farmers where the inputs are paid for by the off-taker need to be quantified.
2. **Increased sorghum production**
   - The cost-benefit of increased sorghum production, assuming that the yield and return requirements for farmers can be achieved at their targeted prices, will be determined in terms of the increased land utilization, employment and investment in productive commercial agriculture. This will be aligned to the market opportunities identified in the chapter on the Establishment of Market Opportunities.
3. **Increased industrial sorghum processing**
   - The impact of the increased sorghum availability as a result of improved farming operations will create additional employment in the value chain, as well as additional investments. The cost-benefit of smaller decentralized manufacturing or food processing

facilities utilizing modern technology, such as twin-screw extrusion cooking, will also be investigated, specifically with the view that these decentralized facilities will create local employment opportunities and logistic cost savings.

4. **Trade Balance Gain**
   - If the competitiveness of South African sorghum can be improved, the capitalization on the export market opportunities in East Africa, and the replacement of imports, could introduce an export earnings and forex saving that results in a net forex gain of as much as R837 million per year.

The cost-benefit analysis of government investment in the primary driver of the value chain initiative, which is the yield improvement or cost-reduction of the farm, accompanied by other measures as proposed in this report (removal of VAT, broadening the definition of traditional African beer, etc.), will be determined as the contribution that this upgrade programme will have on the government income via taxes and duties.

The main focus of the last phase of the project is on quantifying and qualifying the cost-benefit analysis in terms of the above and incorporating that into the implementation plan. The following Table represents a very high-level benefit analysis that the opportunities that have been identified can present in terms of contribution to GDP (agriculture and manufacturing), employment, taxes and forex savings and earnings.

Benefit in numbers	Annual GDP and tax benefits					
Assumption	**Develop market opportunities for circa 348 000 tons of primary sorghum products**					
Primary production benefit	Agriculture/farm	Price	R2,900	348,000.00	ton	R1,009,200,000
Trade balance						
Forex saving	Import replacement	Price	R4,100	70,000.00		R287,000,000
Export			R2,500	220,000.00		R550,000,000
NET FOREX GAIN						**R837,000,000**
Manufacturing						
Local value add	Beer	Price	R26,100	40,000.00		R1,044,000,000
	Consumer foods	Price	R40,000	18,000.00		R720,000,000
TOTAL VALUE ADD						**R1,764,000,000**
Employment						
Primary production	Farms	ha	53,538	0.25		13,385
Downstream	Processing	tons	58,000	0.50		2,417
Indirect	Services, utilities etc			2.00		31,603
TOTAL NET EMPLOYMENT						**47,404**
TAX						
excise duty				1.80%		R18,792,000
VAT				15%		R264,600,000
TOTAL TAX GAIN						**R283,392,000**
Contribution to GDP						
Agriculture						R1,009,200,000
Manufacturing						R1,764,000,000
TOTAL GDP contribution						**R2,773,200,000**

Table 22: Potential Benefit of Sorghum Value Chain Upgrades

Part 9:
SWOT Analysis

9 SWOT Analysis

The Situational Analysis that was conducted during the first phase of the study contained a comprehensive SWOT analysis of the sorghum industry, however, throughout the course of the study new information has come to light. This section contains an updated SWOT analysis which incorporates opportunities identified later in the study.

9.1.1 Strengths

1. **Nutritional benefits of sorghum**

   Sorghum holds various nutritional and health benefits (discussed previously in the document). Some of which include:

   - The starch in sorghum food products can be slowly digestible;
   - Its consumption may prevent of Type 2 diabetes and cardiovascular disease; and
   - Rich source of phenolic phytochemicals which contribute protection against oxidative stress, have anti-obesity, anti-inflammatory and antihypertensive properties, and protect against Type 2 diabetes and may be protective against certain cancers.

   The nutritional quality of sorghum is classed both as a Strength and an Opportunity. It is imperative that more emphasis be laid on the nutritional value of sorghum, and that the consumer market be made aware of the health benefits of the crop.

2. **Agricultural production of sorghum**

   South Africa has experienced commercial sorghum farmers available that understand sorghum farming practices. At its peak, in the mid-eighties more than 300,000 hectares of sorghum was planted. However, as producers switched to more profitable crops like maize and soybeans, sorghum production decreased dramatically over the past two decades. In the 2010/11 marketing year, South Africa was self-sufficient in sorghum production and was a net exporter of sorghum, indicating that South African farmers have the capacity to enable the country to be at least self-sufficient in sorghum production.

   Furthermore, the Sorghum Forum, the sorghum stakeholder's organisation is actively supporting GFADA, the Grain Farmer Development Association assist emerging commercial sorghum farmers to efficiently cultivate sorghum.

3. **Experienced sorghum food and beverage manufacturing sector**

   South Africa has a well-developed food and beverage manufacturing sector, with an abundance of manufacturing and processing companies. There are numerous companies that have processed sorghum over the years into a variety of products such as meals, instant porridges, flours, alcoholic and non-alcoholic beverages and even bakery products and snack foods, with 114 registered companies in the sorghum industry. The major players in the processing of sorghum include companies such as Tiger Brands, RCL Foods, Bokomo and Pride Milling, United National Breweries.

4. **World-class research and development work on sorghum in the areas of plant pathology, food science & technology and phytochemicals**

Research and development in the sorghum industry in South Africa is conducted a number of institutions, including:

- Agricultural Research Council:
  The operations of the Grains and Industrial Crops division of ARC are carried out through the following business units:
    - *ARC-Grain Crops Institute (Potchefstroom)*
    - This unit works towards the improvement and cultivation of grain crops - for example summer grains such as maize, sorghum and millet, as well as oil and protein seeds such as sunflower, groundnut, soybeans, dry beans, cowpeas, sweet white lupin and bambara. With respect to sorghum, research activities cover plant breeding, the evaluation of cultivars, plant physiology, tillage, weed science, plant pathology, entomology and yield potential.
- The Council for Scientific and Industrial Research (CSIR)
  The CSIR is a world-class African research and development organisation established through an Act of Parliament in 1945. The CSIR undertakes directed, multidisciplinary research and technological innovation that contributes to the improved quality of life of South Africans. With respect to sorghum, the CSIR develops new technologies that are then made available for licensing, such as the instant sorghum based dry pre-mix containing milled vegetable ingredients. Additionally, the CSIR has experience and capacity in sorghum biotechnology, including recombinant DNA technology (genetic engineering).
- The Sorghum Trust:
  After the termination of the Sorghum Board in 1997, all funds of the Sorghum Board were transferred to the Sorghum Trust. Such funds became the discretionary funds of the Sorghum Trust, governed by the Trustees in terms of the Trust Deed. The main objective of the Sorghum Trust is to maximise the income of the Trust and to provide funding for the benefit of the Sorghum Industry - in particular for sorghum research & development projects and the maintenance of information required by the Sorghum Industry. The funds are used to support R&D projects; current projects supported include work by the ARC and the Southern Africa Grains Laboratory (SAGL).
- Grain SA
  Grain SA has two units namely Grain Economy and Grain Research and Policy Centre that focus on escalating Grain SA's active role in the co-ordination of need-driven grain research. Grain SA works with other stakeholders such as universities and other appropriate public private stakeholders to conduct research for the development and growth of the grain industry in South Africa. In the sorghum industry, Grain SA organises i sorghum cultivar yield evaluation trails and training of emerging sorghum farmers.
- SAGL

The SAGL provides accredited analysis and quality testing to the agricultural industry, specifically the Grain Industry. In sorghum, SAGL is responsible for the sorghum crop quality survey and undertaking the evaluation of the milling quality of sorghum cultivars, with the support of the Sorghum Trust.

- Universities
  Several universities, including Free State, Pretoria, KwaZulu-Natal, North West, Johannesburg, Limpopo, Tshwane and Venda undertake research into sorghum. There are three notable centres of expertise: Research training in sorghum breeding - University of KwaZulu-Natal's Africa Centre for Crop Improvement, Sorghum plant pathology – University of the Free State, Sorghum food and technology and phytochemicals – University of Pretoria.

5. Local manufacture of extrusion cookers and expertise in processing African grains

The Centre for Advanced Manufacturing (CFAM) Technologies in Potchefstroom develops, constructs and markets twin-screw extrusion cookers for processing cereals and pulses like soya. CFAM has particular expertise in extrusion processing of African grains and the production of food products specifically for the African market. Its extrusion technology is used to process sorghum into, for example, instant porridges, ready-to-eat cereals and shake-type beverages. CFAM has a considerable track record of success in implementing turn-key cereal food processing plants based its extrusion cooking technology.

Figure 64: CFAM Twin-Screw Extruder Technology

6. Well-established and operational associations and institutions that support the grain industry at large including the sorghum industry

Industry associations and organisations that support the grain, including the sorghum industry, include the following:

- Grain SA;
- Agri SA;
- Sorghum Forum;
- South African Grain Information Services (SAGIS);
- Southern African Grain Laboratory (SAGL); and
- Agbiz Grain.

9.1.2 Weaknesses

1. **Very limited sorghum breeding currently being carried out locally, l and there are intermittent shortages of suitable sorghum seed**

   As the market for sorghum is very small, seed companies are not currently prepared to do research and development in sorghum because there is a perceived continuing low demand for sorghum, and the demand for maize is far higher[14]. This has led to a situation where the locally available sorghum cultivars are increasingly yielding less and less economically competitively with those of other commercially valuable crops, notably maize and soybeans.

   Furthermore, local sorghum seed production, especially for sweet (non-tannin) cultivars does not meet demand. This has led to a situation where sorghum seed is now being imported. However, imported cultivars are not always suitable because of disease susceptibility. The climate, diseases and pests in South Africa differ from those found in other countries.

   These factors together are resulting in a situation where locally produced sorghum is not sufficiently price competitive with imported sorghum.

2. **Sorghum food manufacture is dominated by a few companies, which limits competition in the market**

   The sorghum food manufacturing industry is dominated by a few large companies, and the contract prices offered by these companies are linked to the SAFEX sorghum price, which as explained earlier is unrealistically low. Due to the low yields that the farmers can get on the land, it is not attractive to produce sorghum. Sorghum is not freely traded in South Africa, and almost all sorghum produced in South Africa is produced on a contract basis with processors. The lack of a free-trade system therefore provides the buyers with a very strong bargaining position, leaving the farmers with a weak bargaining position. The relatively low price and convenient availability of imported sorghum has resulted in the major food manufacturers using a high proportion of imported sorghum in their products.

3. **Lack of reliable South African market and marketing research about sorghum**

   The lack of market research and marketing of sorghum products by the sorghum industry is a key weakness in the industry. While there are research programmes directed at the growth and

[14] Based on discussions with the major South African sorghum seed companies

development of the sorghum industry, very little is being done in the market itself establish what the market wants and to promote the grain and consumption of sorghum foods.

4. **Lack of innovative new sorghum food and beverage products**

The development of innovative new sorghum food and beverages in South Africa has not received adequate attention. Market opportunities like health foods, ancient grains, gluten free, pasteurised traditional beer are not being taken advantage of. Currently, there are small scale efforts at producing novel sorghum food products, such as the long shelf-life Motoho (soured beverage), SoYum sorghum-based biscuits and sorghum popcorn. However, for the most part, it appears that consumers still regard sorghum as a "poor man's food" and there does not appear to be a concerted effort by food manufacturers to change this perception through innovative products.

5. **Lack of suitable sorghum cultivars for novel and high-quality food product applications**

This ties in with the previous point, if there is no clear demand for sorghum products, then breeders will not develop the required sorghum cultivars that have appropriate end-use attributes. In contrast, the USA is making excellent progress in this regard, for example the Grain Berry range of products. These are made with the Onyx sorghum variety which was developed by Texas A&M University. The Onyx variety is both rich in 3-deoxyanthocyanins and condensed tannins polyphenolic phytochemicals. Products being produced by Grain Berry include a variety of cereals, pancakes and baking mixes, smoothie boosters and pastas. Another example is the so-called food grade white sorghums which are better suited to produce bakery flours than red sorghums.

Figure 65: Examples of Grain Berry Breakfast Cereal Products

6. **Sorghum milling technology is not well developed,**

Wheat, maize and rice milling technology is very well developed so that highly refined, essentially pure endosperm products such as white bread and cake flours, super grade maize meal and white rice can be produced with a relatively low milling loss. These refined products are much preferred by the consumers in comparison to their less refined counterparts like brown bread, sifted maize meal and brown rice. However, because current sorghum milling technology is primitive, milling

losses would be excessive if highly refined sorghum meal or flour were produced. Hence, to keep sorghum milling losses to acceptable levels, sorghum meal and flour contain high levels of coarse bran and are subject to fat rancidity, which makes them unattractive to consumers.

7. **The high price of local sorghum**
   Because sorghum yields are substantially lower than maize yields and because of the shortage of locally available sweet (non-tannin) sorghum, the price of sweet sorghum is between R500 and R1000/ton higher than that of maize. This contributes to sorghum foods products being more expensive than their maize counterparts and makes sorghum very unattractive as a feed grain.

8. **Unfamiliarity and some negative connotations among black South Africans with the name sorghum**
   Most consumers do not realise that sorghum and mabele are the same. Related to this is that the majority of consumers are not aware of the health benefits and nutritional value of sorghum, although they may associate these positive attributes with mabele. This is mainly because of a lack of consumer awareness as a result on the fact that marketing and promotion of sorghum is not being undertaken producers and food manufacturers.

   Further, as has been previously mentioned, there is a perception that sorghum is a "poor man's food", very much associated with more rural areas in South Africa and also the country's apartheid legacy.

9. **Ongoing declining market for traditional beer in South Africa**
   The demand for traditional Africa beer in South Africa continues to decline. This, in part, is related to urbanization in South Africa, with more people moving from rural areas to urban areas, and thus leaving behind traditional ways. Coupled with it, is the status symbol that beer represents, with consumers viewing African beer as inferior to lager beer[15]. There is also an apartheid legacy issue with African beer being associated with townships and municipal beer halls. Another weakness of the current liquid Traditional Africa beer products is its very short shelf-life, less than a week and the fact the beer cartons and drums leak and smell.

10. **Maize, especially Genetically Modified (GM) maize, produces higher yields than sorghum**
    Maize benefits from many times the research inputs to improve yield in comparison with sorghum. Additionally, most of the maize produced in South Africa is GM, with herbicide-resistant traits, an example being "RoundUp Ready" maize. This trait enables a herbicide to be sprayed on a crop field killing the weeds to but not the crop. As a result, yields are higher and weed control costs can be lower. Over the 10 years 2007/8 to 2017/18 the average yield of white and yellow maize was 65% and 100% higher than sorghum, respectively. The consequences are that cultivation of maize is more profitable than sorghum and the cost of maize is less than sorghum.

[15] Based on discussion with AB InBEV

11. **VAT is levied on sorghum and not on maize**
    Value added tax, currently 15% is levied on sorghum meal but not maize meal. This is additionally contributing to maize meal being substantially cheaper than sorghum. However, it should be noted that VAT is levied on all value-added maize and sorghum products such as instant porridge powders.

12. **The restrictive South African Revenue Services (SARS) definition of traditional African beer prevents beverage innovation such as "Chibuku Super" (pasteurized opaque beer)**
    In South Africa, traditional African beer is subject to a far lower excise duty than lager beers and other co-called clear beers, approximately 7.8 cents/litre versus 511.8 cents/litre. However, in its definition of traditional African beer (TAB), the South African Revenue Service specifies that "In order for the product to qualify as a TAB, the fermentation process must be natural and may not be stopped artificially." This restrictive definition therefore precludes the "Chibuku Super" type pasteurised opaque beer. As a consequence, it is not economical to brew pasteurised opaque beer in South Africa. This legislation has inhibited innovation in the industry, which in turn has contributed its continuing decline.

13. **Focus of sorghum breeding in South Africa has been on malting quality and not so much on yield**
    Up until recently, sorghum cultivars have been selected and released on the basis of their ability to produce a malt with high diastatic power (amylase activity) which is important for sorghum malt used in industrial traditional beer brewing. This required sorghum end-use quality trait, which was unique to South Africa, undoubtedly adversely affected improvement in sorghum yields as the source of suitable germplasm was very limited. Malting quality is not any longer an official cultivar quality requirement and is in the process of being replaced by milling quality. Since the milling quality of sorghum is important in nearly all food applications, suitable germplasm which also has high yield potential should be much more available. However, excessive focus on milling quality may also limit sorghum cultivar yield potential.

9.1.3 Opportunities

1. **Sorghum exports to other sub-Saharan African countries**
   The region is chronically food insecure due limited adoption of modern agricultural technologies and is subject to frequent droughts. These disrupt agricultural production in particular countries and sub-regions, for example the recent droughts in Kenya and Zimbabwe. The USA has in recent years supplied substantial quantities of sorghum to countries such as Kenya, Sudan, Cameroon and Zimbabwe. South Africa is geographically and politically well placed to export sorghum to other SADC countries and East Africa.

2. **Sorghum's adaptation to cultivation in harsh climatic conditions**
   Extensive studies have been conducted to determine the potential impact of climate change (increased temperatures and more erratic rainfall) on various crops. One such study (conducted by Knox J. et al 2012 Environ. Res), concluded that maize yields are likely to decline by 11% in

southern Africa by 2050 due to the impact of climate change, whereas sorghum and wheat yields would not be affected.

3. **Consumers trading down due to their declining economic circumstances**
   As result of South Africa's poor economic situation, which is being greatly exacerbated by the Covid-19 pandemic, consumers are increasing changing to less costly beverages alternatives, for example from lager beer to traditional-type beers. A significant opportunity is powder based, so called "instant" traditional beer where the consumer suspends the powder in warm water and beer brews and is ready to drink in 24 hours.

4. **Replacement of imported yellow maize for animal feed**
   Large quantities (approx. 100 000 tons) of yellow maize are imported into the Western and East Cape for use animal feed. This is done as it is more economical than transporting maize from the inland areas of production. If sorghum can be produced economically in the Eastern Cape this is opportunity.

5. **Specific health-promoting attributes of sorghum**
   Sorghum holds various nutritional and health benefits (discussed previously in the document). Some of which include:
   - The starch in sorghum food products can be slowly digestible;
   - Its consumption may prevent of Type 2 diabetes and cardiovascular disease; and
   - Rich source of phenolic phytochemicals which contribute protection against oxidative stress, have anti-obesity, anti-inflammatory and antihypertensive properties, and protect against Type 2 diabetes and may be protective against certain cancers.

6. **Ready-to-eat Instant porridges based on sorghum for: Food Aid programmes, School feeding, Breakfast porridges**
   The South African government has various feeding initiatives, for example the National School Nutrition Programme that focuses on school feeding and nutrition education. There is an opportunity to use sorghum-based products (such as instant porridges which require only boiling water to be added) in these feeding initiatives and programmes. T

7. **Development of a positive perception among South Africans about sorghum being a healthy food**
   Producers and food processors need to work with retailers to promote sorghum to the consumer market and raise awareness amongst consumers about the nutritional and health benefits of the product.

8. **Growth in demand for sorghum meal, albeit from a very low base**

There has been a growth in demand for sorghum meal, especially instant sorghum porridge powder although it was from a very small base[16]. For the past 10 years the category of sorghum meal has accounted for more 50% of the South African sorghum market. This indicates that there is potential for new sorghum food products in the local market

9. **Grain SA starting cultivar yield trials involving all the major seed companies**
   For the past three years, Grain SA has been running sorghum yield evaluation trials where local and foreign sorghum cultivars are being assessed. There have been some encouraging results with some local and foreign cultivars. For example, it is understood that the trials indicated that a French cultivar achieved average yields of 5-6 tons/ha. This indicates that significant sorghum yield improvements are possible in South Africa.

10. **Consumer demands for greater variety in grain food and specifically for Ancient grains**
    Affluent consumers today are seeking foods, especially grain food, which they consider as being more healthy, natural and environmentally sustainable than grains such as maize and wheat. There are several terms that are used for these foods such as Ancient Grains, Super Foods, Nutrifoods, Smart Foods, Climate-smart Foods. Sorghum is considered to be one of the few grains that fits in all these categories.

11. **African indigenous knowledge about sorghum's health benefits and sorghum foods and beverages**
    Due to the urbanization and westernization of the African continent, traditional food recipes and uses are disappearing. Although there is a historical cultural perception that sorghum and sorghum products contributed to health and better living, these traditions have not been carried over to the today's urban westernized population in the major centres in South Africa. There is evidence from the development and market success of modern convenience versions of traditional African foods and beverages that tradition and culture still play a significant role in the popularity of sorghum foods in South Africa. This indicates that consumers will change from maize to an equivalent sorghum product if the price and taste are right.

12. **Currently 40-50% of requirement for sweet (non-tannin) sorghum has to be imported to meet processors' needs**
    Sorghum imports into South Africa are sweet (non-tannin) sorghum, with production of sweet sorghum not being able to supply local demand. Although there are various challenges with regards to the production of sweet sorghum, such as the quelea birds, this is major opportunity for import replacement.

9.1.4 Threats

1. **Botswana's commercial sorghum production - greatly reduced export opportunities in the Southern African Customs Union**

[16] Based on discussions with representatives from the Sorghum Forum

Up until 2015 Botswana was by the biggest importer of South African sorghum, accounting for >90% of South African sorghum exports. However, for many years, Botswana has striving to become self-sufficient in sorghum. Since 2015, large-scale commercial sorghum farming has taken off in Botswana and the import of sorghum by Botswana from South Africa has been dramatically reduced. Swaziland (Eswatini) is now the largest importer of South African sorghum but is imports have at best remained static, at only about 2000 tons per annum.

2. **Increasing problem of quelea bird predation due to climate change**

Sorghum because the seeds are borne on an open panicle (head) on the top of the plant is particularly prone to predation by birds during cultivation. The major bird pest is the red-billed quelea, which gather as huge flocks that roost communally in trees near the sorghum fields. A flock of quelea can destroy an entire sorghum crop within a day.

The quelea has traditionally migrated down to South Africa in the Summer. As result of warmer winters, the queleas are now overwintering so increasing their numbers. Also, in the past, DALRRD had an efficient quelea control programme whereby when a farmer reported a flock of quelea, control measures would be taken before the crop was destroyed. For several reasons including environmental and animal rights concerns about the nature of the control measures used and lack of funding, control measuring is no longer being performed effectively.

3. **Efficient US and Australian sorghum producers make it economically viable to import sorghum**

For local processing companies buying all their sorghum requirements from an international grain trading company avoids the inconvenience and expense of negotiating separate contracts with numerous local farmers.

4. **Loss of African food culture with Westernization**

As was previously discussed under weaknesses, the increasing rate of urbanization and change to Western-type food diet in South Africa, referred to as Nutrition Transition, is resulting in loss of the traditional African food culture, where sorghum was such an important component.

5. **Ongoing improvement in agronomic characteristics of maize with respect to cultivation under dry conditions**

Sorghum's agronomic advantage over maize of being more water efficient and drought tolerant is being eroded by breeding improvements in maize with respect to these traits. For example, in the public sector, since 2012 CIMMYT (the CGIAR maize and wheat improvement centre) together with the support of funders such as the Bill and Melinda Gates Foundation has developed 53 maize varieties and cultivars with better tolerance to high temperature, limited water and drought using conventional-type breeding technologies.. Of specific relevance to Africa is the Water Efficient Maize for Africa (WEMA) initiative. At the same time, private sector multinational seed companies have also developed GM maize cultivars combining these and other valuable agronomic traits.

Part 10:
Business Case

10 Business Case

10.1 Introduction

Key assumptions to develop the business case for the sorghum value chain upgrade include the following:

1. The objectives of the business case:
    a. To support the growth of the industry which includes the development of market opportunities, increasing the competitiveness of sorghum in the grain industry in South Africa, and within the sub-Saharan African region;
    b. To increase local production to replace imported sorghum and exploit opportunities in export markets so that the trade balance in sorghum trade is favourable and becomes a foreign exchange earner;
    c. To implement modern processing technologies, such as twin screw extrusion cooking that reduces the cost of processing sorghum into value added consumer products;
    d. To support inclusivity through the integration and participation of smallholder farmers in the sorghum industry and specifically in rural areas.
2. The business case proposes an implementation plan that has the following key elements:
    a. Sorghum advanced germplasm development programme. The objective of this programme is to address the development of sorghum cultivars being used by farmers in South Africa to be more competitive in terms of yield and cost of production;
    b. The establishment of a sorghum cluster. The sorghum cluster will draw in key participants of the entire value chain from seed companies, organised agriculture, agro-chemical suppliers, millers, malting companies, food, beer and beverage processors and retailers. The cluster programme should also draw in participation of technology companies with an interest in agriculture development as well as NGOs and multi-national aid organisations.
    c. A business case for the establishment of a localised value chain in the Eastern Cape through the use of small-scale, economically feasible extrusion technology, using raw materials that are produced and supplied from within the region by primarily smallholder farmers, a centralised processing facility and distribution through local traders and retail outlets.

These elements of the proposed sorghum business case address key pressure points of the current sorghum industry, and it is proposed that they be implemented as part of a comprehensive sorghum industry development plan, although they are run as separate initiatives. For example, the cultivar development programme should benefit the industry as a whole, the Eastern Cape Pilot business case can be rolled out nationally once the key learning points have been established and confirmed, whilst the cluster initiative seeks to integrate the entire value chain to ensure that the benefits of a national value chain improvement programme benefit all the players in the value chain.

10.2 Sorghum Advanced Germplasm Development (Pre-breeding) Programme

Requirement for a commercially orientated sorghum pre-breeding programme in South Africa

The sorghum cultivars being used by farmers in South Africa are yielding less competitively with those used by farmers in the countries from which we are now increasingly importing sorghum, i.e., the USA and Australia (non-tannin (sweet)) sorghum) and Argentina (tannin (bitter)) sorghum. Equally importantly, local sorghum yields are far lower than those obtained with GM hybrid maize with the result that sorghum is considerably more costly than maize as a food and totally uneconomically more expensive than maize as an animal feed grain. This latter situation is at deviance with that in all other sorghum producing countries that cultivate sorghum by mechanized farming, e.g., the USA, Argentina, Brazil, France, Uruguay and Australia, where sorghum is either competitively priced or cheaper than yellow maize and hence is used extensively as animal feed.

There are three general reasons why sorghum farming productivity in South Africa is increasing becoming less competitive:

1. Since the PANNAR seed company's sorghum breeding programme ceased in 2012, there is essentially no breeding of sorghum cultivars being undertaken by commercial seed companies in South Africa. Hence, there have been no new sorghum cultivars developed for the past decade. The problem has been compounded by the fact that supplies of seed of the better-adapted sorghum cultivars, particularly the PANNAR cultivars, are limited. This has resulted in a situation where there are scarcities of seed of the desirable sorghum cultivars and some farmers are forced to either plant less suitable cultivars or choose not to cultivate sorghum.

2. The Agricultural Research Council (ARC) only undertakes breeding of open pollenated sorghum varieties (OPVs) to be used by small-holder sorghum farmer and not hybrids as used in mechanized commercial farming. The situation is exacerbated by the fact the ARC's sorghum breeding programme is chronically underfunded to the extent that it now does not have capacity (human resources and infrastructure) to even breed OPVs and certainly not hybrids. This problem is further exacerbated by the fact that the PANNAR Company (now part of Corteva) apparently refused to make its sorghum germplasm available to the South African government or to a local commercial company. These factors together mean there is very limited modern sorghum germplasm locally available for trait improvement even if another company, the ARC or a university wanted to start a breeding programme.

3. As a consequence of the above, an increasing proportion of the sorghum cultivars being cultivated by farmers in South Africa are now being obtained from the major sorghum producing countries, especially Australia, in the form of imported seed. These cultivars are not ideal for South African climatic conditions, e.g., the heavy soils in the Mpumalanga province, and have susceptibility to some of the important sorghum pests prevalent in South Africa such as smut. Furthermore, the fact that the seed itself is imported and not multiplied

locally means that there is the ever-present risk of seed shortage as the foreign seed companies obviously give preference to their local markets.

Hence, if the issue of sorghum breeding is not seriously addressed, sorghum farming productivity in South Africa will continue to become progressively less competitive, resulting in a further decline in cultivation and use of sorghum, with a concomitant reduction in economic activity and employment in the sorghum agri-food/feed industry.

Proposal

Arising from the analysis of regional and global best practices for sorghum targeted at potential cultivars in the Phase 2 report, it is proposed that a well-resourced sorghum pre-breeding programme should be established at either at the ARC's Grain Crops Institute in Potchefstroom of the University of KwaZulu-Natal's Africa Centre for Crop Improvement (ACCI), or jointly between the two institutions.

The goal of the pre-breeding programme would be to apply modern genomics-based breeding technologies to develop elite sorghum lines that are well-adapted to South and Southern African climatic conditions and have specific resistance to locally important pests and diseases.

How the entire cultivar development programme will function is illustrated in the Figure below. To ensure successful implementation and commercialization of the developed germplasm, the Advanced Germplasm Development Programme will be integrated with the current Sorghum Cultivar Yield Trials programme being run by Grain SA.

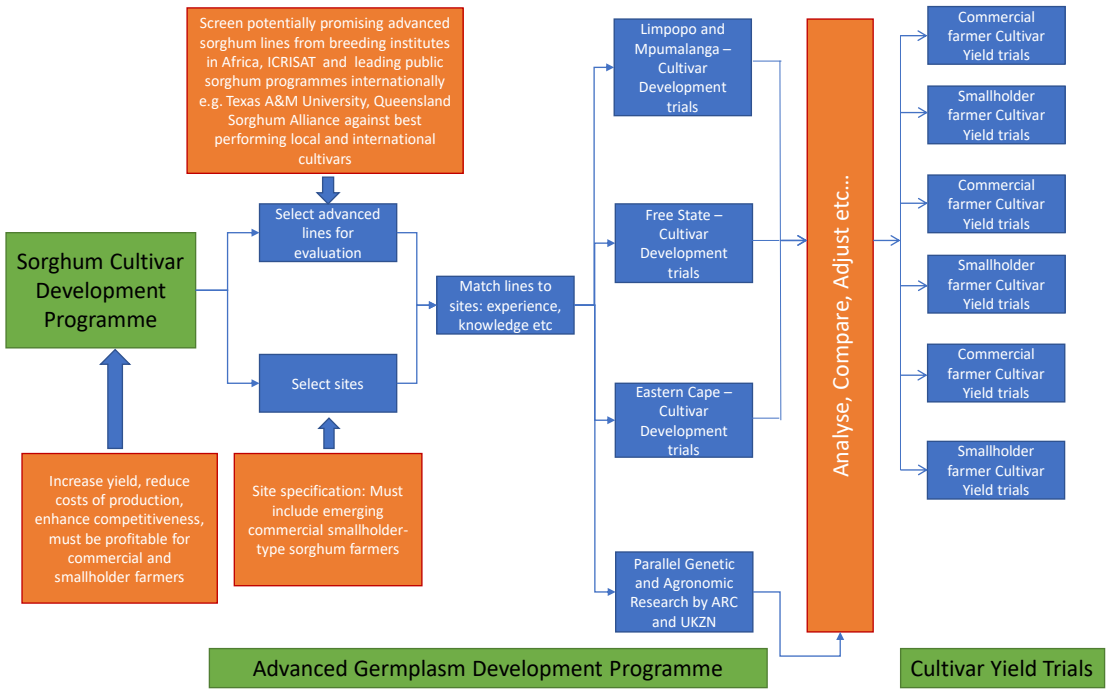


Figure 66: Overview of Design and Functioning of Sorghum Cultivar Development Programme

Based on the Australian sorghum breeding experience over 20 years (interview with Prof David Jordan, head of the Australian sorghum pre-breeding research programme), the improved sorghum cultivar genetics resulting from such a programme would result in a sustained average yield increase of 2% per annum. Although not a straight comparison, sorghum yield data from the 2017/2018 SAGL Crop Quality report indicate a decline in local sorghum yields, with average yield over the preceding 10-year period being 2.59 t/ha, 2.49 t/ha over the preceding 5 year period and only 2.29 t/ha over the preceding three year period (South African Sorghum Crop Quality Report, 2017/2018, SAGL, 2019).

The elite lines developed by the programme could then be directly taken up by commercial seed companies in South Africa in the SADC region to produce hybrid cultivars for large scale-mechanized agriculture and by national agricultural research institutes and seed companies in SADC to produce improved OPVs for smaller scale farming enterprises.

The SADC regional component of the programme is essential as the sorghum breeding problems are at least as acute in the other countries in the region as in South Africa. Dr Medson Chisi, the former sorghum and millet breeder for the Zambian Agricultural Research Institute and Zambia Presidential Award recipient, when interviewed for the Study stated "*The science has changed a lot especially in the approaches to germplasm enhancement. Most of the sorghum lines utilized by NARS programme are indeed very old and few private companies are into sorghum breeding now. Secondly, funding to NARS sorghum breeding programmes is next zero in most countries in Africa".*

The following illustrates the complexity of the breeding science and technology required to produce sorghum hybrids with desired traits. Production of sorghum hybrids requires three different types of lines that vary for pollen viability based on the interaction of the cytoplasm and nuclear genes. "The A-lines are the female seed parents for hybrids. The line is always sterile, will never shed pollen, and is genetically identical to the B-line except for sterile cytoplasm. A-lines are created by crossing a line to a known A-line and identifying resulting sterile progeny. The sterile progeny can then be backcrossed to the B-line. After several backcrosses the lines are genetically identical except for pollen restorer genes in the B-line cytoplasm. The B-line is also known as a "maintainer" line. Crossing the A-line by the corresponding B-line produces more A-line seed. The R-line has a normal (fertile) cytoplasm, fertile nuclear genes and the male parent for a hybrid. Crossing an A-line to an R-line produces a fertile F1 hybrid. A sorghum breeding programme will generally maintain two distinct gene pools – B-line and R-line. B-lines are crossed only with B-lines and R-lines with R-lines with selection practiced within the different gene pools. As much as possible in the introduction of new sources of favourable genes – abiotic or biotic stress resistance, grain weathering/mould resistance, grain quality, etc. – the 'exotic' or introduced line will be crossed in only one gene pool" (from Chisi and Peterson, 2019).

Line	Name	Cytoplasm	Fertility Genes
A	**Sterile**	Sterile (S)	Sterile (*rf rf*)
B	**Maintainer**	Fertile (F)	Sterile (*rf rf*)
R	**Restorer**	Fertile (F)	Fertile (*Rf Rf)*

To produce A-line seed: A-line (Cytoplasm = S, Fertility = *rf rf*) x B-line (Cytoplasm = S, Fertility = *rf rf*) → **A-line** (Cytoplasm = S, Fertility = *rf rf*)

To produce a hybrid: A-line (Cytoplasm = S, Fertility = *rf rf*) x R-line (Cytoplasm = F, Fertility = *Rf Rf*) → **Hybrid** (Cytoplasm = S, Fertility = *Rf rf*)

Figure 67: Description of Cytoplasm and Nuclear Genes Needed to Produce Sorghum Hybrids

Source: Chis, M. and Peterson, G. 2019. Breeding and agronomy. In: Sorghum and Millets: Chemistry, Technology and Nutritional Attributes, 2nd Edition. (Taylor, J.R.N. and Duodu, K.G., eds.), Woodhead Publishing, Duxford, UK, pp. 23-50)

It is vital that the sorghum pre-breeding programme starts to deliver improved germplasm as quickly as possible. To achieve this goal, it is essential that omics-based breeding technologies are used in combination with traditional trait-based breeding, which is based primarily on in-field observation of phenotypes. The science and technology of omics-based plant breeding is highly complex and is still rapidly advancing. The core principle is that of Marker Assisted Breeding, whereby breeding selections are made on the basis of using morphological, biochemical or genetic markers for the trait of interest rather than the trait itself. Commonly, this is a genetic marker, and the most widely applied methodology involves the determination of Quantitative Trait Loci (QTLs). A QTL is a region of DNA which is associated with a particular phenotypic trait, which varies in degree i.e., is quantitative and is attributable to polygenic effects, i.e., the product of multiple genes and also the environment.

QTLs for numerous important sorghum yield-related agronomic traits are well established (Reddy, R.N., Madhusudhana, R. et al. 2013. Mapping QTL for grain yield and other agronomic traits in post-rainy sorghum [*Sorghum bicolor* (L.) Moench]. Theoretical and Applied Genetics, 126, 1921). Unfortunately, although there is good expertise in South Africa in crop plant genomics and in marker assisted breeding technologies, there is limited specific expertise in their application to sorghum breeding, although some work in this area takes place at the University of KwaZulu-Natal's ACCI (Amelework, B., Shimelis, H. and Laing, M., 2016. Genetic variation in sorghum as revealed by phenotypic and SSR markers: implications for combining ability and heterosis for grain yield. Plant Genetic Resources, doi:10.1017/S1479262115000696). Additionally, the ACCI, like other sorghum breeding research groups, has been studying an improved technology which could significantly accelerate sorghum hybrid development, that of inducing male line sterility through the use of gametocides (Amelework, A., Laing, M. and Shimelis, H., 2016. Evaluation of effective gametocides for selective induction of male sterility in sorghum. Czech Journal of Genetics and Plant Breeding, 52, 163).

As can be seen from the foregoing, the sorghum pre-breeding programme proposed is by its very nature rather ambitious. However, this is essential if South African sorghum agriculture is to be competitive locally, never mind globally competitive. Hence, for the programme to be successful, it will require several conditions to be in place:

1. The active support and buy in of all stakeholders. These include national agricultural institutes in SADC; national departments of agriculture and science and technology; commercial seed companies; commercial sorghum food and beverage manufacturing companies; animal feed companies; international sorghum breeding technology partners such as ICRISAT, the Queensland Sorghum Alliance and Texas A&M University; and funding from international development agencies such as the African Development Bank;

2. Provision of the required high-level genetics and plant breeding human resources and of genomics scientific and technological infrastructure. Some of this is already available at the ARC and the ACCI. However, the remainder will have to be developed with the help of international and regional experts.

3. Since this would be a SADC initiative, an integrated programme involving high level training and technological and financial support of sorghum breeding across the region, both in-country and in South Africa needs to be essential components.

Indicative cost of the pre-breeding programme

An indicative annual budget of between R3 M - R5 M per annum will be required for the five years of the programme to establish it. This is with assumption that the institute undertaking the programme already has an employed experienced doctoral level sorghum breeder and that the basic breeding infrastructure is in place.

It envisaged that the costs would be less once the programme had been established and that the sorghum industry itself could bear the costs.

Budget items would include:

- Personnel: Technical staff to preform trait, crop disease and yield analysis, Semi-skilled staff to perform farming operations, Post-graduate research students;
- Technology provision and support from organisations such as ICRISAT, Queensland Sorghum Alliance and Texas A&M University, including the provision of germplasm via material transfer agreements;
- Local and in-country training and technological support for National Agricultural Research Systems (NARS) sorghum breeding programmes in other SADC countries;
- Laboratory services in genetics and marker analysis;
- Purchase of specialized equipment such as a small mechanical seed planter and a thresher.

The detailed planning, consultations and budgeting that are required to initiate such a programme are, as is evident, very involved, and hence fall outside the scope of this Market Opportunities Study.

10.3 Cluster Initiative

Clusters can broadly be defined as geographic concentrations of interconnected companies and institutions in a particular field or industry. Clusters encompass an array of linked industries or sub-sectors within industries, and other entities important to competition.

Clusters include suppliers of inputs as well as service providers. Clusters also extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies or common inputs. Many clusters also include government and other institutions, such as universities, standard setting agencies, training providers and trade associations.

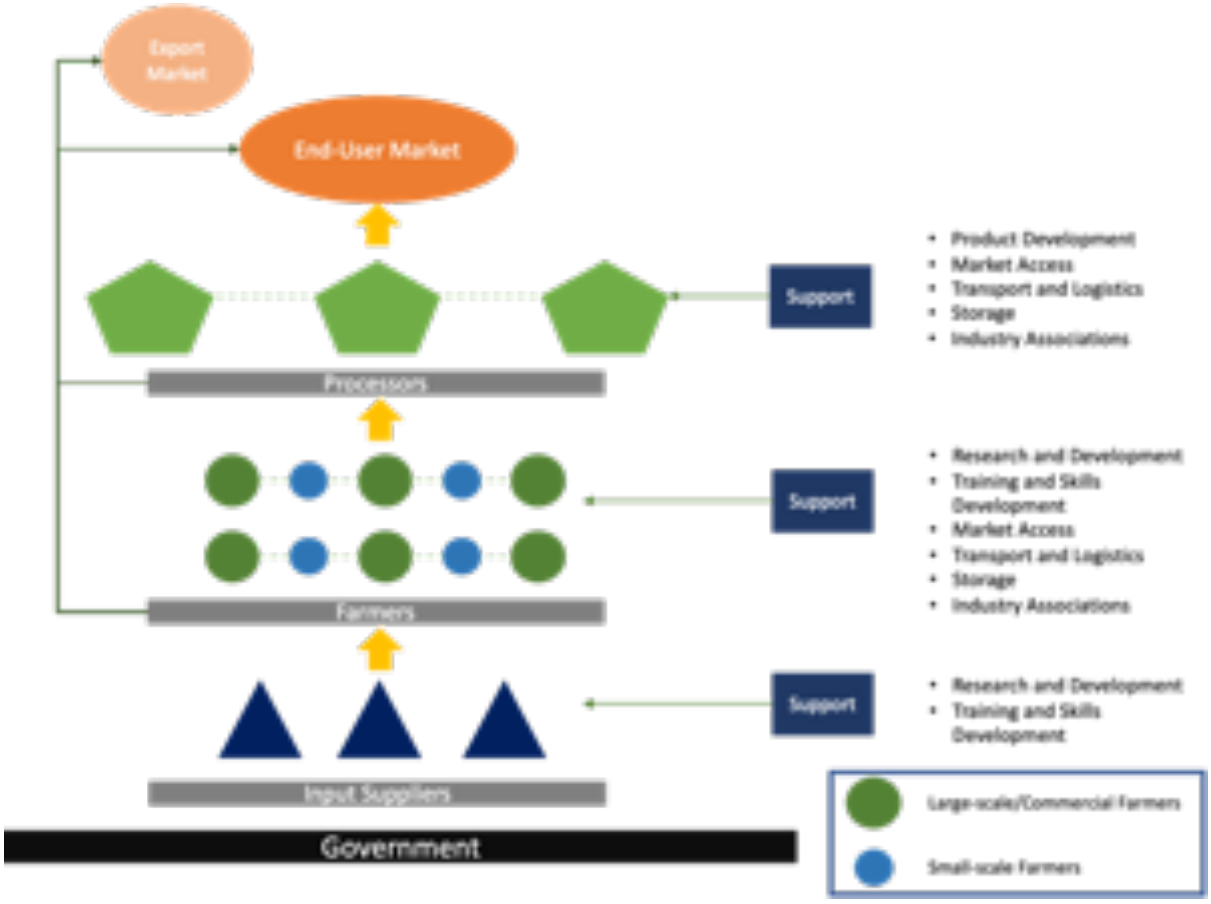


Figure 68: Illustration of a Cluster Concept

An agricultural cluster comprises of various stakeholders in the value chain, such as input suppliers, farmers, processors and organised agriculture (such as Agri SA and Grain SA). The approach is aimed at encouraging strategies that create closer market linkages, improve supply chains and foster co-operation among value-chain participants.

The cluster approach is based on the establishment of a value network. A value network is the aggregation of:

- Vertical relationships among suppliers of input materials, agricultural producers, processors and exporters, buyers and retailers;
- Horizontal relationships between processors and farmers; and
- Support relationships between processors and farmers, and facilitating organizations (e.g. local government, business service providers, research institutes, universities and training institutions, and non-government service organizations) that reinforce the quality, efficiency and sustainability of the value chain.

Vertical Relationships

Vertical relationships within the agricultural cluster are the links between trading partners. Organisations within the cluster all rely on suppliers of various types and, after adding their own value to products and produce, they sell their products or services to customers. These relationships within a cluster are of prime importance. The objective of the cluster would be to continuously exploit the synergies of these relationships and assist with the flow of the production process, from input suppliers right through to end-consumers.

Horizontal Relationships

These relationships are between organisations at the same stages of production (such as between input suppliers, farmers and support service providers). These firms compete with each other and cooperate along dimensions that benefit them. However, in the case of the small-holder farmers, it is envisaged that farmers will partake in more collaborative than competitive efforts to improve their access to input materials and marketing channels. Organisations within the cluster can collaborate on various issues such as lobbying the government regarding regulations that affect the entire industry, forming joint venture to attack difficult markets and exploring basic knowledge that is still removed from application. Economic advantage is driven by bonds of trust and associations, which will help organisations, and especially farmers, learn from each other and trade knowledge.

Enterprises Involved in the Cluster

The following is a list of enterprises that could potentially form part of the sorghum cluster:

1. **Support Service Providers**
    - Support service providers would comprise of agricultural organisations such as AgriSA, GrainSA, SA Grain Information Services (SAGIS), Agricultural Research Council, etc. Universities and agricultural training institutions will also form part of the support service providers.

    - Government Departments, such as the Department of Agriculture, Land Reform and Rural Development and the Department of Science, Technology and Innovation, would also fall under the support service providers category, as they would provide support with the development and establishment of the cluster, as well as providing social facilitation services, policy support and funding.

    - There are various other organisations that are active throughout Africa who can be approached to form part of, or support, the sorghum cluster initiative. An overview of selected organisations is provided in Annexure A of this document.

2. **Input Suppliers**
    - Input suppliers will comprise of all organisations that will supply the farmers and processors with the required inputs (for example, fertilizers, pesticides, chemicals, faming equipment, etc.)

3. **Farmers and Farming Organisations**
    - Large-scale/commercial farmers as well as small-holder farmers and co-operatives will form a key sub-sector of the cluster. The objective is to establish relationships between farmers and enable an environment in which mentorship, training and support is fostered. Furthermore, it is well-evidenced that Co-opetition serves to promote the healthy and sustainable development of industries.

4. **Processors**
    - Processors are another key sub-sector of the cluster. The objective of the cluster would be to foster relationships between farmers, processors and end-user markets in order to drive the growth and development of the industry.

5. **End-Users**
    - It is envisaged that end-users such as retailers would form part of the cluster. This would assist with keeping farmers and processors up to date with developments in the consumer market, and assisting farmers and processors with market access for their products.

Benefits of a Cluster

There are numerous benefits associated with an effective cluster. The following are some of the key benefits:

- Greater understanding of customer needs and the market opportunities for the South African industry (also creates links to Export Councils)
- Improved relationships between customers and suppliers
- Stronger competitive platform in terms of the availability of skills, information and infrastructure
- Assistance to develop “world-class” capabilities in South Africa
- Lowering inter-firm transaction costs by eliminating bottlenecks and cost-drivers
- Identification of opportunities of joint procurement, export promotion or distribution
- Opportunities to explore partnerships and discussions with government and parastatals in areas such as trade agreements, trade missions, infrastructure requirements, opportunities for trade and investment
- Overcome historical conflict and isolation within industries and society in order to identify opportunities for synergy and mutual benefit

10.3.1 Clustering for the Promotion of Smallholder Farmer Development

South Africa’s agricultural sector is dualistic, characterised by a highly commercial sector running parallel to a smallholder sector of two million dominated by black producers who are still finding it difficult to become sustainable and commercial. Smallholder farmers face significant challenges – particularly in the current socio-economic environment and the growing food crisis as millions of poor South Africans cannot afford food.

There is an enormous gap between large-scale commercial farmers and smallholder farmers, who have limited access to resources, land and machinery. This has resulted in many farmers simply not being able to regularly produce the quantities of crops required to enter formal markets.

Often, these farmers benefit from corporate social investment (CSI) programmes that help them to develop skills and increase output. However, this is not the case for all smallholder farmers, as they struggle to compete effectively with limited capacity to produce.

The Cluster Concept is a model that enables a group of farmers to collaborate on purchases for their input requirements. These farmers then receive support to produce selected crops to similar standards on each of their farms. The aggregate output of these farmers is then combined and sold to clients.

Once properly implemented, clustering provides an ideal enabling environment to support smallholder farmers' involvement in value chains. Smallholder farmers are not only faced with major production constraints, but are also challenged by constraints specific to marketing and finance acquisition. Apart from allowing farmers to share resources from production, clustering also enable farmers to partake in collective marketing of their products, and facilitates opportunities for smallholder farmers to be mentored by commercial farmers.

10.3.2 Dedicated Organisation to Promote Sorghum

In line with the proposal of the establishment of a Sorghum Cluster, it is also proposed that the Sorghum Trust be supported to enable it to enhance its role in the sorghum industry. To illustrate possible elements of the enhanced Sorghum Trust's role in the industry, the Sorghum Checkoff (USA) and SorghumID (Europe) are good examples of such sorghum industry promotion organisations. How they function is explained in section 8.6

10.3.3 Steps in the Establishment of a Cluster

The following are some of the key steps in the establishment and development of a cluster:

- Information gathering and data analysis in order to obtain a clear understanding of the identified sector and the environment in which it operates. This will include the following:
    - Industry analysis (supply and demand)
    - Industry contribution to GDP and employment
    - Identification of key role-players / stakeholders in the industry
    - Comprehensive SWOT analysis
    - Industry structure
- Stakeholder Engagement:
    - Convene possible cluster members and test interest
    - Establish a database and recruit members
- Formalise Cluster as a Legal Entity:
    - Register non-profit organisation

  - Elect board members from cluster members
  - Open bank accounts, appoint auditors, etc.
- Develop a Vision for the Cluster:
  - Determine how the Cluster and the members (participating role players and stakeholders) can enable the achievement of the vision
  - Develop a mission and vision statement
  - Ensure buy-in from role-players and stakeholders
- Prioritise key issues to enhance cluster competitiveness
- Form working groups and task teams to deal with specific challenges and opportunities
- Quantify identified opportunities into projects
- Fund-raising for projects

10.3.4 Estimated Budget for the Establishment of a Cluster

The estimated budget for the establishment of a cluster and the associated timelines is indicated in the table below:

Activity	Timeframe	Cost
Initial Industry Engagement to Promote the Cluster and Secure Participation - Identification of key stakeholders - Telephonic, face-to-face engagements - Workshop to introduce the cluster programme	2 months	R500,000
Establishment of the Cluster and Necessary Statutory Protocols and Membership Sign-Up - Registration of the Cluster - Signing up members - Developing Cluster website - Establishing Board of Directors - Selection of Cluster Office Location - Developing Cluster Management Protocols, Memorandum of Incorporation, Policies, etc.	10 months	R1,500,000
Establishment and Running of the Cluster Management Office (12-month period) - Monthly meetings with Board Members - Update website with news and events - Arrange cluster events – i.e. bi-annual informal and formal gatherings, workshops, conferences - Identify cluster projects - Assessment of identified projects	12 months	R1,800,000

Activity	Timeframe	Cost
- Selection of projects to put forward to members for participation - Facilitation of project development - Facilitation of engagements between cluster members and industry stakeholders - Promotion of the cluster - Fund raising for projects - Quarterly newsletters		

Table 23: High-Level Budget for the Establishment of a Cluster

In the past, funding for the establishment of a cluster could have been obtained in the form of a grant from the Department of Trade and Industry. However, the Cluster Development Programme has been suspended, and as such this is not currently a feasible option. However, there are other avenues of funding that could be pursued for funding, for example utilising provincial government funds for the development of the agricultural industry, funding from members and industry associations.

10.3.5 Case Study: Sustainable Cotton Cluster

The Sustainable Cotton Cluster (SCC) was established in June 2014, funded by an initial grant of R200 million from the former Department of Trade and Industry (Dti). The grant supported a five-year plan to establish a strong momentum for the growth and development of the Southern African cotton sub-cluster.

The SCC brings together the entire cotton value chain, including the public sector, organised labour, consumer organisations, service providers and dedicated cluster management.

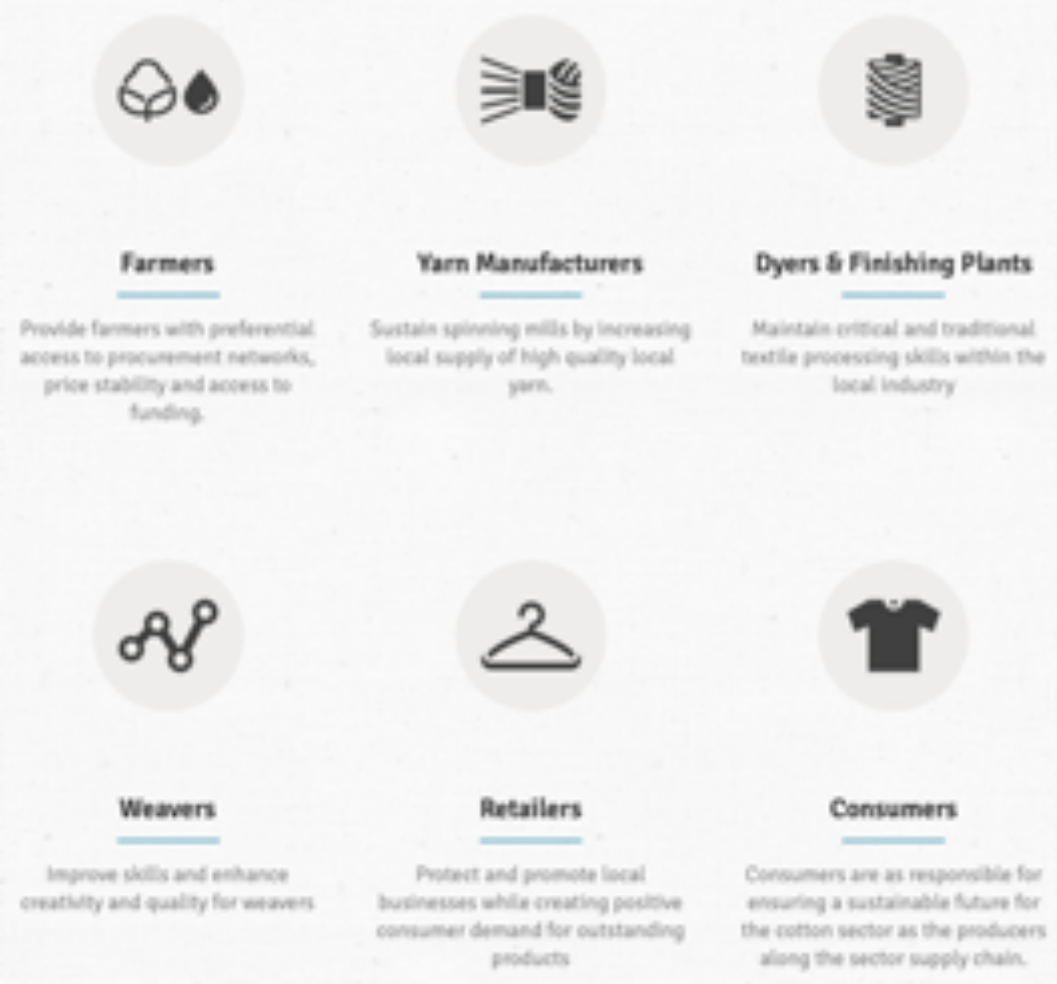


Figure 69: Stakeholder Groups of the Sustainable Cotton Cluster

Source: Sustainable Cotton Cluster

The mission of the SCC is to effectively integrate the entire cotton supply chain with the aim to:

- Facilitate forward planning and long-term contracting to ensure that production meets demand;
- Create partnerships among supply chain stakeholders and service providers to ensure scalable solutions;
- Incubate, develop and encourage participation by SMME's; and
- Ensure supply chain traceability to protect the integrity of sustainability claims to measure programme impact.

The objective of the SCC is shown in the image below.

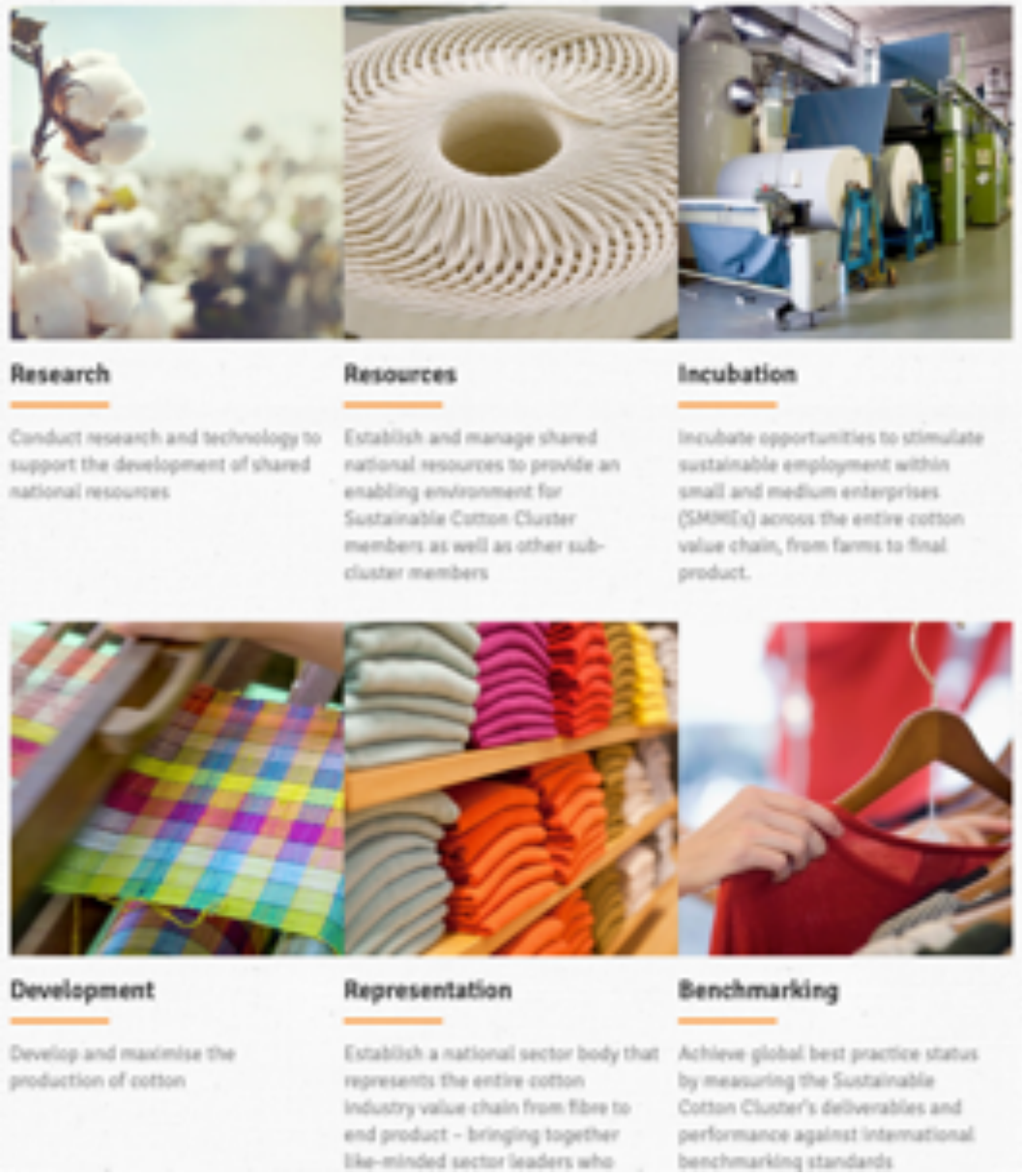


Figure 70: Objectives of the Sustainable Cotton Cluster

Source: Sustainable Cotton Cluster

In the six years that the cotton cluster has been in operation, cotton production and processing has increased 800% and almost 50,000 jobs have been created or maintained in the cotton sector. One of the main purposes of the SCC is to increase consumption of cotton by local retailers, aiming to increase local procurement from the pre-COVID average of 45% to 63% by 2030.

The COVID-19 pandemic has had an immensely negative impact on the cotton industry, as is the case with most industries globally. Exports were suspended initially, and while restrictions have mostly been lifted, the global demand for cotton has decreased and so have global prices. With approximately 80% of locally produced cotton being exported, this has been a devastating blow to the industry.

However, the cluster platform provides the industry with networks and relationships that build on each other in order to address challenges, such as the one the industry is currently facing in light of the COVID-19 pandemic. One of the key objectives of the SCC in the short-to-medium term is to diversify the market and mitigate risks. The cluster platform is proving to be a vital component for the industry during this time, and it serves as an example of how industry stakeholders can join hands to overcome challenges for the benefit of all involved.

10.4 Pilot Sites

The research team proposed that, in support of the development and enhancement of the sorghum industry in South Africa, two types of pilot sites be considered:

1. In terms of the cultivar development programme, pilot sites for the implementation of trial growing programmes should be in the same regions as where the current sorghum growers are established, i.e. Limpopo (Springbok Flats), Mpumalanga (Standerton) and eastern Free State (Koppies, Vredefort). These sites will be able to turn the benefit of new varieties into immediate commercial opportunities with the support of established commercial farmers in these areas. It is further essential that the seed development programme incorporate the Eastern Cape as a key site. Utilising multiple sites for the seed development programme is critical to determine the yield stability of cultivars under differing climatic conditions, soil and plant disease conditions.
2. To support the integration of emerging commercial farmers into the sorghum value chain, it is proposed that the Eastern Cape be considered as a pilot site to demonstrate the value of establishing a local processing centres and engagement of emerging commercial farmers to supply sorghum to such centres. The reason for selecting the Eastern Cape is supported by the fact that it is considered to have high potential for sorghum cultivation, especially as climate change increasingly negatively impacts on South African agriculture in some of the current high potential regions . Additionally, United National Breweries, the traditional African beer brewing company, has already been sourcing sorghum from smallholder farmers in the Eastern Cape to supply its Isithebe malting plant in KwaZulu-Natal. This activity was originally supported by the Diageo Foundation, Diageo being the company that up until 2020 owned UNB. In addition to producing sorghum in the Eastern Cape to meet requirements of the of the processing centre it will also help improve the viability of sorghum farming to supply UNB.

10.4.1 Limpopo

Limpopo accounted for 36% of sorghum production in 2018/19. Area utilised for sorghum production has varied significantly in the past 5 years (see Figure below), most likely due to the impact of climatic conditions on farmers' crop decisions.

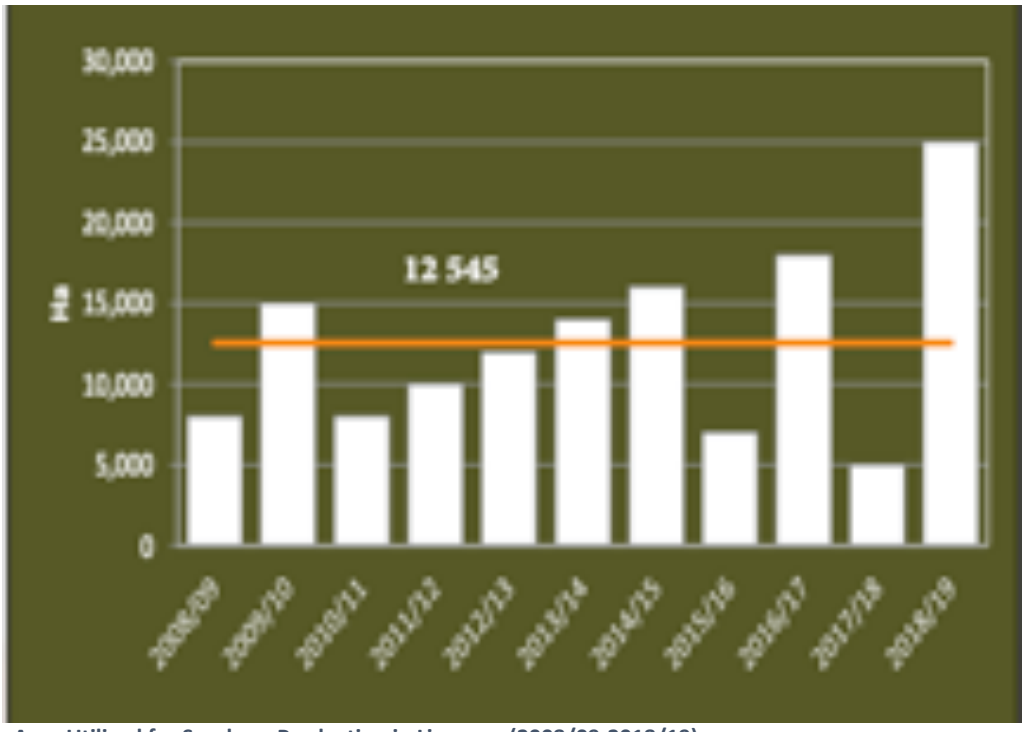


Figure 71: Area Utilised for Sorghum Production in Limpopo (2008/09-2018/19)

Source: SAGL

The recent expansion in the area planted in Limpopo, which accounts for approximately half of the area planted, can be partially explained by the fact that sorghum has a low water requirement and is drought tolerant, and is therefore, the best alternative crop for some farmers when maize cannot be planted.

In the Province, much sorghum farming is undertaken by smallholder farmers who face major challenges in how to improve production and productivity. The cultivar development programme could address these challenges and provide opportunities for small-scale farmers to work with large-scale commercial farmers in the region in order to increase yields and overall productivity.

10.4.2 Mpumalanga

The Mpumalanga province is the second largest contributor to sorghum production, accounting for 28% of annual production in 2018/19. The area utilised for sorghum production in the Province has declined significantly since a high of more than 16,000 hectares in 2008/9, to less than 8,000 hectares in 2018/19.

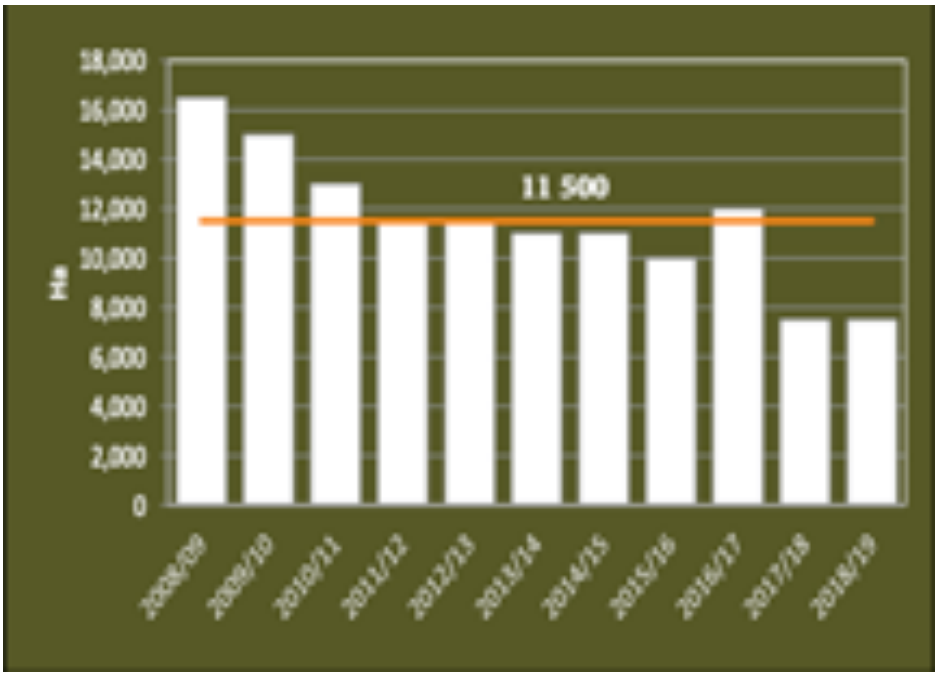


Figure 72: Area Utilised for Sorghum Production in Mpumalanga, 2008/09 – 2018/19

Source: SAGL

One of the challenges with regards to grain farming in Mpumalanga is that the mining activity in the region has led to mining companies buying agricultural land for coal mining. In 2016, Grain SA suggested that the agricultural sector needs to migrate about one million tonnes of grain production from Mpumalanga to the Eastern Cape by 2020 due to the coal mining activity in the province[17].

More than 80% of South Africa's coal is currently produced in Mpumalanga, which hosts 24 of the country's 27 coal mines. Mining and quarrying is also the largest contributor to the provincial economy, while most of the some 93,000 direct jobs in the coal value chain are associated with Mpumalanga's coal sector. Approximately 13.5% of the province's land is already being mined, while 40% is subject to prospecting applications.

If coal mining continues to grow in Mpumalanga, approximately 240,000 ha of high-potential farming land could be lost. Today, the province produces 35% of South Africa's sorghum, 44% of its soyabeans, 21% of its citrus and 67% of the country's banana crop. It is also the fourth biggest seller of cattle and has a sizeable poultry industry.

There will always be a tug of war between mining companies and agricultural activity in Mpumalanga due to its rich natural resource base.

[17] Grain South Africa on Drought Impacts and its Food Security Strategy, https://pmg.org.za/committee-meeting/22036/

10.5 Eastern Cape

The agricultural industry in the Eastern Cape is a vital contributor to the livelihoods of approximately 500,000 small-scale farmers are involved in the informal agricultural industry as well as subsistence farming. The following Figure illustrates the number of agricultural households per province in South Africa.

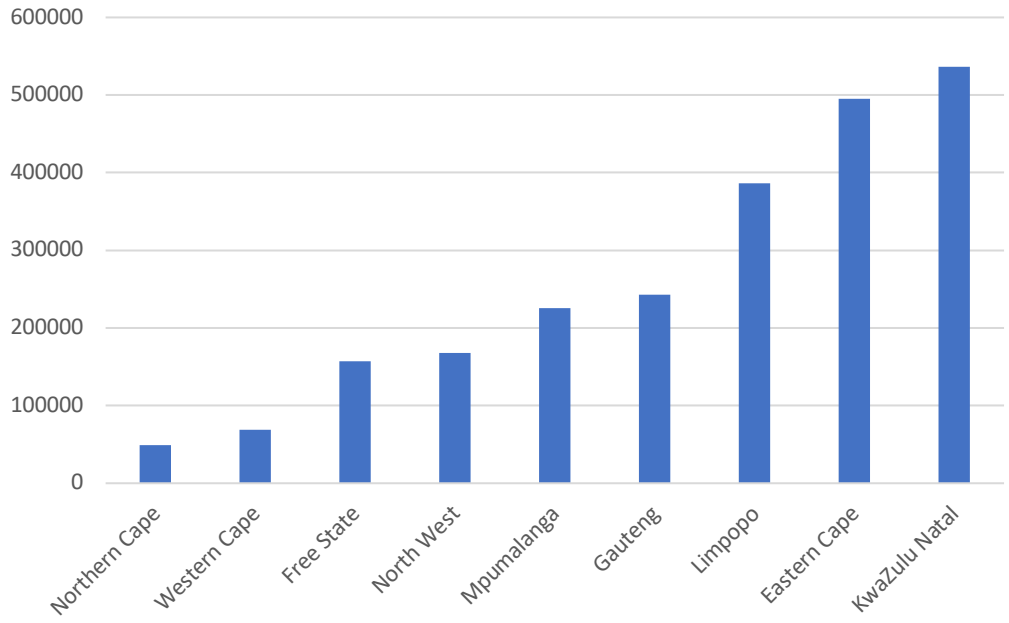


Figure 73: Number of Agricultural Households in the Eastern Cape

Source: SARS, 2019

The Eastern Cape is not traditionally a grain-producing Province (as illustrated in the Figure below), which shows that grain does not feature as one of the principal commodities of the Province.

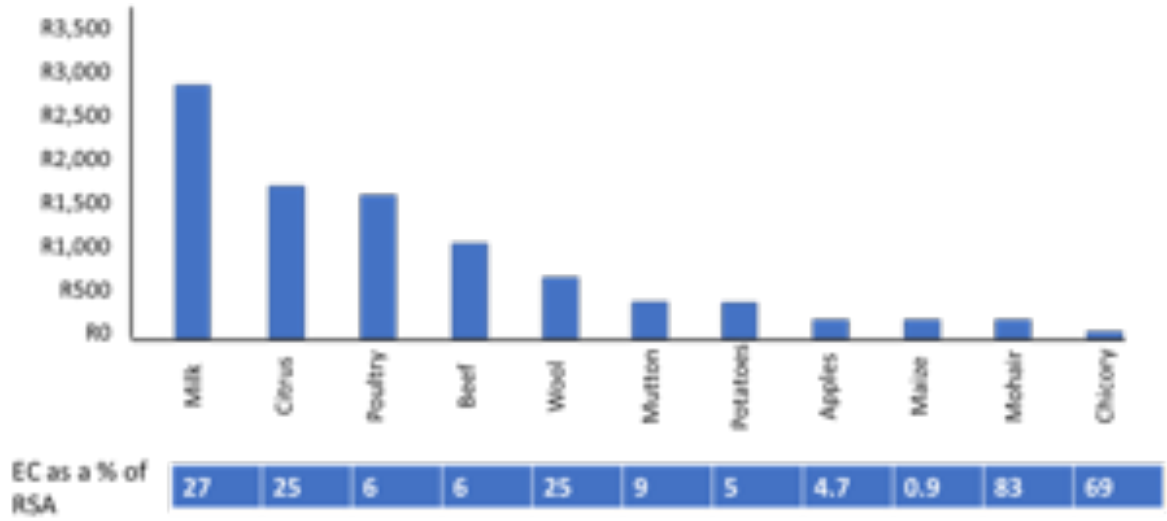


Figure 74: Gross Annual Income for Principal Commodities in the Eastern Cape (R'000,000)

Source: Eastern Cape Development Corporation

At present the Province is responsible for just 1% of South Africa's total maize production and contributes approximately 15,000 wheat per annum to the national breadbasket. However, the Province has begun to make significant contributions to South Africa's grain crop. The Figure below illustrates the production volumes for various crops in the Eastern Cape, highlighting the northern part of the province as the main grain producing region.

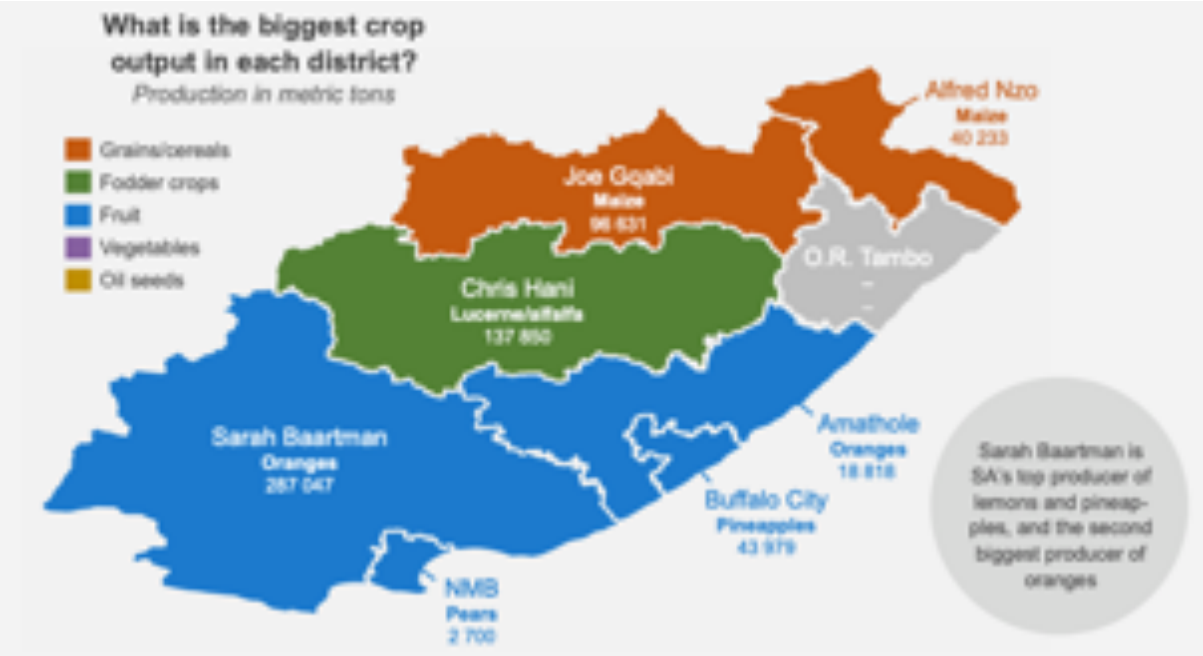


Figure 75: Crop Production in the Eastern Cape

Source: StatsSA Factsheet, 2020

In July 2020, AFGRI Agri Services announced that they will construct a new grain bunker in the Eastern Cape to support the local farming community. The new bunker will be near Butterworth in the Eastern Cape and will offer state-of-the art storage facilities for both maize and soybeans, offering capacity of 15,000 tons. This will be the first commercial bunker in the province and will make a huge contribution to the efforts of local farmers, who will in future be able to securely store their crop without worrying about the produce rotting before it can get to market.

A study conducted by Grain SA in 2014 proposed the reallocation of maize production from Mpumalanga's current productive land that may potentially be transformed due to mining, to land with similar potential in the Eastern Cape. Agronomically, sorghum can be cultivated and grown anywhere where maize can be cultivated and grown, and due to a lack of available research on sorghum, research on the potential for maize in the Eastern Cape will be used for illustrative purposes.

There are three factors that motivate the notion for the Eastern Cape to be considered for the reallocation of maize (and as such, sorghum) production. Firstly, based on a modelled crop suitability

assessment[18], the Eastern Cape has the potential to grow maize successfully. Secondly, from a rural development perspective, former homeland areas such as Transkei, could benefit from expanding agricultural production. Moreover, the Eastern Cape has the most untapped and currently underutilised land resources are available for enhancing agricultural production in South Africa.

The key inhibiting factors in the Eastern Cape are market access and the high cost of transportation to get sorghum from the Province to key markets in the rest of South Africa. However, there are opportunities to develop value add to the crops through processing in the Eastern Cape through the utilisation of existing infrastructure such as the Rural Economic Development (RED) Hubs in the Province.

10.5.1 RED Hubs

Regional Economic Development (RED) Hubs is a flagship programme of the Eastern Cape Rural Development Agency (ECRDA) based on the concept of prioritising villages as operational centres. The RED Hub concept has at its core a Mega Farm approach which emphasises the establishment of viable economic units which entail pulling together fallow land in rural communities and turning these dormant assets into productive clusters. The ECRDA has established RED Hubs in Ncorha and Emalahleni at the Chris Hani District Municipality, Mqanduli at the OR Tambo District Municipality, Mbizana at the Alfred Nzo District Municipality and in Tshabo at the Buffalo City Metropolitan Municipality.

The Red Hub links three market elements of production, processing and marketing to boost the competitiveness of rural economies and communities. These physical hubs link production to the mills and other value adding operations as well as marketing. The result is that production receives the market support it needs to flourish and money is kept ‘alive’ and circulates within a community as long as possible. This implies that value adding should be done by the community rather than by conglomerates far from these communities.

[18] National Department of Agriculture. 2014. Minister speech at Grain South Africa’s Opening. Qumbu. Eastern Cape. South Africa.

Figure 76: Creating a Circular Economy within Communities

There are 4 RED Hubs that have been established in the Eastern Cape, namely:

1. The Ncora RED Hub in the Chris Hani District Municipality
2. The Emalahleni RED Hub in the Chris Hani District Municipality
3. The Mqanduli RED Hub in the OR Tambo District Municipality
4. The Mbizana RED Hub in the Alfred Nzo District Municipality

The following table lists key considerations for the utilisation of the RED Hubs for processing sorghum:

RHM	LOCATION	KEY CONSIDERATIONS
Mbizana	Kokstad	Out of target area for processing
Mqanduli	Mthata	Within target area - Focussed on white maize processing
Ncora	Engcobo	Politically sensitive - have not operated in over two years. High Risk
Ibuyambo	Lady Frere	Out of target area for processing.

Figure 77: Key Considerations for Utilising RED Hubs in the Eastern Cape

Realistically, only the Mqanduli site could support the extrusion facility due only to its geographic positioning, as the other sites are readily disqualified.

The Mqanduli RED Hub

The RED hub that has been identified as one with the highest potential for sorghum processing is the Mqanduli RED Hub. The Mqanduli RED Hub is situated in the OR Tambo District Municipality, on the outskirts of town and optimally positioned to receive maize feedstock from nearly cultivated lands. In 2016/17 seven primary cooperatives delivered 173.9 tonnes of white maize to the hub's storage silos from 899 hectares planted. The RED Hub has a 0.8 ton per hour processing mill that is fully operational. The mill currently produces white maize that is being sold in Spar stores in the Eastern Cape.

Figure 78: The Mqanduli RED Hub

The Mqanduli Red HUB presently does not have the physical space and additional infrastructure would need to be built to accommodate the extrusion cooking production equipment, offices and staff amenities. The current storeroom is too small and may need to be extended, space permitting.

The RED HUBS have been introduced to the SPAR group on two occasions, 2016 and 2018 with large volume offtake commitment. In both cases the RHM could not supply product to meet the demand. Logistics, sales and marketing capacities were problematic in not keeping to the market access planning schedules.

The positioning of an extrusion facility in the Mthata area is however strategic (between East London and KwaZulu-Natal producers) and could be pursued on that basis. Other options for facilities and partnerships are possible, however it is recommended that this pilot be a primarily private sector managed commercial model for the first 5 years possibly as a design, co-finance, build, operate and transfer (DFBOT) model to leverage institutional support programme capacity.

Via the DTIC Capital infrastructure Programme (CIP), grants have been committed to two facilities:

- The Vulindlela Heights Industrial Park in Mthatha was recently upgraded to the tune of R22-million to increase manufacturing in the region and allow entrepreneurship to thrive (2017/18); and
- Wild Coast Special Economic Zone (SEZ), Mthatha - Infrastructure Phase 1 (2020)

10.5.2 Sorghum Processing in the Eastern Cape

Instant porridge flour produced from grains can be fortified with the full range of minerals and vitamins, including Vitamin A, B vitamins, iron and zinc, which are used to fortify maize and wheat flour in South Africa. A problem when ordinary cereal flours are cooked in water in the traditional way is that some of the vitamins are destroyed by the heat during the cooking process. Extrusion technology offers a solution here, as the vitamins and nutrients are added to the cooked, dry product.

The establishment of a sorghum extrusion facility within close proximity to local farmers in the Eastern Cape would, to a degree, address the challenge of market access. The CFAM Extrusion technology has been identified as a high-potential option for developing sorghum processing in the Eastern Cape.

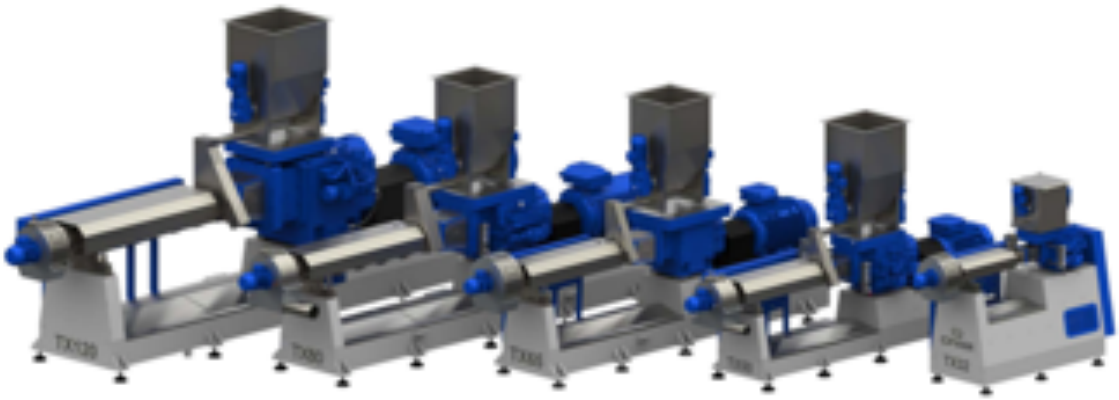


Figure 79: CFAM Extruders

As explained, extrusion cooking is continuous short-time, high pressure, high temperature, effluent-free cooking process, which can be used to process a wide variety of raw materials and create an even wider range of products.

The Extrusion Cooking Process

Materials, normally cereals and/or legumes like soya are fed into the barrel through the feed opening in moist raw, granular form, e.g., coarse sorghum flour. The extruder screw conveys the material forward through the barrel, where external heat from a jacket (electrically or steam heated) around the barrel plus frictional heat generated between the product, screw and barrel, causing the product to melt and become plastic. Thereafter, final cooking and texturizing takes place, using a combination of friction and pressure. High die pressure is then generated as a result of the compression of the material at the die orifice. Material is conveyed and forced through the die, where pressure drops across the die, and the superheated water flashes-off. The die diameter and shape and degree of pressure drop at that die exit gives each particular product its characteristic internal structure and external form, for example pre-cooked porridge flour, expanded snack food, or aquaculture feed.

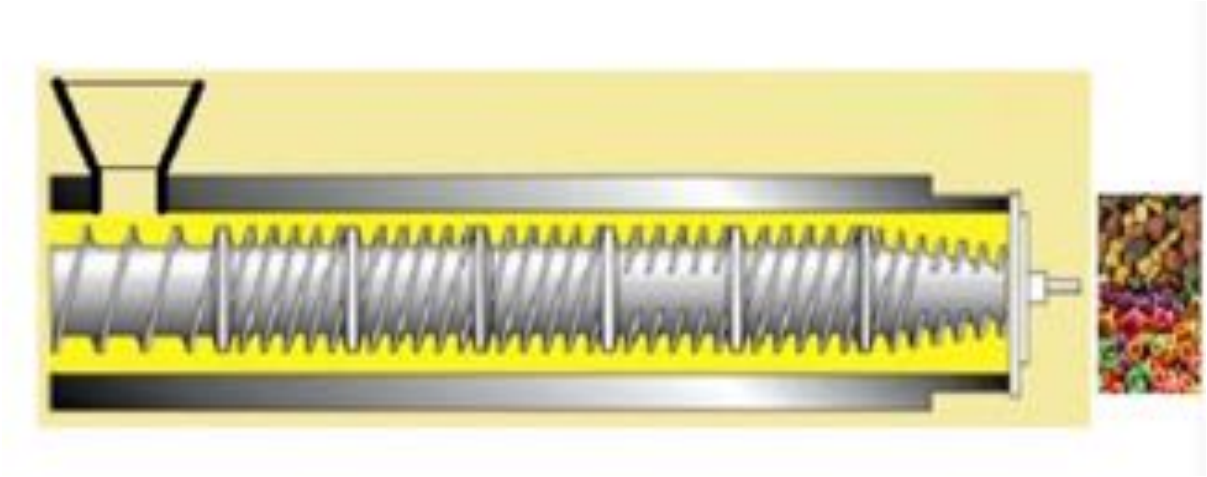


Figure 80: Extruder Cooker Basic Concept

An illustration of the process flow in a basic extrusion plant is illustrated in the Figure below:

Figure 81: Basic Extrusion Plant

Applications of extrusion cooking manufacture include the following:

- Ready-to-eat porridges
- Instant maize/sorghum meal
- Snacks
- Breakfast cereals
- Pet food
- Aqua feeds
- Niche and specialised products

The establishment of a Sorghum Cluster in the Eastern Cape would link in well with the establishment of a sorghum extrusion facility, as benefits through cluster buying and selling would reduce transaction costs in order to ease farm margins. Furthermore, the establishment of a processing (extrusion) facility close to local farmers would enable the Province to produce higher value products which could offset the transportation costs.

The establishment of an extrusion facility to produce instant sorghum porridge that has the potential to process and package up to 1,250kg per hour is projected at R22 million for the plant and equipment, and a further R7,25 million for installation, commissioning, power and utilities and other unforeseen expenses. This brings the total amount for the establishment of the facility to R39,6 million. During operations, a further R4 million is required to finance working capital. Therefore R43,6 million investment is required to set up such a facility. Note that it is assumed that existing buildings can be used to house the plant and equipment.

Based on a production capacity build-up as illustrated in the following Table, the proposed extrusion plant yields very attractive returns.

Production Figures - Average per month							
Description			**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
%Utilisation		%	33%	48%	65%	78%	89%
Production Rate		kg/h	1,250	1,250	1,250	1,250	1,250
Hour/day		hours	24	24	24	24	24
Days/month		days	22	22	22	22	22
Operating Hours/month		hours	174	253	341	409	471
Production per Month		**Tonnes**	**218**	**316**	**426**	**512**	**588**
Production per Year		**Tonnes**	**2,614**	**3,790**	**5,116**	**6,139**	**7,060**
% of Total Production Capacity		%	**33%**	**48%**	**65%**	**78%**	**89%**

Figure 82: Sorghum Porridge Extrusion Plant Production Figures

The cost of producing 1 tonne of instant sorghum porridge is reflected in the following table:

Instant sorghum porridge				
	Base	Fall	Rise	Value Add
Materials		R -	R 7,192	R 7,192
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
	R 7,192	R -	R -	R -
Processing	R 7,192	R -	R 7,808	R 7,808
Wholesale	R 15,000	R -	R 3,000	R 3,000
Retail	R 18,000	R -	R 4,500	R 4,500
	R 22,500	R -	R -	R -
	R 22,500	R -	R -	
Consumer	R 22,500			

Table 24: Cost of Producing 1 Tonne of Instant Sorghum Porridge

**Note: The calculations in the Table above are based on a sorghum raw material cost of R2,500 per tonne.*

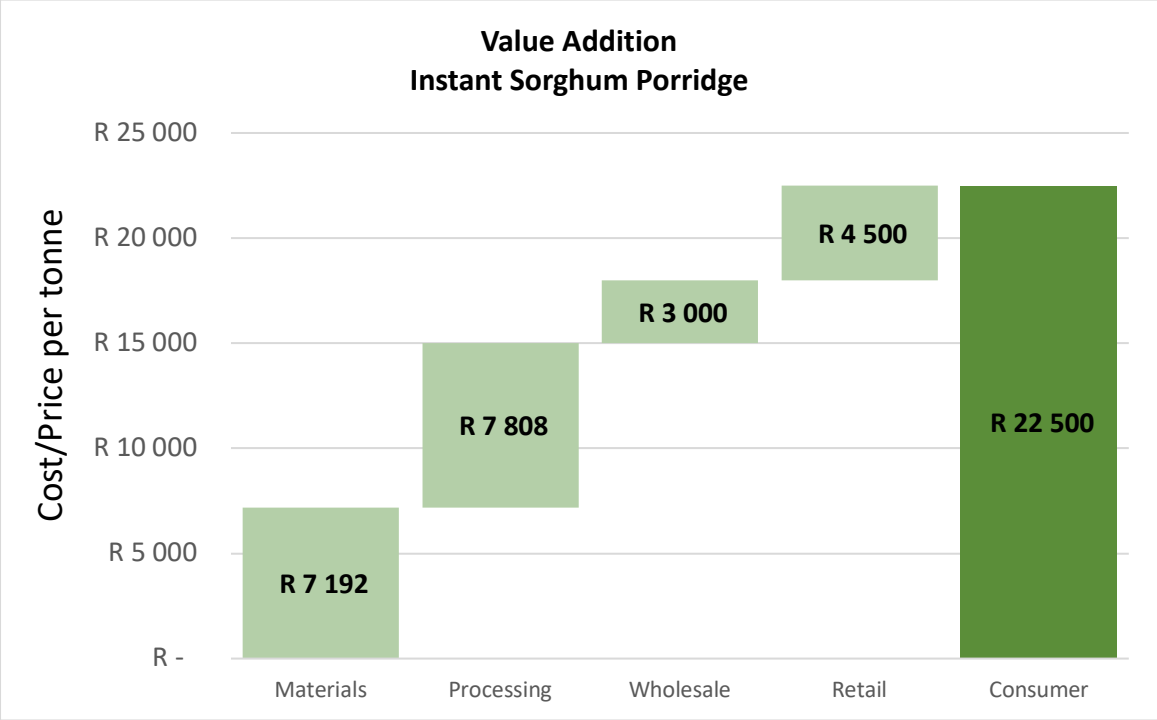


Figure 83: Value Addition in Instant Sorghum Porridge

The financial performance of the facility is provided in the following Table:

Key Performance Indicators	Monthly	Year 1	Year 2	Year 3	Year 4	Year 5
	Avg Monthly Year	R/tonne	R/tonne	R/tonne	R/tonne	R/tonne
Sales	R 3,267,000	R 15,000	R 15,900	R 16,854	R 17,865	R 18,937
Cost of Production	R 1,566,372	R 7,192	R 7,623	R 8,081	R 8,566	R 9,079
Accounting Fees	R 10,000	R 46	R 34	R 26	R 23	R 21
Advertising & Marketing	R 30,000	R 138	R 101	R 79	R 70	R 64
Bank Charges	R 5,000	R 23	R 17	R 13	R 12	R 11
Cleaning Expenses	R 5,000	R 23	R 17	R 13	R 12	R 11
Computer Expenses	R 3,000	R 14	R 10	R 8	R 7	R 6
Consumables	R 4,000	R 18	R 13	R 11	R 9	R 9
Electricity & Water	R 165,609	R 760	R 733	R 733	R 754	R 784
Entertainment	R 5,000	R 23	R 17	R 13	R 12	R 11
HACCP	R 25,000	R 115	R 84	R 66	R 58	R 54
Insurance	R 27,914	R 128	R 94	R 74	R 65	R 60
Legal Fees	R 5,000	R 23	R 17	R 13	R 12	R 11
Motor Vehicle Expenses	R -	R -	R -	R -	R -	R -
Postage	R 2,000	R 9	R 7	R 5	R 5	R 4
Printing & Stationery	R 2,000	R 9	R 7	R 5	R 5	R 4
Professional Fees	R -	R -	R -	R -	R -	R -
Building Rent	R -	R -	R -	R -	R -	R -
Transport to Warehouse	R -	R -	R -	R -	R -	R -
Salaries & Wages	R 243,000	R 1,116	R 1,223	R 1,089	R 1,131	R 1,304
Security	R 25,000	R 115	R 84	R 66	R 58	R 54
Subscriptions	R 2,500	R 11	R 8	R 7	R 6	R 5
Telephone & Fax	R 5,000	R 23	R 17	R 13	R 12	R 11
Training	R 5,000	R 23	R 17	R 13	R 12	R 11
Plant Maintenance	R 55,829	R 256	R 187	R 147	R 130	R 120
Total for Operating Expenses	R 625,853	R 2,874	R 2,686	R 2,394	R 2,391	R 2,554
Surplus/Loss	R 1,074,776	R 4,935	R 5,591	R 6,379	R 6,908	R 7,304
Gross Profit	R 1,700,628	R 7,808	R 8,277	R 8,773	R 9,300	R 9,858
% Gross Profit	52%	52%	52%	52%	52%	52%
% Surplus/loss on sales	33%	33%	35%	38%	39%	39%

Table 25: Financial Performance of the proposed Extrusion Facility

In order to justify this investment, a bankable feasibility study needs to be executed. This feasibility study will address the market opportunity and specifically the potential demand that can be channelled through local informal distribution channels and formal retail distribution channels such as Spar. It will also cover the sorghum production plan which will include the identification of suitable land and farmers to produce up to 6,600 tons of sorghum per annum. At a yield of 3 tons per hectare, this will require 2,200 hectares. It will also potentially create more than 400 employment opportunities in the entire value chain. The feasibility study can be presented to the local Eastern Cape government departments such as ECRDA and the IDC of SA for funding. The business plan should also include the identification and participation of strategic operating partners to support the establishment of the farming operations and the operation of the processing plant and the engagement of the retail outlets.

10.6 Transport and Logistics Costs

Logistics costs are the summation of all expenditures undertaken to make available a product or a service to the market, mainly the end consumer. Logistics cost are made up of various elements as depicted in the graph below.

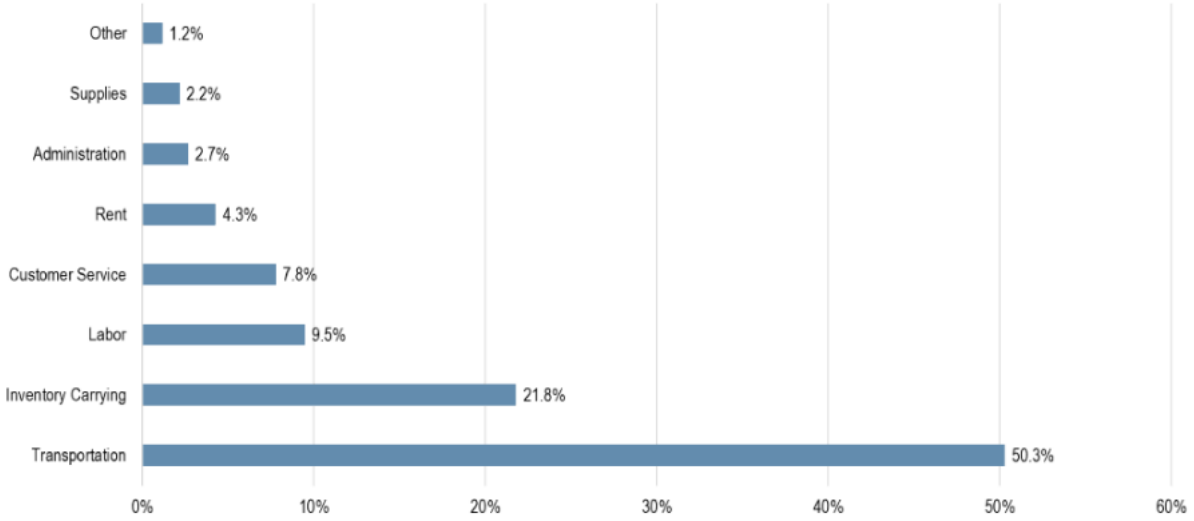


Figure 84: Composition of Logistics Costs - Source: Establish, Inc. / HWD & Grubb & Ellis Global Logistics

Transportation costs remain the dominant consideration as it accounts for about half of the logistics costs of any product or service.

According to the National Agricultural Marketing Council (NAMC) report on "The Role of Transport in Logistics of Agriculture" there are two main elements to consider during the analysis of transportation cost for grain, namely operating costs and operational efficiency.

- Operating costs reviews and evaluates the impact of current transport operating costs at various stages from post-harvest to consumers when traversing rural, corridor and metro roads.
- Transport efficiency reviews the impact of infrastructure and the operating environment on the productivity of vehicles at different stages from post-harvest to consumers.

Sorghum's transport operating costs are influenced by its physical characteristics, handling requirements and durability. Furthermore, the volumes, distance, availability of the farmer's own transport, choice of silo and access to outsourcing are some of the factors that determine the type and size of vehicles used in this phase of transporting grains.

Sorghum's road transport efficiency costs are influenced by factors such as:

- Silos and mills were often built to receive sorghum by rail, which results in delays when unloading.
- Poor road conditions that damage vehicles especially in the rural and informal areas.
- Maintenance cost of vehicles in these key areas due to unavailability of parts and components.
- Lack of return loads for trucks transporting sorghum.
- Fluctuating fuel prices.
- Silos sizes being too small which results in double handling.

In terms of the sorghum value chain, the logistics cost can be broken down in three phases as presented below.

- Phase one – transporting the sorghum harvest to silos, mills and processing facilities.
- Phase two – transporting sorghum products from Fast Moving Consumer Goods (FMCG) and other producers to distribution centres and supply chain service providers.
- Phase three – transporting sorghum food products to wholesalers and retailers.

For the purposes of this report however, the focus was mainly on phase one of the logistics costs spectrum, which relates to the cost of transport of the actual sorghum harvest to the processors, which in turn influences the price of sorghum to the point where it is processed.

Cost Analysis

The cost of transporting grain have been documented in various reports such as the SAGIS Reports, the NAMC report on "The Role of Transport in Logistics of Agriculture" and the "Income and Cost Budgets for Summer Crops - 2018/2019" report of the Bureau for Food and Agricultural Policy (BFAP), Protein Research Foundation (PRF), Oil & Protein Seeds Development Trust / Oilseeds Advisory Committee and Grain South Africa dated September 2018.

The information below is a summary of the grain transportation costs as presented in the "Income and Cost Budgets for Summer Crops - 2018/2019" report.

The information below is a summary of the grain transportation costs as presented in the "Income and Cost Budgets for Summer Crops - 2018/2019" report.

Transportation Cost for Maize - 2018/2019				
No.	Region	R/Ton	Maize Price	
1	KZN - Bloedrivier	R317,00	R2 494,00	13%
2	Mpumalanga - Middelburg/Trichardt	R200,00	R2 494,00	8%
3	Mpumalanga - Ermelo	R269,00	R2 494,00	11%
4	Eastern Free State	R253,00	R2 494,00	10%
5	Western Free State - Wesselsbron	R277,00	R2 393,00	12%
6	Western Free State - Bothaville	R217,00	R2 393,00	9%
7	North West - Koster	R148,00	R2 393,00	6%
8	North West - Lichtenburg	R197,00	R2 393,00	8%
9	Northern Cape	R292,00	R2 494,00	12%
10	KZN - Bergrivier	R297,00	R2 494,00	12%
11	Nort West Brits/Northan/Koedoeskop	R144,00	R2 494,00	6%
12	Limpopo	R246,00	R2 494,00	10%
Average percentage of transportation cost				10%

Table 26: Average Transportation Cost for Maize

Apart for the importation cost of Sorghum by rail and transportation costs quoted by the stakeholders interviewed, the transportation cost of sorghum is not readily available in the public domain.

The SAGIS reports estimate the cost of railage of sorghum from Durban to Randfontein, the major processing area for sorghum, to be around R517,00 per ton. The Table below represents the average percentage of the railage for the import of sorghum as at the import price recorded on 06 November 2020.

Imported Sorghum			
Country	USA	Argentine	Australia
Price per Ton	R5 190,50	R2 929,26	R4 849,94
Railage	R517,52	R517,52	R517,52
Percentage cost	10%	18%	11%
Average percentage of railage cost			13%

Table 27: Transport Cost of Imported Sorghum

From the above two Tables it could be assumed that transportation cost, excluding handling fees and other logistics costs for grain, makes make up approximately 10% to 13% of the cost.

The NAMC report however indicated that the type of mode of transportation used can also range significantly. The transportation cost estimates, based on 2009 statistics almost double from R299,00 per ton and R 488,00 per ton if compared between a 34-ton payload and an 8-ton payload vehicle. Many farmers deliver to the producers directly, mostly with smaller payload vehicles, which equates to higher transportation cost, which will raise the percentage of the transportation cost to approximately 16% of the cost of sorghum.

The producers interviewed in the Eastern Cape recorded cost as high a R600,00 per ton for sorghum for delivery to Randfontein and R350,00 per ton to Durban. The sorghum selling price for locally procured sorghum reportedly range between R2 400,00 and R3 400,00 per ton.

The cost analysis of this scenario is presented below.

Transportation Cost of Sorghum Produced in the Eastern Cape		
	Low Price	High Price
	R2 400,00	R3 400,00
Johannesburg cost	R600,00	R600,00
Percentage	25%	18%
Durban cost	R350,00	R350,00
Percentage	15%	10%

Table 28: Transportation Cost of Sorghum in the Eastern Cape

The cost of transportation for sorghum produced from the Eastern Cape to Johannesburg, where most of the processors are based therefore escalates to between 18% and 25% of the sorghum price.

The logistics cost of transportation sorghum to a processing facility can therefore be a deciding factor to the viability of farming with Sorghum. Transportation cost is however an integral part of the value chain and cannot be removed altogether.

The only way to increase the margin for the producers is to ensure sufficient processing facilities and market uptake of the sorghum products in the regions where it is processed.

10.7 Extension Support Services

As stated in the Phase 2 report, according to Prof David Jordan of the Queensland Sorghum Alliance, 50% of Australia's average 4% per annum increase in sorghum yields has been due to genetic improvements in the cultivars and 50% due to improved agronomic practices. In Australia, the largest component of the yield gain from improved agronomic practices has been due to more efficient use of the expected rainfall and available soil moisture. Critically, this and other types of yield gains are being increasingly driven by Precision Agriculture whereby sophisticated crop modeling is used, for example to optimise plant density even across a single field according soil type and available moisture.

In addition to traditional physical and chemical soil and crop analyses, the implementation of precision agriculture requires a portfolio of other emerging technologies, including: supercomputing to handle the so-called big data generated by single plant multiple trait analysis, remote phenotyping of the performance and health of individual plants in the field by multi- or hyperspectral imaging, and obtaining the data by satellite, unmanned aerial vehicle or ground robot (Maes, W.H. and Steppe, K., 2019. Perspectives for remote sensing with unmanned aerial vehicles in precision agriculture. Trends in Plant Science, 24, 152-164).

It is thus evident that for South African commercial sorghum farming to become globally competitive, significantly improved and state of the art agronomic practices are required in addition to a well-resourced pre-breeding programme to drive the development of better adapted hybrid cultivars. In fact, the two developments must go "hand-in-hand".

Achieving the required ongoing improvements in commercial sorghum farming agronomic practices will, like the pre-breeding programme, also be somewhat challenging. A positive aspect is that existing South African commercial farmers already have long-established and well developed systems of extension support, including: Organised agriculture – The former farmer cooperatives and organizations like Grain SA; Input suppliers of seed, fertilizer and agrochemicals directly through their technical experts and by farmers' days; and also through Farmers' own informal networks. In addition, many commercial farmers have sufficient finances to obtain some information themselves directly from overseas. These systems should enable quite rapid implementation of the new technologies.

Emerging commercial sorghum farmers will, however, need greater support, particularly by way of existing commercial farmers directly sharing their expertise. Additionally, they will require financial support to access the technologies.

Implementation of precision agriculture

To introduce and implement the emerging and rapidly developing technologies of precision agriculture, specific interventions are proposed:

1. A formal agreement between Grain SA and the Queensland Sorghum Alliance. A key element of the agreement should be the facilitation of Australian experts to talk directly to South African farmer groups to provide know-how and training.

2. Creation of a funded Chair in Crop Precision Agriculture at a local university. The Chair must include formal extension training in its mandate in addition to just research as has been the case with such chairs to date.

10.8 Cost Benefit Analysis

10.8.1 Introduction

The key objective of the intervention programme, i.e. the germplasm development programme, is to increase sorghum yield or reduce the cost of producing sorghum so that the sorghum can be more competitive to access opportunities such as:

- Replacing imported sorghum and imported yellow maize;
- Competing effectively with other grain meals and flours to pass on the health benefits of sorghum to the consumer;
- Supporting and enabling the product development and market growth plans and initiatives of UNB to produce a longer, more environmentally acceptable traditional African beer for local consumers;
- Ultimately competing in the Sub-Saharan African market against imported sorghum from USA and Argentina to meet regional shortfalls in supply that is estimated at circa 220,000 tons per annum in East African countries.

The cost benefit analysis (CBA) of the proposed sorghum enhancement initiative looked at the cost of the proposed germplasm development programme as proposed in this document, i.e. that it has to be linked directly to the current sorghum cultivar yield trial programme, and the ensuing benefits for the country through:

- Forex savings and earnings. The assumption is that the net gain in forex will benefit the South African government at a rate of 2% per annum, based on LIBOR (London Interbank Offered Rate) inter-bank borrowing rate.
    - The cost of 60,000 tons imported sorghum at R4000 per ton contributes towards an outflow of R240 million per annum. At a 2% LIBOR rate, this amounts to a cost of R4.8 million per annum.
    - The export of 100,000 tons of sorghum to African countries at a price of R2,800 per ton will earn South Africa a forex earnings of R280million per annum. At a LIBOR rate of 2% this amounts to a saving of R5.6 million per annum.
    - The combined net gain of forex of R520 million amounts to a saving of R10.4 million per annum for the South African fiscus.

- Increased local production of sorghum assuming that the programme be successful. Due to the improved competitiveness of local sorghum, South Africa should be able to produce an additional 250,000 tons per annum. The local cultivation of sorghum, assuming a 5t/ha yield, will require 50,000 ha of farmland to be developed.
    - Input costs comprise of imported agrochemicals and local sourced chemicals and fertilisers (a component of which is still imported). The net local value add is assumed to be R1550/ha in distribution and warehousing expenses, retail margins and manufacturer profits. In total this amounts to a net local value add of R78 million per annum. The government VAT of 15% amounts to circa R11.6 million per annum.
    - Assuming that commercial farmers account for 50% of the new productive capacity, and farmer profits estimated at R1050/ha and taxed at 28%, the commercial farmers will contribute a further R7.35 million per annum.
    - Farm staff, labourers and casual workers will contribute R210 million towards the local economy and assuming that 5% of the salaries and wages ends up in government coffers, the tax (VAT, PAYE) gain for government can amount to R10.5 million per annum.
- The deployment of input materials and farmer extension services, estimated at R3,500 per ha) to the smallholder farmers farming on circa 50,000 ha producing at a yield of 2.5 t/ha will require an investment of circa R105 million per annum from government funds. Assuming that the overall cultivar development programme is successful and yields are doubled, the same output will be generated on 30,000 ha (or more sorghum can be produced) at a cost of R105 million per annum. The benefit of the programme could therefore translate into a R70 million saving.

10.8.2 Cost / benefit Outcome

For the purpose of the cost benefit analysis, it was assumed that the germplasm development programme will an investment of circa R37 million over 7 years (based on R5 million per annum, inflated at 5% per annum for 5 years and then reducing by 50% per annum for the 6th and 7th years of the program. It is assumed that with the participation of seed companies in the project, further research and development from the 8th year onwards will be absorbed by these companies and/or the sorghum industry. The cost of pilot sites as part of the development programme is included in this budget.

The benefit to Government for the investment lies in the forex gain (savings + earnings), increased tax revenues (VAT, income tax and PAYE) and the projected benefit of savings on smallholder farmer support program. For the purpose of illustration, it is assumed that circa 50% of the land earmarked for the sorghum development and growth plan is allocated to smallholder farmers:

- The yields will be lower than that for commercial farmers and therefore additional land needs to be allocated to these farmers.
- Government support is provided in the form of seeds and fertilisers as well as extension services and is projected at R3,500/ha.

The following Table summarises the net government benefit of the proposed sorghum development programme, that has as its target increasing yield to 5t/ha (on average in South Africa across all regions) with no significant increase in costs. Notable the yield and profitability will be dependent on the region in South Africa.

Source		Amount	Adjusted for value add	farmland ha in production	total value of increase	rate applied	Government benefit
Forex gain	LIBOR	R520,000,000				2%	R10,400,000
Farmer input	VAT	R3,872	0.4	50,000	R77,448,000.00	15%	R11,617,200
Farmer profits	Income Tax	R1,050		25,000	R26,250,000.00	28%	R7,350,000
Farm workers	Wages per annum	R42,000	0.2	25,000	R210,000,000.00	5%	R10,500,000
Government gain/benefit							**R39,867,200**
Government grant fund/small holder farmer savings							
Smallholder farm input support		R3,500	R/ha	50,000			R175,000,000
Smallholder farm input support		R3,500	R/ha	30,000			R105,000,000
Government savings							**R70,000,000**

Table 29: Net Government Benefit of Proposed Sorghum Development Programme

10.8.3 Government return

The return/benefit of the investment is calculated over a 10-year period based on the above annual benefit, phased in over 5 years at a rate of 20% in year 1, 50% in year 2, 75% and 80% respectively in years 3 and 4 and achieving optimal benefit in the 5th year post implementation.

(R'000)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Germplasm Investment	- 5,000	- 5,250	- 5,788	- 6,700	- 8,144	- 1,629	- 326			
Benefit to Government						10,176	26,713	42,073	47,122	61,847
Benefit phase in factor						20%	50%	75%	80%	100%
NET FUND FLOW	**- 5,000**	**- 5,250**	**- 5,788**	**- 6,700**	**- 8,144**	**8,547**	**26,387**	**42,073**	**47,122**	**61,847**
IRR	38%									
Inflation (% pa)	5%									

Table 30: Return on Investment in the Sorghum Development Programme

The cost/benefit relationship is graphically illustrated in the following graph.

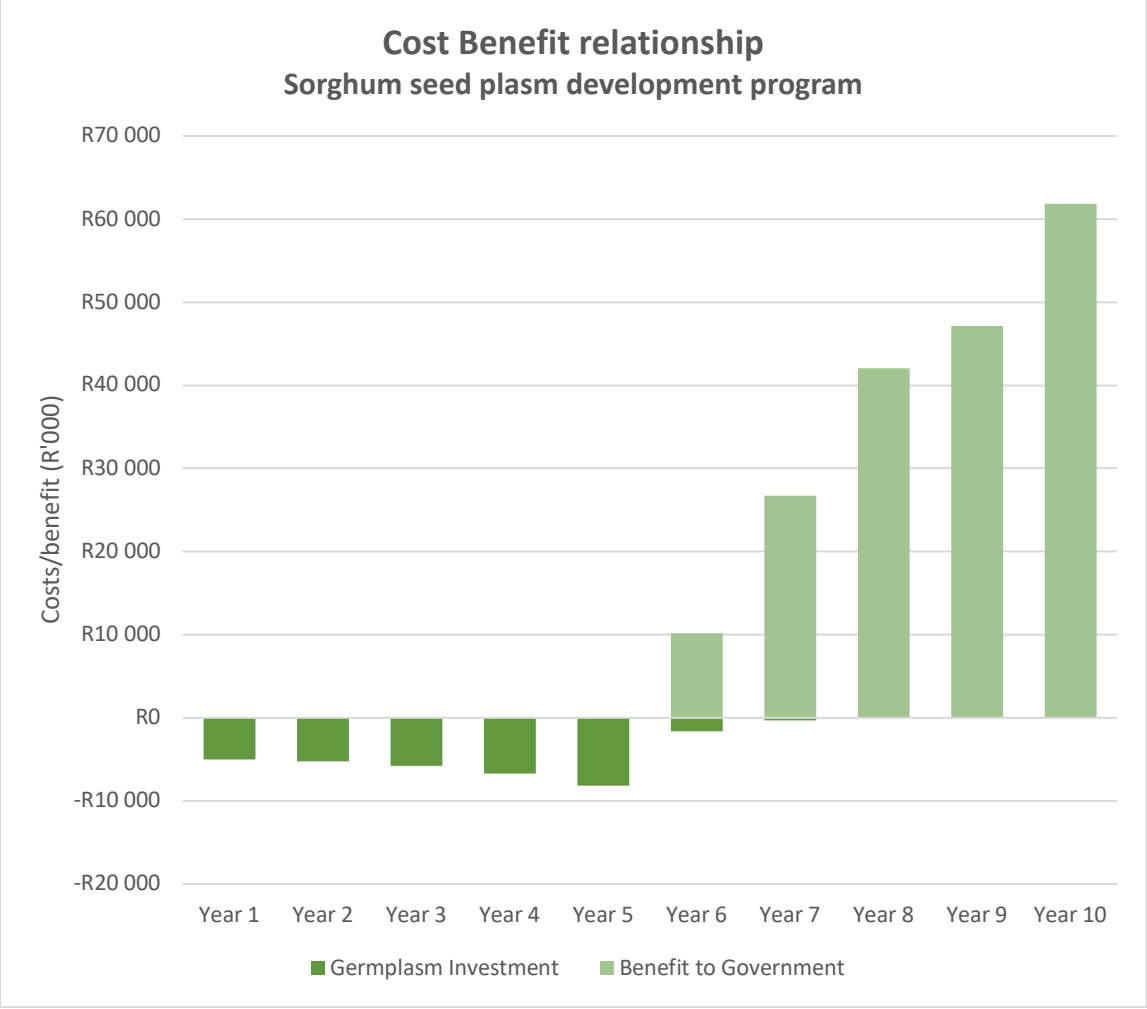


Figure 85: Cost-Benefit Relationship

Part 11:
Financial Model

11 Financial Model

11.1 Key assumptions: Commercial farm model

A financial model for sorghum farming was developed based on the crop budgets from Grain SA. It is a simplistic model based on the farm/land in question being used for the cultivation of 3 cereal type crops.

11.1.1 Model functions

The Dashboard is the first sheet in the model and is used to navigate through the model and populate the model with the relevant data as per the land utilisation and projected outcomes in terms of:

- Crops selected
- Land owned/rented (it allows for a farmer to use rented land to supplement its own operations)
- Size of the land (ha)
- Projected yield (t/ha)
- Projected contract or sales price (Rand/ton)
- Marketing costs (R/ton)

Figure 86: Financial model dashboard

Other model parameters that need to be completed in the dashboard, includes:

- Interest rates on loans for land and fixed assets procurement
- % of the asset financed. Depending on the nature of the asset up to 80% of the asset procurement can be financed.
- % of production costs that can be financed by a production loan
- Overhead % costs allocation to crops.
- Tax rate

- Farmland rental rate in the event that additional land is required.

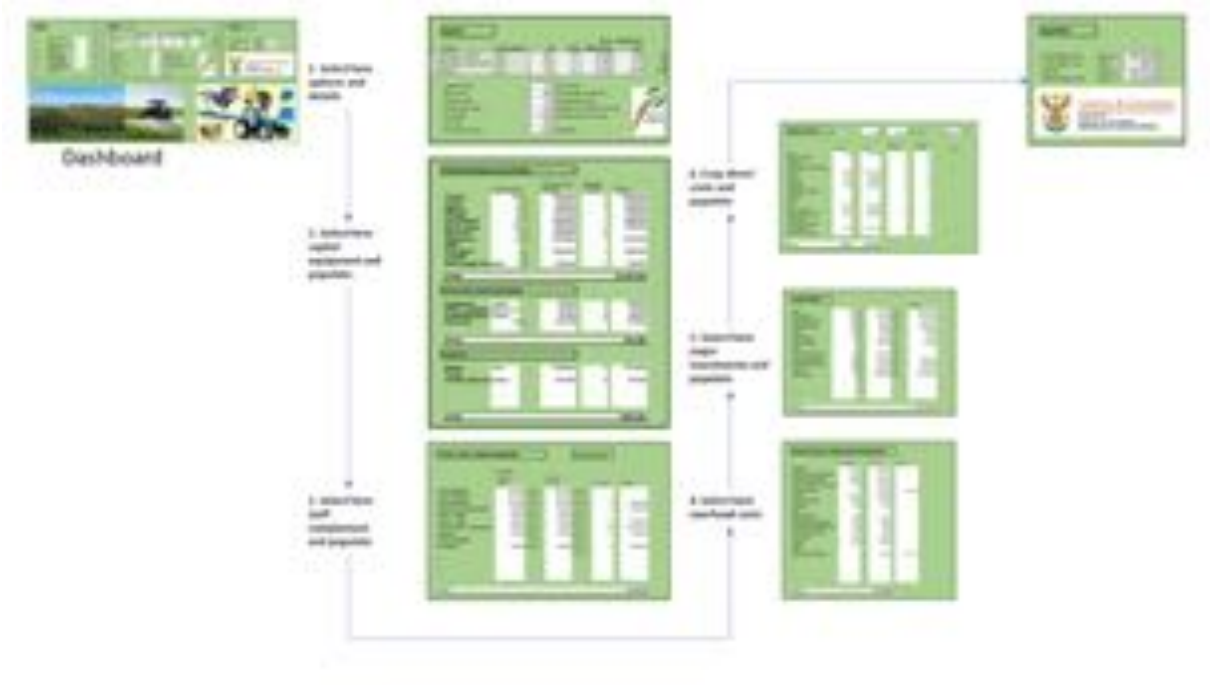
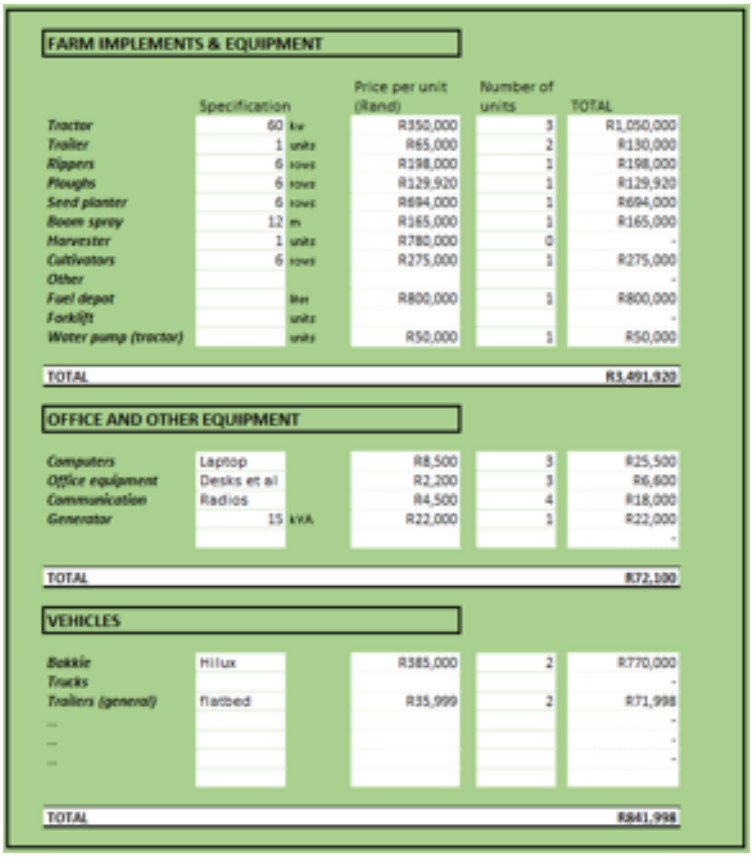


Figure 87: Process flow of populating the financial model.

The rest of the spreadsheets is used to provide further details of:

- Farm capital equipment



FARM IMPLEMENTS & EQUIPMENT

	Specification		Price per unit (Rand)	Number of units	TOTAL
Tractor	60	kw	R350,000	3	R1,050,000
Trailer	1	units	R65,000	2	R130,000
Rippers	6	rows	R198,000	1	R198,000
Ploughs	6	rows	R129,920	1	R129,920
Seed planter	6	rows	R694,000	1	R694,000
Boom spray	12	m	R165,000	1	R165,000
Harvester	1	units	R780,000	0	-
Cultivators	6	rows	R275,000	1	R275,000
Other					-
Fuel depot		liter	R800,000	1	R800,000
Forklift		units			-
Water pump (tractor)		units	R50,000	1	R50,000
TOTAL					R3,491,920

OFFICE AND OTHER EQUIPMENT

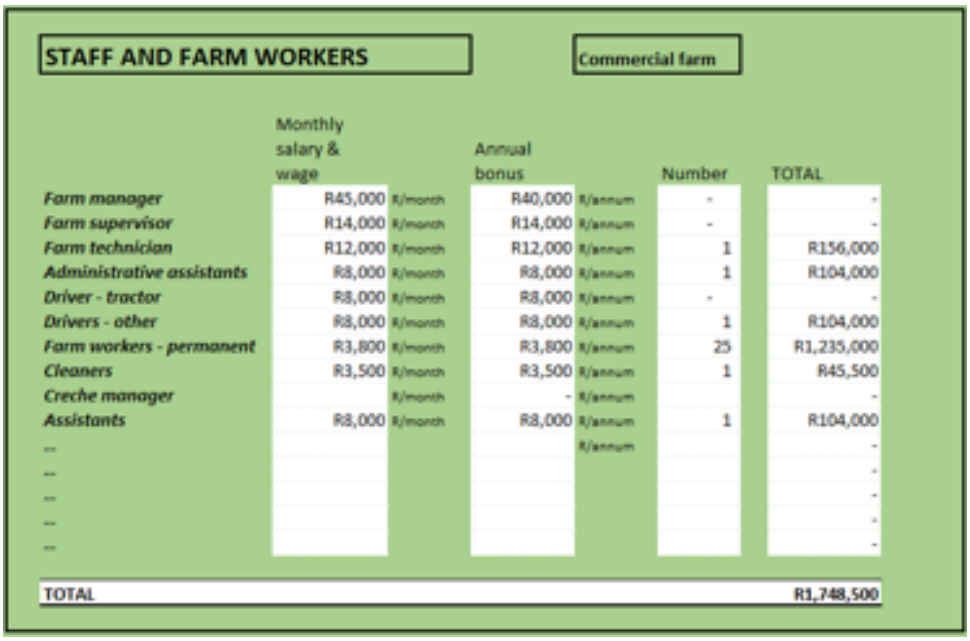
Computers	Laptop		R8,500	3	R25,500
Office equipment	Desks et al		R2,200	3	R6,600
Communication	Radios		R4,500	4	R18,000
Generator	15	kVA	R22,000	1	R22,000
					-
TOTAL					R72,100

VEHICLES

Bakkie	Hilux		R385,000	2	R770,000
Trucks					-
Trailers (general)	flatbed		R35,999	2	R71,998
...					-
...					-
...					-
TOTAL					R841,998

Table 31: Farm capital equipment table

- Farm staff complement and remuneration



STAFF AND FARM WORKERS — **Commercial farm**

	Monthly salary & wage		Annual bonus		Number	TOTAL
Farm manager	R45,000	R/month	R40,000	R/annum	-	-
Farm supervisor	R14,000	R/month	R14,000	R/annum	-	-
Farm technician	R12,000	R/month	R12,000	R/annum	1	R156,000
Administrative assistants	R8,000	R/month	R8,000	R/annum	1	R104,000
Driver - tractor	R8,000	R/month	R8,000	R/annum	-	-
Drivers - other	R8,000	R/month	R8,000	R/annum	1	R104,000
Farm workers - permanent	R3,800	R/month	R3,800	R/annum	25	R1,235,000
Cleaners	R3,500	R/month	R3,500	R/annum	1	R45,500
Creche manager		R/month	-	R/annum		-
Assistants	R8,000	R/month	R8,000	R/annum	1	R104,000
...				R/annum		-
...						-
...						-
...						-
...						-
TOTAL						R1,748,500

Table 32: Farm staff table

- Capture of overhead costs for the operation

OPERATIONAL EXPENSES/OVERHEADS

	Monthly	Annual	Month
Utilities	R3,200	R38,400	
Administration expenses	R560	R6,720	
Insurance (general)	R5,000	R60,000	
Audit and accounting fees	R850	R10,200	
Consulting fees		R30,000	Sep-20
Travel	R1,200	R14,400	
Communication	R450	R5,400	
Postage	R60	R720	
Rent		-	
Subscriptions	R60	R720	
Fuel and oil (general)	R120	R1,440	
Maintanance (office etc.)	R50	R600	
Cleaning materials	R50	R600	
Loose tools	R150	R1,800	
Sundry	R150	R1,800	
Other		-	
Gifts and Donations		R5,000	Nov-21
---		-	
---		-	
---		-	
---		-	
---		-	
TOTAL		R177,800	

Table 33: Farm overhead costs table

- Major capital investments, e.g. land, land clearance and other capitalised costs

INVESTMENT

					TOTAL
Farm	600	ha	R15,000	R/ha	R9,000,000
Farm house	250	m2	R12,000	R/m2	R3,000,000
Implement Store	100	m2	R5,500	R/m2	R550,000
Products Store	250	m2	R8,000	R/m2	R2,000,000
Shed	12	m2	R9,000	unit	R9,000
Watertanks	10	kl	R5,000	unit	R5,000
Diesel storage		kl	R15,000	unit	R15,000
Dam		kl		unit	-
Land clearing trees	0	ha	R50,000	R/ha	-
Land clearing bush	20	ha	R25,000	R/ha	R500,000
Land clearing grass	80	ha	R10,000	R/ha	R800,000
Fencing	10	km	R200,000	R/km	R2,000,000
Farm roads	5	km	R250,000	R/km	R1,250,000
---					-
---					-
---					-
---					-
TOTAL					R19,129,000

Table 34: Farm major capital investment table

- Worksheets for direct crop costs. There are 3 sheets for the selected crops. It is important that the direct costs match the crop to which these costs are assigned.

DIRECT COSTS		600 ha	Aug-20 Start month		sorghum Crop
	Rand/ha	TOTAL	Months from start	Duration months	Notes
Seed	R430	R258,000	1	1	
Soil Preparation		-	2	1	
Planting			3	2	
Contract land preparation		-			1
Fertiliser	R2,125	R1,275,000	2	3	
Lime	R147	R88,200	2	1	
Pesticides	R530	R318,000	2	3	
Herbicides	R715	R429,000	2	3	
Laboratory analysis		-	2	1	
Electricity		-			
Water		-			
Fuel	R1,027	R616,200	1	8	
Crop insurance	R183	R109,800	2	1	
Repairs/Maintenance	R657	R394,200	3	7	
Aerial spray		-			
Contract harvesting		-	5	4	2
Casual labour	R192	R115,200	2	3	
Other (land rental)	-	-			3
TOTAL	R6,006	R3,603,600			

Table 35: Farm crop budget for sorghum

11.1.2 Assumptions

The "Assumptions" worksheet contains the input for shareholder/farmer contribution in cash as well as a non-distributable reserve in the event the assets need to be revalued.

Other assumptions provided for in the model includes cash flow assumptions such as:

- Debtors: First payment of 50% for crop is due when crop is delivered to the mill or processor or agent.
- Creditors: Suppliers of input materials can provide up to 30 days credit for advance of materials required for production.
- Production loan is required to cover input material costs and percentage of overhead costs. The model allows these %'s to be changed. Production loans are settled at the end of the season in full. Interest on the loan is paid monthly.

11.1.3 Model Outcomes

The farm-model works out the profit for a season.

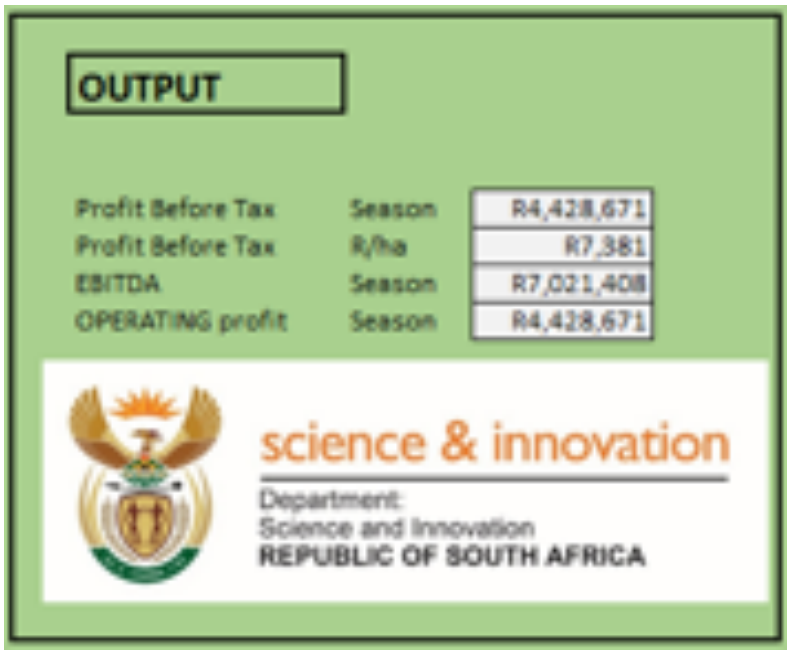


Figure 88: Farm output

11.1.4 Projected financials

The model also provides output of the farm financials per annum and over a 2-year period as per the Annexure B.

The farm model was populated with input metrics as indicated in the various Tables in this chapter and the outcome modelled over a 2-year period to illustrate the impact if interest rate roll-over from one year to another. The second-year financials reflect the ongoing farm profitability.

FINANCIAL STATEMENTS		Farm various crops/District	
		FY2020/21	FY2020/21
INCOME STATEMENT			
Income		**R16,200,000**	**R16,200,000**
Sorghum sweet		R10,260,000	R10,260,000
Sorghum (land rent)		R5,130,000	R5,130,000
Maize		R810,000	R810,000
Marketing costs		**R333,150**	**R333,150**
Sorghum sweet		-	-
Sorghum (land rent)		-	-
Maize		-	-
Direct costs		**R6,285,957**	**R6,285,957**
Sorghum sweet		R3,603,600	R3,603,600
Sorghum (land rent)		R1,891,800	R1,891,800
Maize		R790,557	R790,557
OPERATING EXPENSES		**R5,152,221**	**R5,475,675**
Overheads		R177,800	R177,800
Salaries and Wages		R1,748,500	R1,748,500
Other		-	-
Production loan interest	13%	R633,185	R720,935
Finance costs	12%	R2,592,737	R2,828,440
EBITDA		**R7,654,593**	**R7,654,593**
OPERATING PROFIT		**R4,428,671**	**R4,105,218**
Tax	28%		
Depreciation		2,399,526	2,399,526
NET PROFIT		**2,029,145**	**1,705,692**
Retained earnings (year)		**R2,029,145**	**R1,705,692**
Retained earnings (Cumulative)		**R2,029,145**	**R3,734,837**

Table 36: Farm Model: Income statement for 2 years

FINANCIAL STATEMENTS		Farm various crops/District	
		FY2020/21	FY2020/21
BALANCE SHEET		FY2020/21	FY2020/21
Land		R15,000,000	R15,000,000
Buildings & Land preparation		R10,129,000	R10,129,000
Farm implements		R3,491,920	R3,491,920
Office and Other		R72,100	R72,100
Vehicles		R841,998	R841,998
TOTAL FIXED ASSETS		**R29,535,018**	**R29,535,018**
Depreciation		R2,399,526	R4,799,052
NET ASSETS		**R27,135,492**	**R24,735,966**
Stock materials		-	-
Stock crop		-	-
Debtors		R8,100,000	R8,100,000
Cash		R8,463,988	R12,569,206
CURRENT ASSETS		**R16,563,988**	**R20,669,206**
TOTAL ASSETS		**R43,699,480**	**R45,405,171**
Creditors		-	-
8100000 Production loan	50%	R8,100,000	R8,100,000
TOTAL CURRENT LIABILITIES		**R8,100,000**	**R8,100,000**
LONG TERM LOAN	80%	**R23,570,334**	**R23,570,334**
Owners' contribution		R5,000,000	R5,000,000
Non-distributable reserve		R5,000,000	R5,000,000
Retained earnings		R2,029,145	R3,734,837
OWNERS INTEREST		**R12,029,145**	**R13,734,837**
TOTAL LIABILITIES		**R43,699,480**	**R45,405,171**

Table 37: Farm Model: Balance sheet for 2 years.

11.2 Key assumptions: Small holder farm model

The financial model for smallholder farmers is simplistic and due to the fact that cereal crops for smallholder farmers are seasonal, mostly dry land cultivated with limited assets, the profitability of the season was modelled. The model illustrates the challenges faced by smallholder farmers in terms of financial feasibility as far as current costs and sorghum prices are concerned. Key assumptions include the following:

- Smallholder farmers make use of extension services provided by the provincial department of agriculture and are not charged for the service
- All mechanisation is provided for on a contracted-in basis. This includes harvesting, seed planting etc. Fuel and maintenance costs are included in the mechanisation fee.

- The farmer receives a stipend of circa R1140 per month. This is based on the poverty-line income as determined by World Bank at USD2.50 per day. It is below the minimum wage.
- The farmer and family look after the crop for clearing out weeds. No herbicides are required in this case.
- Yield is a variable and various yield assumptions are used in a comparative outcome assessment.
- No transport costs were included. It is assumed that the government and/or the food contracting buyer of sorghum will collect from the farm or a convenient collection depot in close proximity to the farms.

A key variable in this model is farm size for which a farm of at least 5ha was assumed. The income model Using the current GrainSA crop budget and input costs, the financial outcome is reflected below.

DIRECT COSTS		5 ha	sorghum Crop
	Rand/ha	TOTAL	Notes
Seed	R430	R2,150	
Soil Preparation		-	
Planting			
Fertiliser	R2,125	R10,625	
Lime	R147	R735	
Pesticides	R530	R2,650	
Herbicides		-	
Electricity		-	
Water		-	
Mechanisation	R1,800	R9,000	
Contract harvesting	R850	R4,250	
Stipend (12 months)	R1,140	R13,680	
Co-operative contribution		-	
TOTAL	**R7,022**	**R43,090**	
Selling price	R3,500		
Yield	1900 kg/ha		
Income	R33,250		
Less: deductions	-R43,090		
NET Farmer income	-R9,840		

Table 38: Typical smallholder farm budget

The Table above provides a current scenario with no intervention from either the Government or by processors that contract the farmer for supply of sorghum. It is notable that such a model is not sustainable, and intervention or model enhancement is required.

Based on the basic model, various smallholder farmer engagement models can be assessed for different scenarios.

SUMMARY		Base case	Seed and fertiliser subsidised	Seed and fertiliser subsidised/High yield	High yield – no subsidy
Input costs (Rand)		Rand/ha	Rand/ha		Rand/ha
Seed		R430	R0		R430
Soil Preparation		R0			
Planting					
Fertiliser		R2,125			R2,125
Lime		R147			R147
Pesticides		R530	R530	R530	R530
Herbicides					
Mechanisation		R1,800	R1,800	R1,800	R1,800
Contract harvesting		R850	R850	R850	R850
TOTAL	R/ha	R5,882	R3,180	R3,180	R5,882
	5ha	R29,410	R15,900	R15,900	R29,410
Stipend (12 months)	12 months	R13,680	R13,680	R13,680	R13,680
TOTAL		R43,090	R29,580	R29,580	R43,090
Selling price	R/ton	R3,500	R3,500	R3,500	R3,500
Yield	Ton/ha	1900	1900	3000	3000
Income	5ha	R33,250	R33,250	R52,500	R52,500
Less: deductions		-R43,090	-R29,580	-R29,580	-R43,090
NET Farmer income		-R9,840	R3,670	R22,920	R9,410
TOTAL Farmer income (including stipend)		**N/A**	**R17,350**	**R36,600**	**R23,090**

Table 39: Comparison of smallholder farmer models

The comparison reveals that farmer income in most cases is very low and in fact, even in the case of high yields, the income is less than what the farmer can earn receiving a minimum wage of R3,500 per month. There is therefore little motivation for the farmer to cultivate the sorghum crop under these conditions. It remains therefore, a function of the Government and/or a food processor, to engage with the farmers and provide input materials at no charge to the farmer. The farmer engagement will also have to include extensive support services in training and capacity building and in cases where there is no contracted processor or agent involved, the services should also include providing support to the farmers to access markets.

11.3 Considerations for Smallholder Farm Development

An objective of the Sorghum market development study included the development of a financial model for smallholder farmers. While the model itself is fairly simple, the feasibility of these

smallholder farming operations is a dependent on a number of factors. It is also necessary to qualify certain desired outcomes and categorise smallholder farmers.

- Production for own consumption or backyard farming.
- Smallholder farmers. In some publications from international agencies, smallholder farmers are those on farms of less than 5ha. The department of agriculture in South Africa does not refer to far size but rather the income, i.e. more than R50k up to R1million income per annum qualifies as smallholder farmers.
- Commercial farmers. Larger than 5ha. Small commercial farmers farm on land up to 60ha. The STATSSA classifies farmers in categories of income as per the following Table:

Size group	Income (annual)
Large enterprises	Income > R22 500 000
Medium enterprises	R13 500 000 < Income <= R22 500 000
Small enterprises	R2 250 000 < Income <= R13 500 000
Micro enterprises (one million and above)	R1 000 000 <= Income <= R2 250 000
Micro enterprises (below one million)	Income < R1 000 000

Table 40: Classification of farm sizes in South Africa

The NPO - **African Smallholder Farmers Group** published a report (circa 2017 titled "Supporting Smallholder Farmers in Africa: A framework for an Enabling Environment." [19] Some key observations from the study are extracted herewith as being representative of small holder farmers in Sub-Saharan Africa, including South Africa.

- There are around 500 million smallholder farmers in the world, and they produce up to 80% of the food consumed in Africa and Asia. They are net buyers of food and very vulnerable to food price increases and spikes. As a group, they are among the poorest and most marginalised in the world. They are also stewards of increasingly scarce natural resources and on the frontline of dealing with the impacts of climate change. Smallholders therefore play a critical role in addressing the challenges of food security, poverty and climate change.
- Africa's smallholder farmers face many challenges preventing them from scaling up their participation in markets, including insecure rights to land and natural resources, lack of access to quality inputs and financial services, inadequate support from research and extension services, and high transaction costs caused by poor rural infrastructure. Smallholders have little say in policy decisions that impact on their lives, or in the design of research agendas. In addition, domestic and international markets for agricultural produce are changing rapidly and dramatically, with smaller producers finding it increasingly hard to participate in these markets. Challenges are even greater for women farmers, who constitute the majority of farmers in Africa.
- International efforts to support smallholder farmers tend to follow a conventional approach to boosting agricultural productivity, with much of the emphasis on commercialising agriculture using modern inputs and encouraging integration of smallholders into agricultural

[19] African Smallholder Farmers Group. Supporting Smallholder Farmers in Africa: A framework for an Enabling Environment.

value chains, particularly those producing for export markets. However, evidence suggests that only a small group of wealthier and better-connected smallholders are currently likely to be able to benefit from opportunities created in this way. For the majority of small-scale farmers, and particularly those that are more marginalised, including women farmers, different forms of support are needed to facilitate their greater participation in markets as a means of increasing food security at the national and household level.

Of the two-thirds of sub-Saharan Africa's population that resides in the rural areas, the majority can be considered as smallholder farmers. As a group, smallholder farmers are among the most disadvantaged and vulnerable in the developing world: half of the world's undernourished people, three-quarters of Africa's malnourished children, and the majority of people living in absolute poverty can be found on small farms (International Food Policy Research Institute, 2007). Smallholders have a key role to play not only in achieving food security, but also in generating poverty-reducing agricultural growth. They are also stewards of increasingly scarce natural resources and on the frontline of dealing with the impacts of climate change.

11.3.1 South African smallholder farmers

South Africa's smallholder farmers face similar challenge as those highlighted by the ASFG (African Smallholder Farmers Group). A cursory overview of the RED Hubs in Eastern Cape reveals that these hubs are facing substantial challenges primarily related to farm yield of maize (currently the RED hubs are facing closure due to its poor performance).

South Africa does not appear to have statistics of smallholder farmers, other than Household Statistics (2018) that addresses the number of households involved in agriculture and the Census of Commercial Agriculture that was conducted in 2017.

According to STATISTICAL RELEASE P0318 General Household Survey 2018 only 14,8% of South African households were involved in some sort of agricultural production activities during the reference period. While 37,1% of households in Limpopo and 29,3% of households in Eastern Cape engaged in some agricultural activity, participation was much lower in Western Cape (2,5%) and Gauteng (4,0%). Of the households that were involved in agriculture, 10,1% cultivated farmland while 90,3% created backyard gardens.

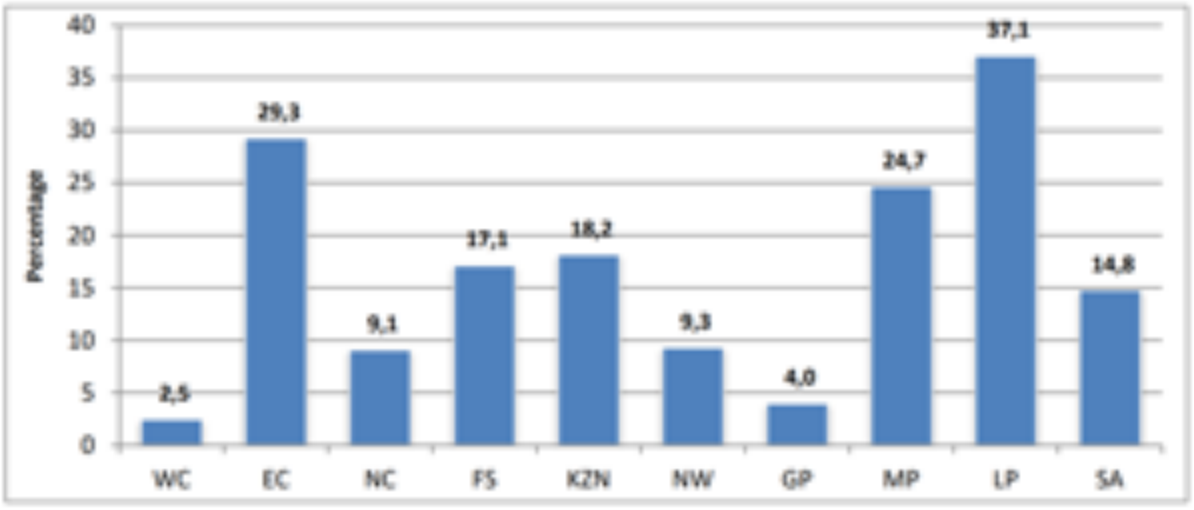
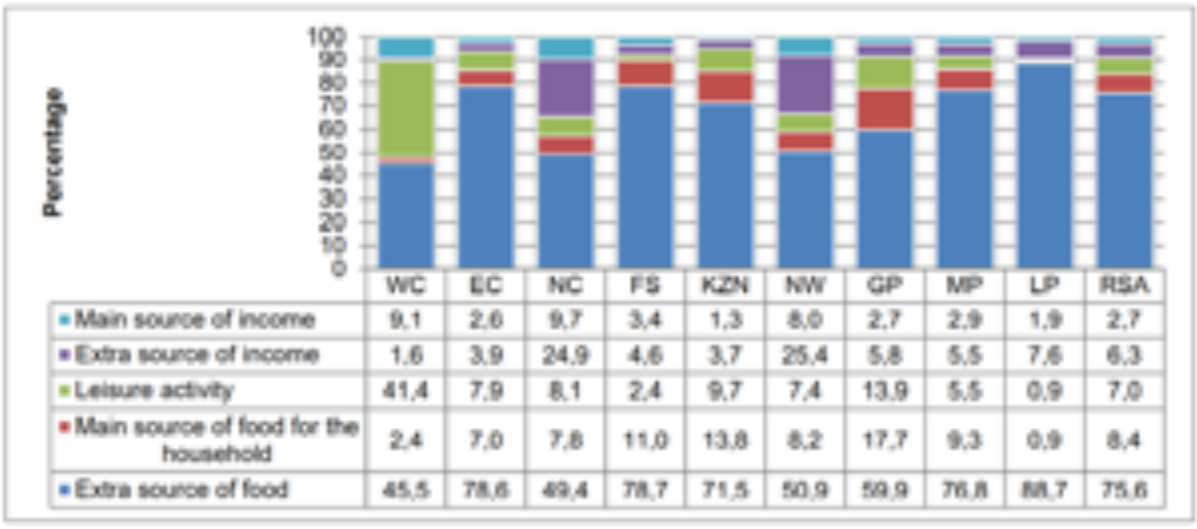


Figure 89: Percentage of Households involved in Agriculture (2018)

Nationally, more than three-quarters (75,6%) of households that were involved in agriculture were involved in an attempt to secure an additional source of food. Provincially, 88,7% of households in Limpopo, and 78,6% of households in the Eastern Cape and 76,8% in Mpumalanga engaged in agricultural activities as a way to augment their existing sources of food. By comparison, 41,4% of households in Western Cape practiced agriculture as a leisure activity. Since agriculture is not so common in Gauteng this finding might point to the fact that many households engage in agriculture as a last option.



	WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
Main source of income	9,1	2,6	9,7	3,4	1,3	8,0	2,7	2,9	1,9	2,7
Extra source of income	1,6	3,9	24,9	4,6	3,7	25,4	5,8	5,5	7,6	6,3
Leisure activity	41,4	7,9	8,1	2,4	9,7	7,4	13,9	5,5	0,9	7,0
Main source of food for the household	2,4	7,0	7,8	11,0	13,8	8,2	17,7	9,3	0,9	8,4
Extra source of food	45,5	78,6	49,4	78,7	71,5	50,9	59,9	76,8	88,7	75,6

Figure 90: Percentage distribution of the main reasons for agricultural involvement by province, 2018

Source: STATISTICAL RELEASE P0318 General Household Survey 2018; STATSSA

Further to the above statistics, the report from STATSSA indicates that:

- Of the households that were engaged in agricultural production, 50.6% cultivated grains, and 53.3% grew fruit and vegetables. Livestock were produced by 48.7% of the country's households, while 36.6% produced poultry.

- Only 10,0% of the households involved in agriculture reported getting agricultural-related support from the government during the year preceding the survey. The only provinces where significant support was provided for farming households were Eastern Cape (25,1%) and Northern Cape (17,3%). Nationally, slightly less than 2% (1.3%) of the households reported receiving training and 6.3% received dipping/ livestock vaccination services.

The STATSSA publication on commercial farming classifies farms according to their income as per the illustration below:

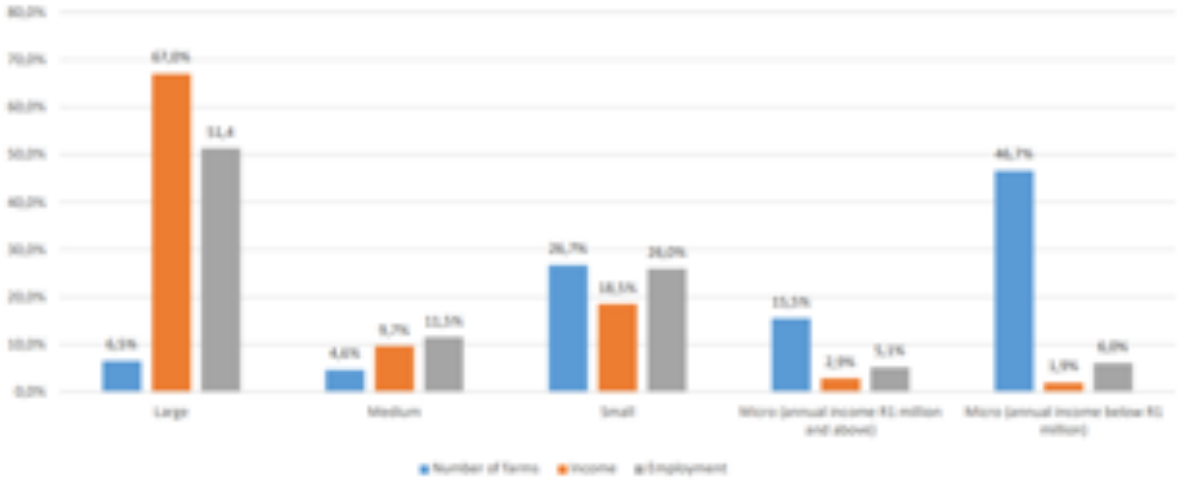


Figure 91: Number of farms, income and employment in commercial agriculture 2017

Source: Census of commercial agriculture, Report No. 11-02-01; STATSSA

The total number of farms/ farming units involved in the commercial agriculture industry in 2017 was 40 122. The largest proportion of farms was in farming of animals (13 639 farms or 33,9% of the total), followed by mixed farming (12 458 or 31,1%) and growing of cereals and other crops (8 559 or 21,3%). 2 610 large farms (those with annual income of more than R22,5 million) constituted 6,5% of the total number of farms in the commercial agriculture industry and accounted for 67,0% of total income and 51,4% of total employment. This was in contrast to the 18 710 micro farms (annual income below R1 million) which made up almost half of the total number of farms, but which accounted for just 1,9% of total income and 6,0% of total employment. Taken together, there were 15 180 large, medium and small farms in 2017, with combined shares of 37,8% of the number of farms, 95,2% of income, and 88,9% of employment. Measured by farm size, small farming units were the second largest in terms of number of farms, income and employment in 2017.

11.3.2 South Africa initiatives in smallholder farming

There are various departments in South Africa that are in some form or another involved in farmer development and specifically smallholder farmer development. While the scope of this report does not cover these initiatives comprehensively, it appears that further study into these initiatives is required to appreciate the breadth of these initiatives and on a provincial level, which entities are responsible for the regional implementation thereof.

The Department of Agriculture, Land Reform and Rural Development has for the past few years been working on building its own capacity to drive the Smallholder Horticulture Empowerment and Promotion (SHEP) Approach in the country from a modernised and sustainable template[20]. As part of this capacity building, the department opened an office in Japan and through this office, linkages to revitalise relations between the DAFF and the Japan International Cooperation Agency (JICA) office in South Africa were established.

The SHEP is a "Market-Oriented Agriculture and Promotion in Africa" project that encourages producers to move away from "growing and selling" their produce to "grow to sell." The SHEP Approach is geared towards assisting smallholder producers to increase their income by means of capacitating them to better manage group dynamics and improving production through various techniques, such as knowing the market requirement before they start to produce.

All provinces will be implementing the SHEP Approach and over 5 000 smallholder producers, of which 50% are youth, will benefit during the current Medium-Term Strategic Framework. Producers will grow their produce to sell instead of growing and selling.

The National Agriculture Marketing Council (NAMC) established a Smallholder Access Research Unit to support smallholder farmer access to markets. The NAMC has since 2016/17 engaged various local and international institutions to participate in several projects to achieve its objective of smallholder farmer integration into mainstream food supply chains. These include:

- GDARD Extension Project The NAMC has signed an agreement with the Gauteng Department of Agriculture and Rural Development (GDARD) to conduct research that covers issues of extension services as catalyst for improved farm productivity in the Gauteng province of South Africa. The agreement spans for a period of 2 years – from 01 April 2019 – 31 March 2021. The research is funded by GDARD and the research output will be owned by the department. Note: some of the challenges in provision of extension services is highlighted later in this report.
- The Australian Centre for International Agricultural Research (ACIAR) The NAMC is in a partnership with the Agriculture Research Council (ARC) and the University of New England (UNE) supported by the ACIAR to assist smallholder and emerging beef cattle farmers in South Africa.
- GCRF-AFRICAP is a four-year multi-stakeholder project funded by the United Kingdom government and advocated by the University of Leeds in collaboration with Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN). The aim of this project is to identify and implement evidence-based policy pathways to facilitate the development of sustainable, productivity, climate smart agricultural systems to meet food security and economic development needs through partnerships and capacity building across the UK and African organisations.

[20] Agriculture, Forestry and Fisheries on Smallholder Horticulture Empowerment and Promotion Approach | South African Government (www.gov.za) (April 2019)

- On the 30th of April 2019, the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) signed a contract with the United Nations (UN) Women - South Africa Multi Country Office (SAMCO) to undertake a scoping and baseline study on the main areas of intervention of the UN Women SAMCO flagship programme on "Creating markets through affirmative procurement of women businesses in South Africa'.

Funding for smallholder farmers is generally available from Government grants aimed at Agriculture and Rural Development and is funded by the Department of Agriculture, Land Reform and Rural Development (DALRRD). Funds from this department, the provincial equivalent departments are funded. DALRRD also uses LandBank to participate in funding, mostly for provision of production loans at the commencement of the planting season.

The participation of an industrial brewing companies and various international institutions in the development of sustainable agriculture is illustrated by Nigerian Breweries (a Heineken subsidiary) engagements with smallholder farmers in Nigeria. A similar approach is followed by East African Breweries in Kenya servicing and supporting sorghum farmers in the East African countries of Kenya, Uganda and Tanzania. The example of Nigerian Breweries is particularly instructive.

11.3.3 Why and how Nigerian Breweries makes extensive use of sorghum

Following the Structural Adjustment Programme (SAP) of the 1980s, the Federal Government of Nigeria in an effort to conserve foreign exchange earnings, and enhance domestic and commercial production, started restricting importation of certain goods. Some categories of goods were completely prohibited from the country's import list. In addition, the Government introduced the policy on Backward Integration, which requested manufacturers to substitute some imported raw and packaging materials with local alternatives. Malted barley importation was banned in 1988 and all breweries were forced to brew with only locally available grains. In response, Nigerian Breweries commenced exploratory work in reformulating some of its brands with local substitutes. One of the local grains that then received the attention and patronage of the Company was sorghum. Some level of success, which was to be improved upon with time, was recorded. Ever since, many sorghum farmers have continued to receive part of the company's corporate social investment outflows as well as market support as part of its grain supply chain development.

In 1999, following a reversal in policy direction by the Nigerian Government, the ban on malted barley importation was lifted. The effort at backward integration was to later peter out following the policy reversal. The net effect was for the beverage industry to re-focus once again from the use of locally grown sorghum to imported malted barley. Thus, the initial attempts at local cultivation of grains waned considerably. Nigerian Breweries, however, driven by corporate social responsibility as well as business interests, continued to work on its sorghum development programme, latching on the experience already gained in incorporating local grains in its beverage formulations. As a result, the Company decided to maintain a substantial level of local grains in most of its products' recipes. This gave the Company the competitive advantage of pioneering the commercial development of hybrid sorghum in Nigeria.

Nigerian Breweries' initial successes in 2006 with the selection of the open pollinated varieties - CSR-01 and CSR-02, with a farm yield of 2.0 to 2.5 tonnes per hectare of land was well received by farmers and other stakeholders. This was because it came at a time when the annual national average was 0.8 to 1.2 tonnes per hectare. With the goal to significantly boost productivity from 2009, the Company decided to shift emphasis from variety seed identification and selection to hybrid seed development. Our aim then was to increase productivity up to 4–5 tonnes per hectare. The decision to shift emphasis to hybrid seeds development triggered a series of activities and motivated a wide range of collaborations with relevant organisations that resulted into the development, certification, registration and release in December 2012 of two new hybrid sorghum seeds, CSR-03H and CSR-04H. The new hybrids are high-yield seed varieties with the potential for 4 metric tonnes per hectare of land.

Participants in the development of the Nigerian sorghum industry included various implementing partners. These include the United States Agency for International Development (USAID)/ Maximizing Agricultural Revenues and Key Enterprises in targeted Sites (USAID/MARKETS). Nigerian Breweries also work with the Institute for Agricultural Research (IAR), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), seed producers, regional production coordinators and other partners in the sorghum value chain.

Up to 2017 and over a period of 10 years Nigerian Breweries has spent US$280k per annum on the Sorghum Value Chain programme and engaged over 10,000 farmers. T Nigerian Breweries provide input costs/materials and extension services to the farmers supplying sorghum.

Similarly, East African Breweries Limited (Kenya) support 60,000 farmers in a similar model by providing input materials (quality seeds) and extension services to smallholder farmers in the East African region[21].

11.3.4 Extension services to support smallholder farmers

Agricultural extension service[22] is one of the main instruments used by Provincial Departments of Agriculture to achieve their agricultural developmental goals. Agricultural extension involves provision of appropriate agricultural information and knowledge to enable and capacitate land users and farmers towards improved, sustainable and economic development. This explains why agricultural extension remains one of the strategies for rural development throughout the world, assist farmers to determine their own problems, help them find desirable solutions and encourage them to take action. Extension services can be organized and delivered in a variety of forms, but their ultimate aim is to increase farmers' productivity and income. Farmers are often blamed for poor adoption of extension services and success or failure is based on the level of adoption without considering the effectiveness of extension delivery mechanisms. There are numerous problems facing the agricultural

[21] EABL 2020 Annual Report; East Africa Breweries Limited; 2020
[22] S. Afr. J. Agric. Ext. Maoba Vol. 44, No. 2, 2016: 167 –173 DOI: http://dx.doi.org/10.17159/2413-3221/2016/v44n2a415 (Copyright) 167 FARMERS' PERCEPTION OF AGRICULTURAL EXTENSION SERVICE DELIVERY IN GERMISTON REGION, GAUTENG PROVINCE, SOUTH AFRICA

extension service such as high level of illiteracy among farmers which sometimes make it difficult for them to comprehend all the ideas being communicated to them. Even after communicating the ideas, some of the farmers cannot subsequently translate the ideas to practice. In the same vein, most of the farmers are conservative and are not ready to accept any positive changes. However, in the Gauteng Province for example, agricultural extension officials have being criticized by some famers for not being visible, effective and efficient when doing their job.

Part 12:
Conclusions and Recommendations

12 Conclusion and Recommendations

12.1 Conclusion

The purpose of the study was to establish market opportunities for sorghum and to make recommendations for upgrading the sorghum value chain in South Africa. The study conducted by the research team confirmed the following:

- The sorghum demand has declined greatly over the past decade, primarily due to the decline in consumption of traditional African beer (sorghum beer) as well as the almost total cessation of exports to Botswana resulting from that country successfully commercially producing sorghum for its own consumption;
- The production of sorghum in South Africa has declined even more precipitously, resulting in a substantial shortfall in local supply, which is now supplemented by imports of sorghum primarily from the United States of America;
- The unrealistically low SAFEX price for sorghum leads to sorghum grain prices being negotiated between producers and users on an import parity basis. The large difference between the SAFEX price and the actual price creates challenges for the farmers to raise funding for production loans prior to the start of the cultivation season;
- The high price of sorghum grain thus determined acts as a deterrent or "grudge purchase" from the food and beverage processing companies since the price impacts negatively on their profit margins in comparison to the prices of other cereal grains. It therefore becomes less attractive for these companies to process sorghum into end-user products. This in turn results in a situation where they are not investing in the development of sorghum products or the promotion thereof despite the fact that sorghum products provide higher processing yields (less chop) and sorghum products offering better nutrition to the consumer;
- Because of its high price, farmers are currently enjoying good profit margins on sorghum despite the fact that in most cases their first choice is to produce maize or other grain commodities. Sorghum production is normally reserved for the lower yielding areas of the farm. Farmers are concerned that overproduction of sorghum in the local market will lead to sorghum prices based on export parity prices that are much lower and therefore less attractive;
- A further knock-on effect of the declining sorghum demand and sorghum grain production, is the reluctance of the seed companies to produce sorghum seed as well as to invest in sorghum cultivar development for the local industry;
- As the South African agriculture sector will not be immune to climate change and its impact, an analysis of climate change impact was specially executed as part of the research work. The findings of the high-level study indicate that cereals agriculture will be adversely affected by climate change, specifically as a result of higher temperatures and

a greater number of extreme weather events. Evidence of this can be seen from what has happened this 2020-21 crop season in the Eastern Free State where there has been massive flooding after years of low rainfall. However, the sorghum crop modeling study undertaken indicated that simple mitigation strategies such on-field crop residue retention can be applied to greatly reduce these adverse effects of climate change on yield. It is therefore also imperative that current low-activity agriculture land areas such as found in the Eastern Cape be investigated to maximise the potential of grain production and specifically sorghum production for the current market and also the long-term future market opportunities;

- The inclusion of small-scale farmers in the sorghum value chain is highlighted as an opportunity to transform the industry and to broaden participation in the industry. Small-scale farming in general is constrained by high-input costs associated with a lack of purchasing power and the high cost of mechanisation that necessitates either the use of manual labour or shared resources in cooperative or communal farming establishments. Inadequate extension services further exacerbates the problems of small-scale grain farmers. The research identified that small-scale farming is being successfully applied in Kenya and Nigeria, driven primarily by commercial initiatives and demand;
- The sorghum industry in Australia and USA enjoys the support of quality research being conducted by institutions such the Queensland Sorghum Alliance and Texas A&M University, respectively. The status of the sorghum industry in Australia and the USA clearly indicates that through dedicated research programmes with adequate funding, the competitive position of sorghum in the grain commodity market can be greatly elevated and strengthened;
- Sorghum market initiatives in these countries are also supported by promotion and advertising of sorghum through organisations such as the United Sorghum Check-off Program in the USA. This has contributed to the amount of sorghum used for human consumption increasing by more than 250% over the last five years in the USA. Sorghum demand is growing by consumer choice because the grain is non-GMO, gluten free and high in antioxidants. It is also considered an excellent source of dietary fibre as well as being potentially protective against type 2 diabetes and cardiovascular disease,. It also has favourable food crop sustainability factors for an eco-friendly environment.

The research team investigated market opportunities for the sorghum industry and identified a number of opportunities, ranging from easily accessible import replacement market, growth opportunities in local food and beer production, and a potential East Africa export market.

On their own, each opportunity has merit and worthwhile pursuing. Combined, these sorghum market opportunities identified herewith, amounts to 348,000 tons per annum on the upside and 169,000 ton per annum conservatively.

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement	40,000	70,000
East Africa export	100,000	220,000
Beer	20,000	40,000
Consumer food	9,000	18,000
TOTAL potential	**169,000**	**348,000**

Table 41: Quantification of Market Opportunities

In order to access these market opportunities, the research findings indicate that local sorghum needs to be priced competitively to maize and exported sorghum from the United States of America. The research also included an assessment of sorghum and maize production in countries that are considered key sorghum producers, i.e., the USA and Australia. These assessments indicated that sorghum is produced and competes effectively with maize in these countries.

Based on the current situational analysis of the sorghum industry in South Africa, the identification of market opportunities and the assessment of the competitive positioning of sorghum in South Africa, USA and Australia, the research team proposed that a key driver for the enhancement of the value chain of the sorghum industry, will be the upgrade of the primary sorghum production. The objective of such an upgrade programme to support the entire value chain will be to produce sorghum at a competitive price to its grain counterparts and primarily white and yellow maize. In order to achieve this, the on-farm yield of sorghum needs to be increased, and/or the production costs thereof need to be reduced. The team believes that this can be achieved through the implementation of an advanced germplasm development (pre-breeding) programme, identification of high-yielding agricultural land and the application of new farming technologies such as precision agriculture. It is imperative that the status of sorghum grain in the local food chain be highlighted in terms of its very important role in agriculture and the food value chain.

12.2 Recommendations

The upgrade of the sorghum value chain rests on the implementation of the following initiatives that can be seen as pillars to establish a new platform from which the sorghum industry can compete and grow:

- **The Advanced Germplasm Development (Pre-Breeding) Programme**
  A well-resourced sorghum pre-breeding Advanced Germplasm Development programme to apply modern genomics-based breeding technologies to develop elite sorghum lines that are well-adapted to South and Southern African climatic conditions and have specific resistance to locally important pests and diseases. For the pre-breeding programme to achieve its goals, it must have the full buy-in by all relevant stakeholders and especially the

commercial seed companies. They will need to commit to taking up the developed improved germplasm and releasing improved new sorghum cultivars.

An indicative annual budget of between **R3 million - R5 million per annum** will be required for **the five years of the programme to establish it.** This is with assumption that the institute undertaking the programme already has an employed experienced doctoral level sorghum breeder and that the basic breeding infrastructure is in place.

- **The Establishment of a Sorghum Cluster Initiative**
  The clustering approach is aimed at encouraging strategies that create closer market linkages, improve supply chains and foster co-operation among value-chain participants. Various stakeholders form part of the cluster programme, forming vertical relationships (among suppliers, producers, processors, buyers and retailers), horizontal relationships (between processors and farmers) and support relationships (between government, service providers, R&D facilities, etc.). The objective of the sorghum cluster will be to promote the growth and development of the industry through the strengthening of these relationships and the upward and downward linkages within the industry value chain.

  The cost of **establishing the cluster (12 months)** and running the cluster for the **first 12 months** is estimated at **R3.8 million**.

- **Pilot Sites**
  In terms of the advanced germplasm development (pre-breeding) programme, pilot sites for the implementation of trial growing programmes should be in the same regions as where the current sorghum growers are established, i.e. Limpopo (Springbok Flats), Mpumalanga (Standerton) and eastern Free State (Koppies, Vredefort). These sites will be able to turn the benefit of new cultivars into immediate commercial opportunities with the support of established commercial farmers in these areas. It is further essential that the germplasm development programme incorporate the Eastern Cape as a key site. Utilising multiple sites for the cultivar development programme is critical to determine the yield stability of cultivars under differing climatic conditions, soil and plant disease conditions.

  The cost for the implementation of a pilot site programme needs to be finalised with the entity that will be tasked with its implementation. GrainSA has been conducting ongoing trials using various sorghum seeds and it is proposed that these trials be expanded to cover a wider area and to support the germplasm development programme.

- **The Eastern Cape – a special focus area**
  To support the integration of emerging commercial farmers into the sorghum value chain, it is proposed that the Eastern Cape be considered as a pilot site to demonstrate the value of establishing a local processing centres and engagement of emerging commercial farmers to supply sorghum to such centres. The reason for selecting the Eastern Cape is supported by the

fact that it is considered to have high potential for sorghum cultivation, especially as climate change increasingly negatively impacts on South African grain agriculture in some of the current high potential regions . Additionally, United National Breweries, the traditional African beer brewing company, has already been sourcing sorghum from smallholder farmers in the Eastern Cape to supply its Isithebe malting plant in KwaZulu-Natal. This activity was originally supported by the Diageo Foundation, Diageo being the company that up until 2020 owned UNB. In addition to producing sorghum in the Eastern Cape to meet requirements of the of the processing centre it will also help improve the viability of sorghum farming to supply UNB.

The establishment of an extrusion cooking food processing facility at one of the RED Hubs should be considered to produce added-value, ready-to-eat foods for the Eastern Cape market using sorghum R produced in the area. An estimated **R43,6 million investment (CAPEX and working capital)** is required to set up such an extrusion facility, assuming that existing buildings and infrastructure can be used. This excludes the establishment of farms to supply the processing facility with up to 30 tons of sorghum per day.

In order to justify this investment, a bankable feasibility study needs to be executed. This feasibility study will address the market opportunity and specifically the potential demand that can be channelled through local informal distribution channels and formal retail distribution channels such as Spar. It will also cover the sorghum production plan which will include the identification of suitable land and farmers to produce up to 6,600 tons of sorghum per annum. At a yield of 3 tons per hectare, this will require 2,200 hectares. It will also potentially create more than 400 employment opportunities in the entire value chain. The feasibility study can be presented to the local Eastern Cape government departments such as ECRDA and the IDC of SA for funding. The business plan should also include the identification and participation of strategic operating partners to support the establishment of the farming operations and the operation of the processing plant and the engagement of the retail outlets.

12.2.1 Key Role Players

The major organisation role players for the implementation of the proposed recommendations are the Sorghum Forum and Grain SA. The Department of Science and Innovation (DSI) should be involved in providing guidance and facilitation in approaching government departments for support.

- The Sorghum Forum with advice from DSI, should be engaged to motivate to Treasury to remove VAT on sorghum grain and meal. This initiative remove unfair tax and duties should be aligned to the initiatives by UNB to achieve the same outcome;
- Sorghum Forum and UNB, with the advice from DSI, to motivate to SARS the amendment of the definition of Traditional African Beer so as to allow an equitable excise duty on pasteurised Traditional African Beer. UNB is also actively engaging the Council for Traditional Leaders to gender support for this specific request;

- DSI, the Sorghum Trust and Grain SA, and possibly the Department of Trade, Industry and Competition (dtic), to fund the sorghum Germplasm Development (pre-breeding) programme;
- The Sorghum Forum and Grain SA with advice from DSI, to motivate to the Department of Higher Education and Training to create a Chair in Precision Agriculture at a university;
- The Sorghum Forum with advice from DSI, to motivate to the Department of Trade, Industry and Competition for the creation of a Sorghum Cluster. The dtic funded cluster initiatives in the past, while the Jobs Fund (administered by Treasury) could also be a potential source to finance the cluster initiative if it is appropriately structured and the job creation benefits highlighted.

Part 13:
Annexures

Annexure A: Sorghum Products

The use of "alternative grains," also known as ancient grains, climate-smart grains, nutrigrains, or traditional grains, like sorghum in modern food products, is becoming common across the world. This is taking place in order to address several socioeconomic trends, especially changing lifestyles (e.g., urbanization, working mothers, and single-parent families) and also consumer nutrition, health, and ethical concerns about obesity and type 2 diabetes, allergies, and environmental sustainability. For example, sorghum is increasingly being explored in gluten-free applications targeting consumers who suffer from coeliac disease and intolerances to wheat and related cereals.

Another perceived advantage of sorghum is that it is not a genetically modified organism (GMO). The GMO-free nature of sorghum is attractive to foodies and allows sorghum-based specialty products to be developed for discerning consumers wanting organic foods as well as for applications in humanitarian aid for countries with GMO restrictions.

The value-add opportunities for sorghum include:

- Sorghum meal/flour - which entails a basic dehulling and milling/sifting process;
- Sorghum malt, which is produced using germinated (sprouted) sorghum. This is used for brewing traditional African beer , lager beers and stouts and to produce malted sorghum breakfast cereal e.g. Maltebella
- Instant sorghum porridge flour - which is basically pre-cooked cooked sorghum flour that can be fortified with vitamins and minerals, e.g. Morvite
- Beers - Both traditional African sorghum beers e.g. Chibuku and sorghum-based lager- and stout beers e.g. Eagle lager and brewed non-alcoholic malt beverages, e.g. Malta
- Sorghum (traditional African beer) beer powder – so-called instant beer powder
- Sorghum malt based powder-based drinks e.g. Milo
- Non-alcoholic sorghum soured beverages e.g. Motoho
- Specialty sorghum products such as breakfast cereals, ready-to-eat snacks, puffed sorghum and popped sorghum
- Bakery products – especially gluten-free breads etc.
- Other alcoholic beverages such as Baijiu and sorghum whisky

12.2.2 Sorghum Meal

The production of dough-based and porridge-type products, rice-like foods, and applications in beverages invariably involves dry milling the grains into a flour or coarse meal to reduce particle size and fractionation of the grain tissues. The latter invariably involves removal of all or part of the outer bran (pericarp and germ tissues) and retention of the starchy endosperm. With sorghum, size reduction and fractionation may be achieved in a single process by roller milling or by two separate processes, often mechanical abrasive dehulling (removing the pericarp) followed by hammer milling to reduce the particle size.

The whole grain flour or meal produced, for example, by hammer or disk milling is generally then sifted or aspirated to remove some bran and hence clean the grain by removal of some physical and chemical contaminants and improve the palatability of the food.

Sorghum meal is produced by a number of companies in South Africa such as Tiger Brands, RCL Foods which are the more known milling and food processing companies and smaller companies such as Brenner Mills, The companies are typically not dedicated to one grain and also process maize and soybeans as well as other grains.

Figure 92: Sorghum Meals and pre-cooked ready-to-eat sorghum porridge flour

12.2.3 Porridges and Pre-Cooked Porridges

Porridges are the most common and simplest foods prepared from sorghum. Porridges are classified into thick and thin porridges, the difference lying in their solids content and consistency. Thick (or stiff) porridges have high solids content, a consistency which may be likened to that of mashed potato and can be eaten by hand, while thin porridges have a comparatively lower solids content and eaten with a spoon.

The flours used for preparation of porridge may be made from whole grain or decorticated grain, and the flour particle size may vary from very fine to a coarse meal. The process for porridge making essentially involves cooking the meal or flour in boiling water.

The sorghum meal is precooked to make an instant ready-to-eat porridge flour whereby it is mixed in boiling water mixes in boiling water. High-temperature short-time extrusion cooking is widely used to produce such instant porridge powders. This high temperature process also lends itself to process various grains and the addition of vitamins, essential minerals and other additives to produce blended products.

Malted sorghum is also used to produce sorghum porridge products, e.g. Maltebella.

12.2.4 Malts

Sorghum malt is manufactured from GM (sweet) and GH (bitter) cultivars with specific characteristics, i.e. high malt amylase activity). It can be manufactured in an outdoor process (floor malting) or

indoors (specifically pneumatic malting, commonly referred to as industrial malting) using mechanical equipment.

In outdoor malting, the sorghum grains are first soaked in water and then laid out in layers of 10 to 30cm thick on a cement floor and kept wet to allow it to germinate in the sun. As soon as germination has taken place satisfactorily, the wetting process is ceased, and the malt is spread out to dry. The malt is then continuously mixed while being dried by the sun. Alternatively, this malt can be dried mechanically as in the case of the manufacture of industrial malt. In order to obtain maximum shelf-life, drying takes place to a specific moisture level, after which the malt is milled and packed.

Industrial malt (higher quality requirements) is processed indoors. After the sorghum has been soaked in water, it is allowed to germinate. Germination takes place in a controlled container system where ventilation is controlled by blowing air through the container of germinating grain to supply the correct amount of oxygen, to remove carbon dioxide and to regulate the temperature. Ventilation is assisted by spiral screws positioned vertically in the container. Drying takes place after germination by blowing hot air through the bed of germinated grain.

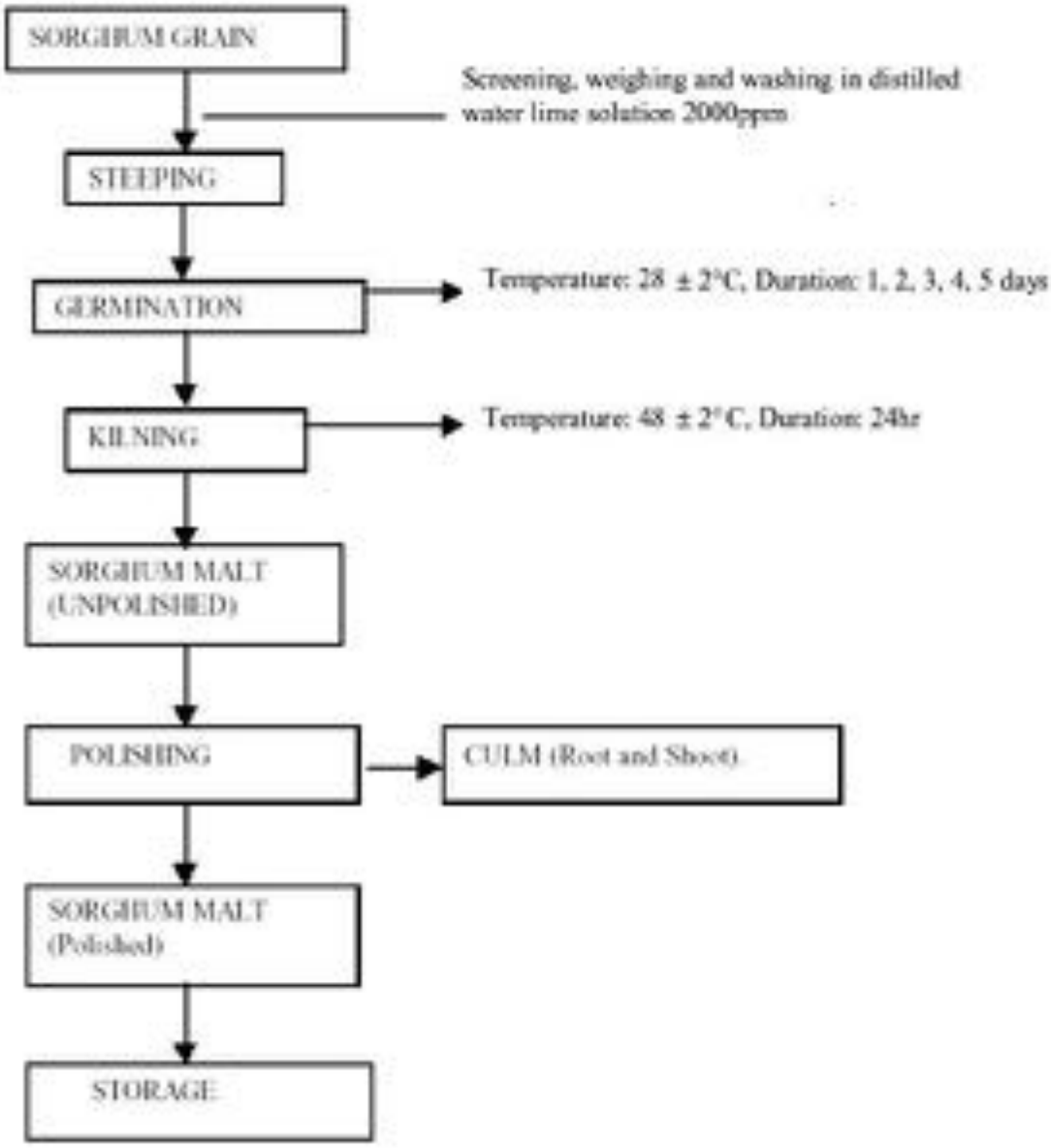


Figure 93: Typical Malting Process[23]

Companies that produce sorghum malt include Tiger Brands, United National Breweries, ISIKO Malt, and Dannhauser Malt.

[23] **The Effect of Kernel Size and Texture on the Malting Properties of Sorghum;** Adeola A. Abiodun *The Journal of Food Technology in Africa Vol. 7 No. 3, 2002, pp. 78-81;* Department of Home Economics, Oyo State College of Education, Nigeria

Figure 94: Typical Sorghum Malt Products

12.2.5 Beer Powder

Home brewing of traditional African beer remains popular y popular in South Africa - cooked maize meal, floor malt and brown sugar (often plus brown bread) are added to water and dry brewer's yeast is added. The brewing process then entails simultaneous souring, mashing and fermentation to produce the beer.

The increasing urbanisation of the traditional consumers of home-brewed traditional African beer has made it impossible or very difficult for many consumers in the urban areas to prepare this product. As a result, so-called instant beer powder is becoming increasing popular. Instant beer powder is a pre-mixed product which consists essentially of sorghum malt, pre-cooked maize meal and dry brewer's yeast. To make the beer, a prescribed quantity of warm water is added, the slurry is mixed to wet the flour and the beer is ready to drink after 24 hours.

12.2.6 Traditional African (Sorghum) Beer

Traditional African beer brewing is the one of the largest consumers of sorghum grain in Africa. Specific varieties have been selected over centuries based on their malting qualities. High-tannin, soft endosperm, red, and brown grains were and generally are the most favoured for brewing in Africa.

Traditional African beers are completely opaque or cloudy in appearance and are yeasty with a sour lingering aftertaste. They are brownish-pink in colour. Lower pH levels produce a more pronounced pink colouring. Most traditional African beers are lower in alcohol, 3% to 4% ABV, than lager beers.

Traditional sorghum beer is consumed in an active state of fermentation, usually within a day or two of production and is still producing a foam. The more foam around the container, the fresher it is considered and the better for consumption. Today, it is sold in various types of containers like milk-type cardboard cartons, plastic bottles and bulk drums.

Although sorghum and millets are the only traditional ingredients in African beer brewing, today maize (introduced from the New World) is frequently used as an adjunct or even as an alternative

ingredient. Inclusion of maize produces a lighter coloured and flavoured beer, which is less expensive that all sorghum or millet beers.

Umqombothi is the common name for South African traditional beer. It is normally made from maize, sorghum malt and water, (and with traditionally wild native yeasts and bacteria to produce the alcohol and lactic acid. It has a distinctive sour aroma from the lactic acid bacteria fermentation and is usually low in alcohol (3% to 4% ABV). The beer has an opaque tan colour and a thick chewy consistency from the maize.

Umqombothi is traditionally prepared with equal parts crushed maize, sorghum malt and maize malt to which warm water is added. It is made outside and cooled outside, rather than in the home. The mixture is left overnight to begin fermenting and bubbling, producing the characteristic sour odour of traditional African beer. The mixture is then cooked, cooled, and poured into a larger container. It is stirred vigorously, covered, and left in a warm place to encourage further fermentation. A match lit near the fermenting mixture is often used to determine whether the progress of the fermentation—if the match blows out quickly, it is ready; if the match does not blow out, the beer will be left to continue fermenting. Once the mixture has fermented, it is filtered through a large steel sieve to remove coarse branny material and poured into a large drum, known as a *Gogogo*. The local beer is sold at markets, served to visitors, and used in special celebrations and ceremonies.

Commercial Brewing of Traditional African Beers

Traditional African beers are an important part of the rural economy, sold at local markets and made at home for all occasions. Large commercial breweries across Africa focus on lager beer brewing but additionally in southern Africa in particular, traditional African beer is widely brewed at large industrial scale..

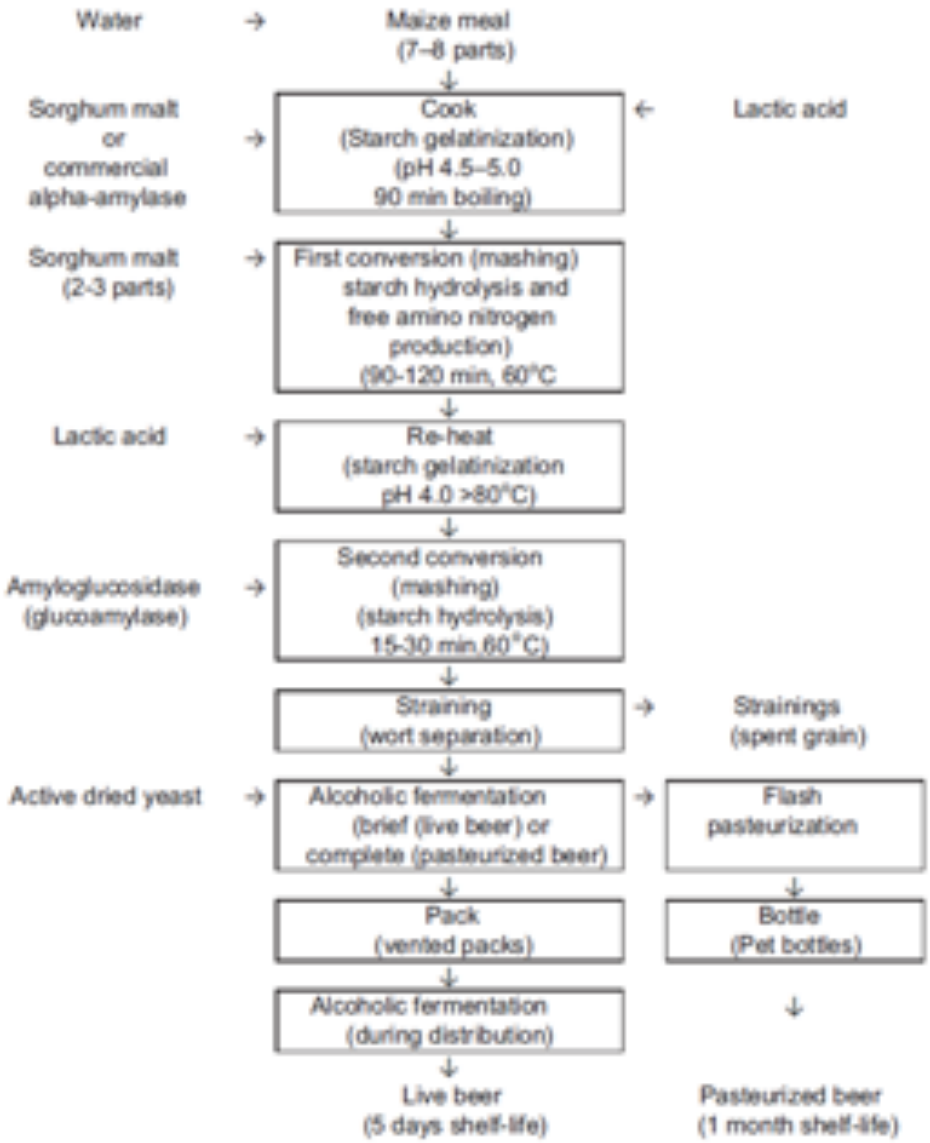


Figure 95: Industrial Traditional African Beer Brewing Process Flow Diagram[24]

The most popular commercial brand in southern African countries is Chibuku, which is made by the Delta Corporation in Zimbabwe, National Breweries in Zambia, Botswana Breweries in Botswana and United National Breweries in South Africa. It is pinkish-brown in colour, completely opaque with a viscous texture. It is yeasty and slightly sour in taste and has alcohol content of 4% ABV.

[24] SORGHUM AND MILLETS CHEMISTRY, TECHNOLOGY, AND NUTRITIONAL ATTRIBUTES; SECOND EDITION Edited by JOHN R.N. TAYLOR KWAKU G. DUODU

Figure 96: Typical African Sorghum Beer Products

By far, the most radical development in industrial opaque beer brewing has been the introduction of pasteurized, shelf-stable beer, which took place in Zimbabwe in 2012. Unlike with conventional live fermenting traditional beer, this beer is fermented in the brewery, where the conditions are controlled. The fermented beer is then flash pasteurized, carbonated, and bottled. The pasteurization and related processes extend the shelf-life of the beer to several weeks. The product is marketed under the name Chibuku Super and sold in 1-L brown-coloured PET bottles. Not only does the pasteurization process provide the consumer with beer of far more consistent quality but also because the PET bottle is sealed, it means that beer cannot spill out. Furthermore, as it resembles a conventional beer bottle, it gives the product a much superior image.

12.2.7 Other Products

Motoho

Motoho is a soured gruel normally prepared from sorghum. Sorghum meal is mixed with warm water (one-part sorghum meal to three parts water) to form a thin slurry to which a traditional starter culture called Tomoso is added, and the mixture is allowed to ferment. Motoho has a shelf-life of about 5 days at temperature below 25°C. This relatively long shelf-life is believed to be a driver for its current successful commercial production. Motoho is produced in South Africa and Lesotho by private individuals and at commercial scale by Denmar Estates in South Africa.

Figure 97: Commercial Motoho Production Process[25]

Ready-to-eat Snacks

Ready-to-eat (RTE) savoury snacks and breakfast cereals constitute a multi-billion-dollar market in the USA. Sorghum has seldom been used as the main ingredient in the production of crispy/crunchy expanded snack and breakfast cereal products, many of which are produced by the high-temperature short-time extrusion cooking process.

Figure 98: Sorghum-based Ready-to-Eat Snacks

Other cereal grains such as maize, wheat, oats, and rice have traditionally been used exclusively for these products. However, today the use of sorghum in this food product category is slowly increasing. One well-publicized example from Grain Berry Mills, USA, is a range of breakfast cereals which includes

[25] SORGHUM AND MILLETS CHEMISTRY, TECHNOLOGY, AND NUTRITIONAL ATTRIBUTES; SECOND EDITION Edited by JOHN R.N. TAYLOR KWAKU G. DUODU

products like puffed sorghum rings, shredded wheat and whole grain bran that contains whole grain sorghum flour and sorghum bran from an antioxidant-rich, high-polyphenol variety.

Figure 99: Sorghum-based Breakfast Cereal

Scientific literature is still relatively scarce but expanding as sorghum gains popularity in these applications. A limited number of studies have focused on expanded snacks using extrusion and sorghum alone) or a combination of sorghum with maize, rice, wheat, groundnut (peanut), and cowpea-based ingredients. Results indicated that addition of maize, rice, or wheat flours to sorghum improved the radial expansion and sensory properties of snacks, while incorporation of the high-protein legume flours like groundnut and cowpea had variable effects.

Puffed and Extruded Products

Popping of sorghum results in a delicious puffed (popped) product, which is consumed as a snack. Grain popping has traditionally been done using roasting. However, with the growing demand for sorghum-based "pops," a number of mechanical popping machines have been developed. The use of microwave oven for popping sorghum has also been explored. There is small commercial production of puffed sorghum in South Africa for gluten-free products.

Exported Value Added Products

The following products are exported from South Africa to predominately African countries:

Sorghum malt and flour

- Sorghum flour to the value of R1,7 million was exported to mainly Eswatini
- Sorghum malt valued at R36 million, representing 5,300 ton was exported in 2018. The statistics are not clear (unclassified) in terms of the target countries

Traditional African beer (instant beer) powder

- Instant beer powder to the value of R33 million and R47 million in 2018 and 2019 respectively was exported primarily to Botswana and Namibia accounting for 55% and 34% respectively. The growth in export sales of the beer powder represents a 40% increase year-on-year.

Traditional African beer exports

- Exports of traditional African beer increased by 98% from R6,6 million in 2018 to R13,2 million in 2019. However, liquid traditional African beer does not travel well due to its short shelf life and will therefore it remain highly unlikely for it to penetrate neighbouring markets.
- However, what represents a growth opportunity is the export of semi-processed sorghum products such as the instant porridge flour, malt and instant beer powder that are traded

through the South African based retailers such as Shoprite, which have expanded into numerous other African countries. Shoprite has 2,829 stores in 15 countries across Africa. Linking locally produced sorghum products with retailers such as Shoprite immediately provides export market access for these products. This saves the manufacturer the cost of developing such markets.

Annexure B: Financial Model

Income statement for one season

		Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21
INCOME STATEMENT													
Income		-	-	-	-	-	-	-	-	**R8,100,000**	-	-	**R8,100,000**
Sorghum sweet		-	-	-	-	-	-	-	-	R5,130,000	-	-	R5,130,000
Sorghum (land rent)		-	-	-	-	-	-	-	-	R2,565,000	-	-	R2,565,000
Maize		-	-	-	-	-	-	-	-	R405,000	-	-	R405,000
Marketing costs		-	-	-	-	-	-	-	-	**R166,575**	-	-	**R166,575**
Sorghum sweet		-	-	-	-	-	-	-	-	R85,050	-	-	R85,050
Sorghum (land rent)		-	-	-	-	-	-	-	-	R42,525	-	-	R42,525
Maize		-	-	-	-	-	-	-	-	R39,000	-	-	R39,000
Direct costs		-	**R613,995**	**R1,731,666**	**R1,436,586**	**R1,436,586**	**R245,374**	**R245,374**	**R245,374**	**R236,819**	**R94,182**	-	-
Sorghum sweet		-	R335,025	R987,425	R845,739	R845,739	R133,339	R133,339	R133,339	R133,339	R56,314	-	-
Sorghum (land rent)		-	R167,513	R506,570	R435,727	R435,727	R79,527	R79,527	R79,527	R79,527	R28,157	-	-
Maize		-	R111,457	R237,671	R155,120	R155,120	R32,508	R32,508	R32,508	R23,953	R9,711	-	-
OPERATING EXPENSES		**R160,525**	**R397,967**	**R406,358**	**R426,857**	**R444,159**	**R461,461**	**R465,858**	**R470,255**	**R474,653**	**R478,957**	**R481,716**	**R483,455**
Overheads		R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817	R14,817
Salaries and Wages		R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708	R145,708
Other													
Production loan interest	13%		R1,739	R10,130	R30,628	R47,930	R65,232	R69,630	R74,027	R78,424	R82,729	R85,488	R87,227
Finance costs	12%		R235,703	R235,703	R235,703	R235,703	R235,703	R235,703	R235,703	R235,703	R235,703	R235,703	R235,703
EBITDA		-R160,525	-R776,259	-R1,902,320	-R1,627,739	-R1,645,042	-R471,132	-R475,529	-R479,926	R7,457,657	-R337,436	-R246,013	R7,685,673
OPERATING PROFIT		**-R160,525**	**-R1,011,962**	**-R2,138,024**	**-R1,863,443**	**-R1,880,745**	**-R706,835**	**-R711,233**	**-R715,630**	**R7,221,954**	**-R573,140**	**-R481,716**	**R7,449,970**
Tax	28%												
Depreciation		199,961	199,961	199,961	199,961	199,961	199,961	199,961	199,961	199,961	199,961	199,961	199,961
NET PROFIT		- **360,486**	- **1,211,923**	- **2,337,984**	- **2,063,403**	- **2,080,705**	- **906,796**	- **911,193**	**915,590**	**7,021,993**	- **773,100**	**681,677**	**7,250,009**
Retained earnings		**-R360,486**	**-R1,572,408**	**-R3,910,392**	**-R5,973,796**	**-R8,054,501**	**-R8,961,297**	**-R9,872,490**	**-R10,788,080**	**-R3,766,087**	**-R4,539,187**	**-R5,220,864**	**R2,029,145**

Balance sheet at the start and end of the season.

BALANCE SHEET		Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21
Land		R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000	R15,000,000
Buildings & Land preparation		R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000	R10,129,000
Farm implements		R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920	R3,491,920
Office and Other		R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100	R72,100
Vehicles		R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998	R841,998
TOTAL FIXED ASSETS		**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**	**R29,535,018**
Depreciation		R199,961	R399,921	R599,882	R799,842	R999,803	R1,199,763	R1,399,724	R1,599,684	R1,799,645	R1,999,605	R2,199,566	R2,399,526
NET ASSETS		**R29,335,057**	**R29,135,097**	**R28,935,136**	**R28,735,176**	**R28,535,215**	**R28,335,255**	**R28,135,294**	**R27,935,334**	**R27,735,373**	**R27,535,413**	**R27,335,452**	**R27,135,492**
Stock materials		R335,025	R987,425	R845,739	R845,739	R133,339	R133,339	R133,339	R133,339	R56,314	-	-	-
Stock crop													
Debtors		-	-	-	-	-	-	-	-	R8,100,000	-	-	R8,100,000
Cash		R4,035,316	R3,797,874	R3,552,041	R3,285,709	R3,002,076	R2,701,140	R2,395,807	R2,086,076	R1,605,374	R9,386,942	R9,065,750	R8,463,988
CURRENT ASSETS		**R4,370,341**	**R4,785,299**	**R4,397,780**	**R4,131,449**	**R3,135,415**	**R2,834,479**	**R2,529,146**	**R2,219,416**	**R9,761,688**	**R9,386,942**	**R9,065,750**	**R16,563,988**
TOTAL ASSETS		**R33,705,399**	**R33,920,396**	**R33,332,917**	**R32,866,625**	**R31,670,630**	**R31,169,734**	**R30,664,440**	**R30,154,750**	**R37,497,062**	**R36,922,355**	**R36,401,203**	**R43,699,480**
Creditors		R335,025	R987,425	R845,739	R845,739	R133,339	R133,339	R133,339	R133,339	R56,314	-	-	-
Production loan	50%	R160,525	R935,045	R2,827,235	R4,424,347	R6,021,458	R6,427,357	R6,833,257	R7,239,156	R7,636,500	R7,891,207	R8,051,732	R8,100,000
TOTAL CURRENT LIABILITIES		**R495,550**	**R1,922,470**	**R3,672,975**	**R5,270,086**	**R6,154,797**	**R6,560,696**	**R6,966,596**	**R7,372,495**	**R7,692,814**	**R7,891,207**	**R8,051,732**	**R8,100,000**
LONG TERM LOAN	80%	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**	**R23,570,334**
Owners' contribution		R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000
Non-distributable reserve		R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000	R5,000,000
Retained earnings		-R360,486	-R1,572,408	-R3,910,392	-R5,973,796	-R8,054,501	-R8,961,297	-R9,872,490	-R10,788,080	-R3,766,087	-R4,539,187	-R5,220,864	R2,029,145
OWNERS INTEREST		**R9,639,514**	**R8,427,592**	**R6,089,608**	**R4,026,204**	**R1,945,499**	**R1,038,703**	**R127,510**	**-R788,080**	**R6,233,913**	**R5,460,813**	**R4,779,136**	**R12,029,145**
TOTAL LIABILITIES		**R33,705,399**	**R33,920,396**	**R33,332,917**	**R32,866,625**	**R31,670,630**	**R31,169,734**	**R30,664,440**	**R30,154,750**	**R37,497,062**	**R36,922,355**	**R36,401,203**	**R43,699,480**

Annexure C: Research and Development Needs

South African Sorghum National Agricultural Research System (NARS) Gaps

As stated in the Study Phase 2 report - Value Chain Analysis, "The National Agricultural Research System, with the exception of Universities, is very under resourced with respect to sorghum. For example, critical activities like breeding for improved agronomic traits such resistance to locally important sorghum diseases such as aphids and fungal smut is not taking place and the system of quelea bird pest control is no longer functioning effectively. In contrast, university training of sorghum agricultural scientists by the University of KwaZulu-Natal's Africa Centre for Crop Improvement with respect to sorghum breeding and the University of the Free State with respect to sorghum pathogens are notable success stories. However, one specific area of weakness with respect to breeding is that training in molecular breeding and sorghum genomics is not generally state of the art.

Additionally, in part because the sorghum market in South Africa has become so small relative to the maize and soybean markets, the local seed companies have ceased to develop new hybrid cultivars. The country is now reliant on old local cultivars and newer cultivars from Australia. These old cultivars do not have the required yield potential and the imported cultivars often do not have the required resistance to locally important diseases and are not well adapted to some South African environments, for example where cold tolerance is required."

South African Sorghum Agricultural Research and Development Needs

Two activities are required to make South African sorghum agriculture globally competitive, one focused on improving plant genetics and the other focused on improving agronomic practices:

1. A well-resourced sorghum pre-breeding Advanced Germplasm Development programme to apply modern genomics-based breeding technologies to develop elite sorghum lines that are well-adapted to South and Southern African climatic conditions and have specific resistance to locally important pests and diseases.

   The elite germplasm will be used by seed breeders (both commercial and public sector) to produce hybrid cultivars and improved varieties for release to farmers. To ensure success, the Advanced Germplasm Programme must be directly linked to the current Sorghum Cultivar Yield Trials programme being run by Grain SA

2. Implementation of precision agriculture by both the large-scale commercial and smaller scale emerging commercial sorghum farmer sectors to increase crop yields while at the same time reducing the levels of the inputs needed (land, water, fertilizer and biocides).

To effectively implement precision agriculture, it is proposed that:

a) A formal agreement between Grain SA and the Queensland Sorghum Alliance. A key element of the agreement should be the facilitation of Australian experts to talk directly to South African farmer groups to provide know-how and training,
b) and b) Creation of a funded Chair in Crop Precision Agriculture at a local university. The Chair must include formal extension training in its mandate in addition to just research as has been the case with such chairs to date.

Part 14:
Addendum

Addendum

The addendum to the report was compiled following a presentation of the findings to a consultative group of industry stakeholders and feedback from the participants regarding points of clarification and requests for additional information from the research team.

Addendum to the Final Report

Table of Tables

Table of Figures

1 Clarification

The sorghum reference team provided feedback in respect of the sorghum study undertaken by AIH research team. The team's response is herewith included as an addendum to the report as defined within the scope of the current project mandate.

1.1 Sorghum types

Red non-tannin sorghum

The market opportunities identified and referred to in the report, largely refers only to red non-tannin sorghum grain (sweet sorghum in South African parlance) as it accounts for the vast majority internationally commercially traded sorghum, probably >95% , and is the only type exported by the USA and Australia.

For the South African market, it is likely that the split in market requirement for the two sorghum types currently cultivated, i.e. red non-tannin sorghum (sweet) and red tannin sorghum (bitter, class GH) will remain essentially the same in the near- to medium-term future, assuming:

a) That imported sorghum is replaced by locally cultivated sorghum,
b) The VAT on sorghum meal is removed, and
c) A more equitable excise duty on pasteurised opaque beer is introduced enabling its manufacture.

This is because a) and b) will result in substantially increased demand for "sweet" sorghum for direct human consumption and c) will result in substantially increased demand for "bitter" sorghum for malting. However, the split for local demand will be different if not all of these developments take place.

On the issue concerning sorghum exports, across Africa, all the different grain sorghum types are produced, i.e. red non-tannin, red-tannin, white non-tannin and white tannin. Some countries such as Kenya produce all four types. However, as explained in the main report, the USA is by far the majority exporter of sorghum to the continent and this only relates to red non-tannin (sweet) sorghum. The basic reason why the red non-tannin sorghum is acceptable to the African market is that its end-use application is not restricted, unlike the other types. Hence, in Africa it can be used directly for human food and for malting and as an un-malted brewing adjunct. Therefore, in order to export to other African countries, South Africa will need to considerably increase red non-tannin sorghum production. Moreover, as explained in the main report, the production and logistical costs will have to be reduced significantly to make South African sorghum cost competitive.

White sorghum

White sorghum refers to what is strictly speaking called white tan-plant sorghum, which in the US is sometimes referred to as "food grade" sorghum so as to distinguish it from the

conventional red non-tannin (sweet) sorghum where it is used for animal feed, unlike in Africa. This white sorghum does not contain tannins and has substantially lower levels of other types of polyphenols than red non-tannin sorghums. In the USA and Australia, white sorghum is produced in small quantity, approximately 3% of their sorghum production. It is used to produce gluten-free products like bakery flours and pasta and in Australia also to make gluten-free "Weet-bix" breakfast cereal.

White sorghum has been cultivated traditionally in the very arid parts of Africa, notably Sudan and Botswana. In recent years, the improved open pollinated white sorghum variety Macia was developed by ICRISAT in Southern Africa and the seed is available in South Africa. At the same time, PANNAR in South Africa developed a several white varieties for Sudan. So, the situation is that there are white sorghum varieties already available or potentially available in South Africa.

Unfortunately, white sorghum is far more susceptible to bird predation and fungal moulding than red non-tannin sorghum due to its low content of polyphenols. In addition to the bird predation issue, cultivation of white sorghum in South Africa is chancy because of the possibility of very damp periods and late rains that will result in mould infection which can destroy the crop. These factors contribute towards white sorghum grain being more costly than red non-tannin sorghum. In view of this and the fact that the local gluten-free food market is extremely small, there seems little prospect of the market in South Africa for white sorghum becoming significant. Thus, creating grading regulations for white sorghum is not worthwhile as it is highly unlikely to be traded on the open market but rather grown under contract.

1.2 Consumer preferences

The study regarding detail on South African consumer preferences for sorghum falls outside the terms of reference of this present study. It should be noted that merely focusing on the enhancement of consumer procurement of sorghum-based products will only contribute marginally towards the growth of the sorghum industry. As per the research outcome through the engagement of food processing companies, the projected impact increased consumer awareness and preferences would only contribute to a 10-15% increase in sorghum demand.
General consumer food trends in South Africa can be summarised as an increasing demand for convenience-type foods, foods perceived to be healthy and nutritious and indulgence-type foods (*Ronquest-Ross, L.C., Vink, N. and Sigge, G.O., 2015. Food consumption changes in South Africa since 1994. South African Journal of Science, 111(9-10), pp. 1-12*). In the Ronquest-Ross et al. (2015) study, the identified convenience-type foods were sweetened soft drinks and sweet and savoury snacks showing that hedonistic pleasure plays a significant role in consumer food purchases. Since this study, price has also become an important factor influencing South African consumer purchasing patterns. This is illustrated by the fact that there has been an up to 10% decline during 2020 in fruit juice sales (Grahame Osler, Denmar Estates Marketing Director, personal communication). This decline started in 2017, paralleling the decline in South African family incomes *(RESEARCH NEWS SOUTH AFRICA 19 July 2018. First decline for RTD fruit juice in five years. https://www.bizcommunity.com/Article/196/168/179635.html)*

Unfortunately, there is no published information concerning the sorghum preferences of South African consumers, both generally and of particular communities. It is likely that some in-depth information on sorghum food consumption trends in South Africa has been obtained by major food companies, but this information is not in the public domain. The very detailed information requested above on the preferences of particular South African communities for sorghum fall outside the scope of this report and would need to be obtained by a specialist consumer food market trends agency through a commissioned study. It is proposed that this be considered as a project within the Sorghum Cluster initiative. The benefits of sorghum and its use in food can be promoted as part of the Sorghum Forum's proposed enhanced industry support service along the lines of the USA's United Sorghum Checkoff programme. United Sorghum Checkoff Program | Investing in Sorghum Profitability | United Sorghum Checkoff

Concerning the comment about "bitter" (tannin) sorghum being used to produce mabele meal, it is known that certain South African sorghum processing companies have investigated admixing tannin sorghum with "sweet" type sorghum. This was done when there was a large surplus of inexpensive tannin sorghum available locally. It is also known that one major company very thoroughly studied the issue of what level of admixture could be achieved without affecting the sensory properties of the meal or final porridge product. However, from our conversations with these sorghum processing companies during the study, there was no indication that admixing of "bitter" sorghum was currently taking place as only "sweet" sorghum was referred to by the representatives of the companies with respect of mabele meal.

1.3 SADC Sorghum Advanced Germplasm Development (Pre-breeding) Programme

Proposal

Arising from the analysis of regional and global best practices for sorghum targeted at potential cultivars in the Phase 2 report, it is proposed that a well-resourced sorghum pre-breeding programme should be established at either at the ARC's Grain Crops Institute in Potchefstroom of the University of KwaZulu-Natal's Africa Centre for Crop Improvement (ACCI), or preferably jointly between the two institutions.

The goal of the pre-breeding programme would be to apply modern genomics-based breeding technologies to develop elite sorghum lines that are well-adapted to South and Southern African climatic conditions and have specific resistance to locally important pests and diseases. How the entire cultivar development programme will function is illustrated in the Figure below. To ensure successful implementation and commercialization of the developed germplasm, the new Pre-breeding Programme will be integrated with the current Sorghum Cultivar Yield Trials programme being run by Grain SA. In short, the elite lines developed in the Pre-breeding Programme will be used by commercial seed companies and the agricultural research institutes in SADC countries to develop new hybrid sorghum cultivars and improved open pollinated varieties. These will then be evaluated for release against existing cultivars in a somewhat expanded version of the current Sorghum Cultivar yields in South Africa and in similar yield trials that are undertaken in other SADC countries.

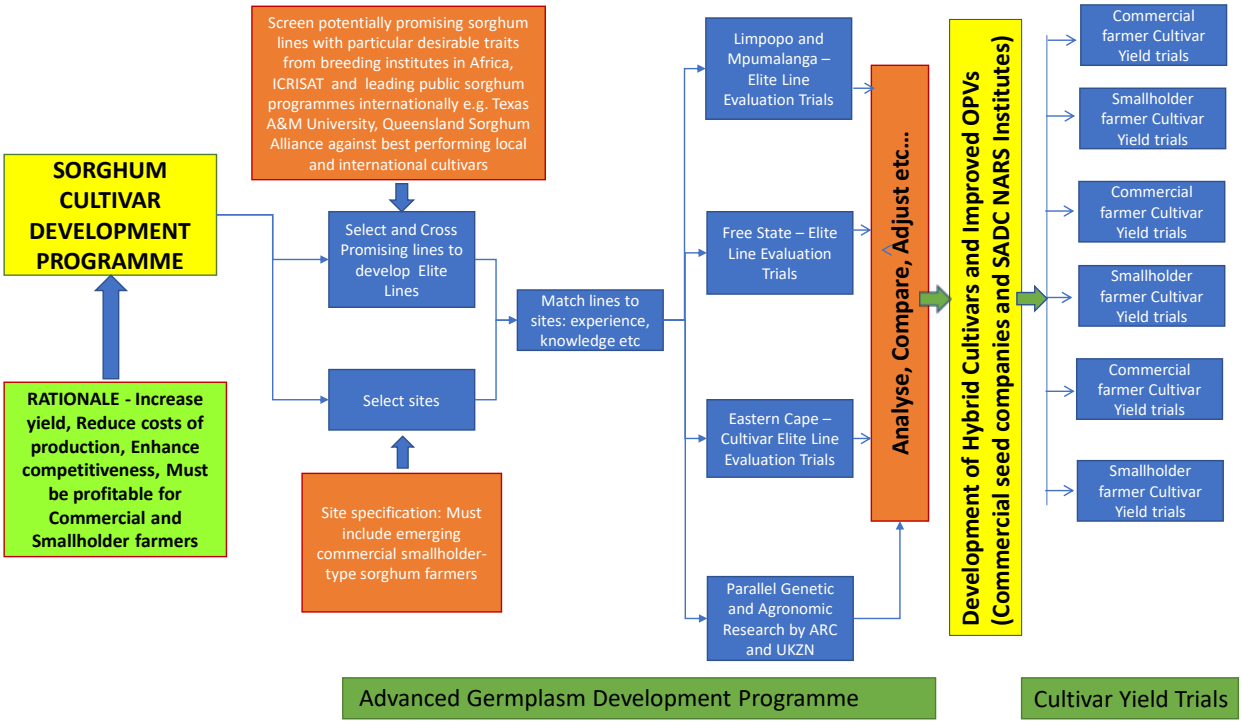


Figure 1-1: Overview of Design and Functioning of Sorghum Cultivar Development Programme

2 Plastic bags from sorghum.

The route to manufacture plastic bags from sorghum entails the production of ethanol and the conversion of ethanol to ethylene and then to high density polyethylene.

2.1 Ethanol production from sorghum.

The following extract from www.sorghumcheckoff.com/market-opportunities/renewables illustrates the importance of sorghum in the renewable chemical industry.

Approximately one-third of the U.S. grain sorghum crop is used for ethanol production. Naturally drought-tolerant, sorghum gives ethanol producers in water-stressed areas a smart choice to help farmers preserve regional resources. Sorghum can be used for many different types of ethanol production. A starch source, sugar source and cellulose source all in a single species, sorghum can be used to produce ethanol using a multitude of platforms. Sorghum and corn are interchangeable in starch-based ethanol production.

The internal combustion engine and Henry Ford's Model T were both designed to run on ethanol, a clean-burning, high octane fuel that lowers the price of gas for consumers. It also lowers USA dependence on foreign oil, keeping our dollars in rural communities.

Biomass sorghum, with its large stature and abundant cellulose, is positioned to serve this market better than any other dedicated energy crop. Sweet sorghum, one of Earth's most efficient convertors of solar energy to sugar, is also positioned well in the next generation renewable fuels space.

Renewable Chemicals is the new drive in the chemical industry. Anything that can be produced with an oil feedstock can be produced with a sugar feedstock. This includes plastics, solvents and many other industrial and common household goods. Without technological barriers, the main driver of a feedstock's success is price. Sweet sorghum is an efficient producer of sugar, giving the crop a significant competitive advantage in renewable chemical production. The same is true for cellulose-based renewable chemicals and biomass sorghum.

In the USA the drive for renewable chemicals has contributed towards significant investment in sorghum over the past several years. Not only has private industry taken an aggressive approach to investing in sorghum research and development, entities such as the Sorghum Checkoff, the U.S. Department of Energy and the U.S. Department of Agriculture have made investments that will contribute to a successful renewable future with sorghum.

The USA United Sorghum Checkoff has committed more than $3.1 million to renewables since 2011. The projects have been balanced between research and development and market development. In many cases, these dollars have been leveraged with private industry, university and federal funds. The industry is already seeing positive results of much of the invested dollars with successes ranging from new product being discovered to heighted awareness of renewable issues.

Since 2011, DOE has committed $72.6 million to sorghum, including a commitment of $62.5 million in 2015 alone. Like with most DOE investments, the projects funded by these dollars are based on technology that disrupts the status quo. As a result of these projects, for the first time sorghum breeders will have access to high-technology tools that breeders of other crops have had access to for decades. These efforts will focus on everything from high-throughput phenotyping using in-field sensory technology to drought tolerance and nitrogen usage efficiency interactions within the plant microbiome.

With one-third of the U.S. sorghum crop going to ethanol, increased access for the fuel is of the upmost importance. Recognizing the need for greater market access, in 2015 USDA committed $100 million for infrastructure to move higher blends of ethanol. There was great interest in the program and the funds were matched using private resources with a ratio of more than 1:1. The funding will support approximately 5,000 pumps at 1,400 fueling stations throughout the USA. Texas and Kansas received dollars under the program for a total of $18.3 million greatly benefiting sorghum ethanol demand in those states. The sorghum industry also contributed $250 million to match.

It is evident from the above citation that applied research in sorghum can contribute to a greater application of the grain in renewable chemicals.

The production of ethanol from sorghum can be done in the following processes:

2.1.1 Ethanol fuel from sweet (sweet-stemmed) sorghum juice

[26]Sweet sorghum juice can be used for syrup, molasses, sugar and ethanol production with average fermentation efficiencies from 85 to 90%. The sweet sorghum juice is not commonly used for crystallized sugar production because of the presence of significant amounts of inverted sugars (glucose and fructose) that makes difficult crystallization in large-scale processes. However, the sweet sorghum juice, which is rich in fermentable sugars, has an excellent potential for yeast fermentation. The sweet sorghum juice is obtained through a mechanical operation with a roller mill composed by a set of cylinders, similar to the ones employed by the sugar cane mills. Water is added during the last stage of the crushing process with the aim to augment the solubilization of residual sugars associated to the bagasse. The sweet sorghum juice yields around 50% in relation to the initial weight of the stems.

[26] **Sorghum as a Multifunctional Crop for the Production of Fuel Ethanol: Current Status and Future Trends**: Sergio O. Serna-Saldívar*, Cristina Chuck-Hernández, Esther Pérez-Carrillo and Erick Heredia-Olea *Departamento de Biotecnología e Ingeniería de Alimentos, Centro de Biotecnología. Tecnológico de Monterrey, Monterrey, N. L.: México*

Figure 2-1: Flowchart for ethanol production from sweet sorghum juice

2.1.2 Ethanol fuel from sorghum grain

The five basic steps in the conventional cereal grain dry-grind ethanol process (as used for maize, sorghum and wheat) are milling, liquefaction, saccharification, fermentation and ethanol distillation/dehydration. Mashing goes throughout the entire process beginning with mixing the grain meal with water (and possibly backset stillage) to obtain a mash ready for fermentation.

Nowadays, advances in transformation and genetic modification in plants make the development of special maize and sorghum cultivars one of the best tactics to overcome the various known factors that reduce ethanol yields.

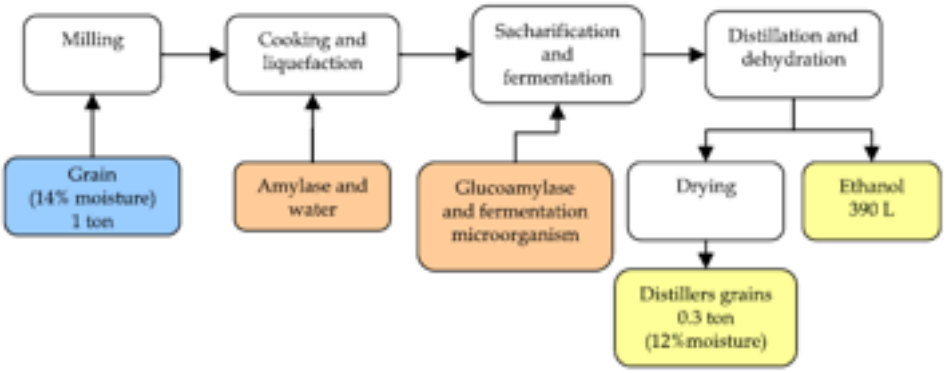


Figure 2-2: Flowchart for ethanol production from cereal grains such as sorghum grain

While modification in starch and protein digestibility affects ethanol production, one of the most important traits in starch conversion is total starch harvested per area. The primary goal of sorghum breeding programs has been and continues to be the development of high-yielding, drought-tolerant and pest-resistant hybrids. This effort will continue and additional gains in yield can be expected which will result in higher ethanol production from each hectare dedicated to sorghum (Rooney et al., 2007).

2.1.3 Estimated ethanol yields

The figures included herewith summarizes and compares average ethanol yields from sorghum grain, sweet juice and potentially from cellulosic biomass. Ethanol yields vary according to variety, geography, soil fertility and temperature. Sweet (sweet-stemmed) sorghums usually yield from 50 up to 120 tons of stalks after the first cut.

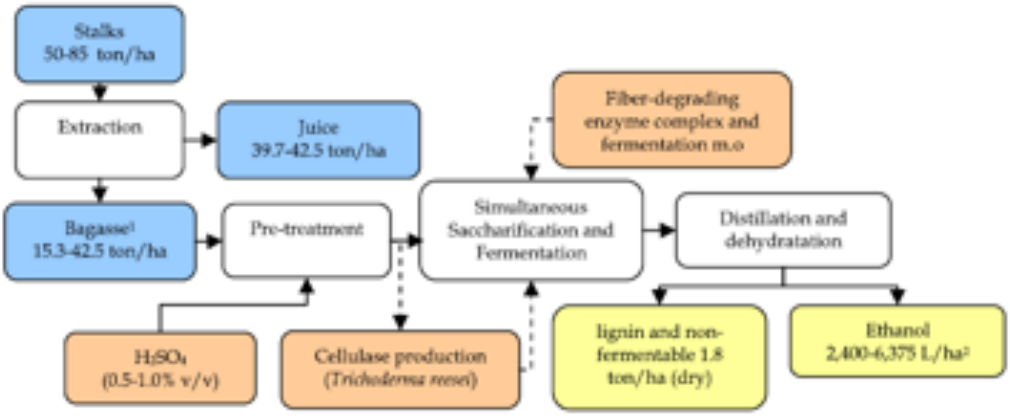


Figure 2-3: Flowchart for ethanol production from sweet (sweet-stemmed) sorghum bagasse.

It is evident that sweet (sweet-stemmed) sorghum has the potential to yield sufficient material to produce ethanol.

2.2 Ethanol to ethylene

The conversion of ethanol to ethylene via catalytic dehydration is now becoming an established process.

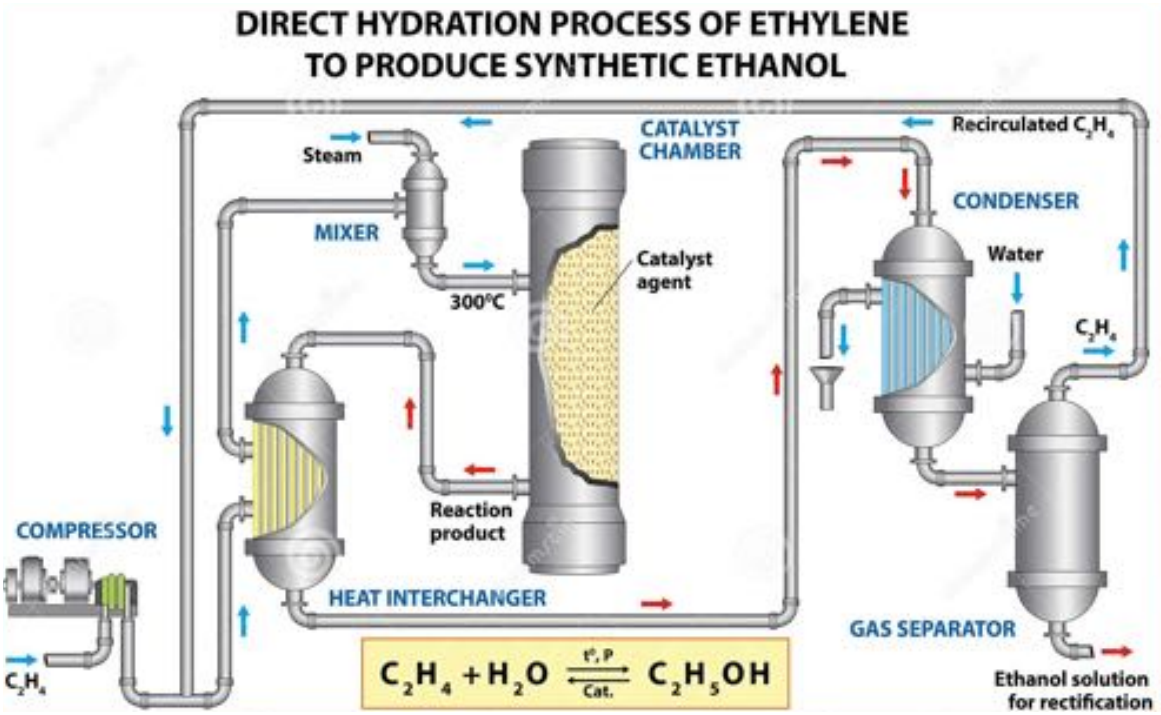


Figure 2-4: Direct hydration of ethanol to ethylene

Ethylene is a critical chemical precursor to a number of different industrial products. It is often derived from petroleum sources and polymerized to polyethylene, one of the most ubiquitous plastics today. Recently there has been a significant effort to develop production pathways utilizing biologically-derived feedstocks, such as maize or cellulosic ethanol, rather than

traditional fossil-fuel sources. Ethylene can be produced from bioethanol via catalytic dehydration over an aluminium oxide catalyst.

The development of ethanol to ethylene conversion technology is well underway and illustrated by the following recent developments:

- TechnipFMC plc is a French-American, UK-domiciled global oil and gas company that provides complete project life cycle services for the energy industry. Recently TechnipFMC announced its first ethanol to ethylene production facility using the Hummingbird technology developed in the UK. TechnipFMC's Hummingbird® Ethylene Technology Selected by LanzaTech for LanzaJet Sustainable Aviation Fuel Biorefinery - TechnipFMC plc
- France-headed technology provider Axens has announced that it has signed an ethanol-to-ethylene technology "Atol" license agreement with Sumitomo Chemical Co. Ltd for Sumitomo Chemical's waste-to-polyolefins project in Japan. In the project, Atol technology will transform ethanol produced from waste into polymer-grade ethylene that will be polymerized in Sumitomo Chemical's assets into polyolefin. The result of a partnership between Axens, Total, and IFP Energies nouvelles (IFPEN), "Atol" is, according to Axens, a technology for the "most profitable production" of polymer grade ethylene by dehydration of any kind of renewable ethanol from biomass or waste. Sumitomo Chemical selects Axens "Atol" ethanol-to-ethylene technology | Bioenergy International

In a recent study conducted in South Africa, the conversion of ethanol to ethylene using ethanol from a gas-to-ethanol bio-fermentation process and using the TechnipFMC technology was undertaken. The study indicated that it is feasible to convert 85,000 tons of ethanol to circa 50,000 tons of ethylene using a dehydration plant that will cost in the region of ZAR900 million.

2.3 Ethylene to High Density Polyethylene (HDPE)

Safripol is an independent plastics manufacturing company that supplies Polypropylene and High-density Polyethylene to the converting industry, for the manufacture of a wide range of packaging and industrial end uses. Safripol is owned by Kap Industries (JSE: KAP). Due to ethylene shortage in the country, Safripol has excess capacity to produce HDPE in its processing facilities in Sasolburg. Without significant investment, the ethylene from the TechnipFMC plant can be converted into a polymer ie HDPE.

2.4 Financial feasibility.

At least 85,000 tons of ethanol is required to satisfy the demand for ethylene required by Safripol. It is also the key economic scale and most likely the minimum feasible scale ethanol-to-ethylene processing plant design. The proposed Mabele Fuels plant in Bothaville was designed to produce 153 million litres of ethanol, ie circa 120kton of ethanol. The cost of the project was projected at R2,5 billion in the early 2000's. Sorghum-based bio-ethanol refinery seeks funding partners | Global Africa Network. In order to supply the sweet stemmed

sorghum needed for the processing facility, 30,000 ha of farmland would be required (yielding 5,000 litre per ha). Depending on the land availability, current land-use (bushes, trees, grassland) and suitability, the investment in farmland establishment could be as much as R900 million.

The total investment therefore amounts to R4,4 billion, allowing for circa R100 million additional expenses for infrastructure and logistics.

Key drivers will be the ultimate cost of the ethylene that is delivered to Safripol and therefore the efficacy of the sorghum to ethanol conversion becomes a key driver which again will be a factor of sorghum cultivar selection for optimal sugar production and biomass yield.

2.5 Summary observation

It is environmentally desirable to use a renewable source of material to produce chemical products that are currently produced from fossil fuels, and while it is certainly technically feasible to produce plastic bags from sorghum (grain, the sugar in the stalks of sweet-stemmed type and potentially from cellulosic bagasse), the challenge lies in the financial feasibility. South Africa possesses the technical experts, ie engineers and chemical scientists, to take on such a project. It is, however, proposed that a detailed feasibility study be conducted to ensure that all the elements of the value chain can be introduced and yield positive returns and most importantly to provide a sustainable supply of sorghum raw materials.

3 Implementation plan

The implementation mechanism proposed by the AIH research team is the establishment of a sorghum cluster initiative to drive the various programs that support the enhanced competitiveness of the sorghum industry in South Africa as the foundation for enhancing the value chain.

3.1 Clusters and their role in industry

Throughout[27] the centuries companies in the same industries have gathered in the same location. This happens for example around natural resources or other external factors. An example of this is Hollywood, where companies in the movie and television industry have gathered. When this happens it is called a cluster: a group of companies and other parties in the same industry positioned in a particular location. According to Michael E. Porter, circa 1998, the cluster starts to attract more companies and the cluster grows bigger when the concentration of companies has reached a certain critical mass. The cluster attracts related and supporting industries to the location, and other supporting functions follow such as teaching and research institutions. The benefits of such a cluster are the benefits that follow a strong industry, such as increased tax revenue, increasing job opportunities etc. A strong cluster is most often also very competitive internationally. Good examples are again the Hollywood movie industry cluster, the computer science cluster in Silicon Valley, and the car manufacturing cluster in München Germany. The term cluster was first introduced formally to the science discussion by Michael E. Porter in 1990 and was later defined by him as: “Clusters are geographic concentrations of interconnected companies and institutions in a particular field.”. As benefits of clusters are being realised, government and industries around the world strengthen existing clusters and even create new clusters. This can for example be done by policy intervention or by attracting companies in the same industry to relocate to a certain location with incentives. A cluster is a very broad term and clusters vary in size, level of co-operation, age, structure, level of government involvement etc. Some clusters have formal cooperation with a cluster management organisation. That organisation is then typically a non-profit organisation (NPO) with the goal of strengthening the cluster. The reason companies start cooperating in a cluster is to get the benefits that follow. The benefits are both directly from the co-operation and indirectly from the mass of companies in the same industry.

The latter benefits of clusters and the introduction of modern communication technology that negates the need for geographic clustering has supported the development of clusters that are demographically concentrated in industry sectors. This is of particular interest in agriculture-based clusters with productive resources being distributed over many thousands of kilometres and even across borders. The Citrus Growers Association (CGA) and the work done by the Citrus Research Institute is an example of an industry cluster that operates across the borders

[27] AN IMPLEMENTATION AND MANAGEMENT FRAMEWORK FOR CLUSTER INITIATIVES IN SOUTH AFRICA By Sigrun Melax Thesis presented in partial fulfilment of the requirements for the degree of Master of Science in Engineering Management (Industrial) at Stellenbosch University

within the SADC region. The CGA has achieved remarkable success in promoting South African citrus products to the world and thereby supported the growth and expansion of the industry to the Chinese and far eastern markets.

The implementation of a cluster and subsequent operation of a cluster within the South African context is well covered in a thesis by Sigrun Melax as referred to in the footnote herewith cited. The implementation of the sorghum cluster can follow the same guidelines and process. While industry clusters can be driven from within the industry itself, the establishment of a sorghum cluster by the government and specifically the Department of Science and Innovation, is considered the appropriate mechanism. This will provide the initial impetus and funding for the cluster management organisation until it becomes a self-sustaining and independently operational cluster.

Figure 3-1: Cluster maturity and growth path

In the current study conducted by AIH team, the "Potential" for the cluster has been identified and accepted by almost all the role players. It is therefore proposed that the cluster initiative be established under the guidance of DSI and possibly in collaboration with DTIC.

3.2 Steps in establishing the sorghum cluster

The first step in the establishment of the cluster is the establishment of the cluster management organisation. The cluster management organisation's sole purpose is the management of cooperation in the cluster, identification of projects aimed at improving the competitiveness of the industry, securing funding for the proposed initiatives, promoting the industry to its key stakeholders in the entire value chain of the sorghum industry, and organising events where the cluster participants share experiences, project proposals, project progress and project outcomes.

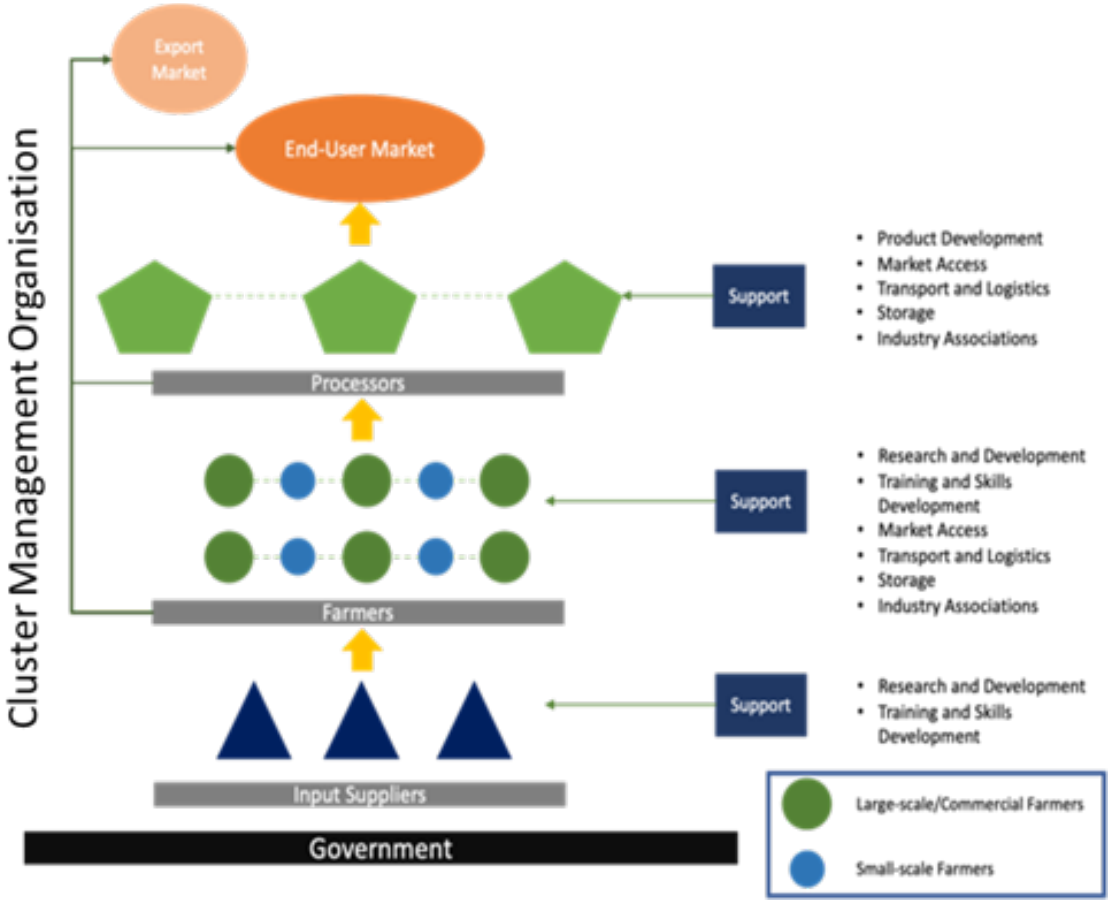


Figure 3-2: Cluster participants and organisation

The cluster management organisation (CMO) will be responsible for establishing and managing the cluster. This will include, but not be limited to, the following activities:

- Stakeholder Engagement:
  - Convene possible cluster members and test interest
  - Establish a database and recruit members

- Formalise Cluster as a Legal Entity:
  - Register non-profit organisation
  - Elect board members from cluster members
  - Open bank accounts, appoint auditors, etc.
- Develop a Vision for the Cluster:
  - Determine how the Cluster and the members (participating role players and stakeholders) can enable the achievement of the vision
  - Develop a mission and vision statement
  - Ensure buy-in from role-players and stakeholders
- Prioritise key issues to enhance cluster competitiveness;
- Form working groups and task teams to deal with specific challenges and opportunities;
- Quantify identified opportunities into projects; and
- Fund-raising for projects.

Activity	Timeframe	Cost
Initial Industry Engagement to Promote the Cluster and Secure Participation - Identification of key stakeholders - Telephonic, face-to-face engagements - Workshop to introduce the cluster programme	2 months	R500,000
Establishment of the Cluster and Necessary Statutory Protocols and Membership Sign-Up - Registration of the Cluster - Signing up members - Developing Cluster website - Establishing Board of Directors - Selection of Cluster Office Location - Developing Cluster Management Protocols, Memorandum of Incorporation, Policies, etc.	10 months	R1,500,000
Establishment and Running of the Cluster Management Office (12-month period) - Monthly meetings with Board Members - Update website with news and events - Arrange cluster events – i.e. bi-annual informal and formal gatherings, workshops, conferences - Identify cluster projects - Assessment of identified projects - Selection of projects to put forward to members for participation - Facilitation of project development - Facilitation of engagements between cluster members and industry stakeholders - Promotion of the cluster - Fund raising for projects - Quarterly newsletters	12 months	R1,800,000

Table 3-1: Cluster implementation programme

3.3 Proposed programmes

The research into the enhancement of the sorghum value chain through market opportunities, revealed the following opportunities:

Target market	Conservative volumes tpa	Optimistic volumes tpa
Import replacement	40,000	70,000
East Africa export	100,000	220,000
Beer	20,000	40,000
Consumer food	9,000	18,000
TOTAL potential	**169,000**	**348,000**

Table 3-2: Summary of Market Opportunities

The value chain upgrade research and outcome pointed out real opportunities and requirements to capitalise on these opportunities. In order to continue with implementation of the recommendations, it is proposed that the CMO proceeds to implement the following programs:

9. **Sorghum Cluster.** Establish a sorghum cluster to draw in the participation of all the key role players in the value chain from the seed suppliers through to the retailers. Such a collaborative initiative can focus on promoting sorghum in the local market and developing the export markets.

   The following **programs can be implemented by the Sorghum Cluster**

10. **Germplasm Development**. Compile a comprehensive germplasm development programme and motivation for funding together with key role players such as NAMC, SANSOR, DSI , GrainSA and participating seed companies. This will fine tune the programme elements, resources needed and funding requirement. The germplasm development program is the foundation for the improvement of the competitiveness of the locally produced sorghum and therefore a key requirement for unlocking higher yields and more cost-effective production of sorghum.

11. **Precision farming.** Precision farming has proven to contribute towards yield improvement. Modern farms and agricultural operations work far differently than those of a few decades ago, primarily because of advances in technology, including sensors, devices, robotics, and information technology. Today's agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial remote multispectral imaging (drones), and GPS technology. The application of these advanced devices and robotic systems in precision agriculture technology allow farming enterprises to be more profitable, efficient, safer, and more environmentally friendly. Microsoft has engaged the DTIC in South Africa to introduce Agritech innovations are already disrupting the sector in South Africa, and innovation will grow

exponentially as more solutions continue to be introduced. This includes the adoption of technology such as smart farming apps that assist farmers in keeping and maintaining accurate farm records; blockchain technology that allows the transparency and traceability of commodity trading from the farmer to the buyer; smart farming sensors that reveal changes in temperatures, rainfall and weather patterns; and lastly the use of drones for effective and efficient crop management and on-demand fertilisation and irrigation. These possibilities are why Microsoft South Africa has introduced its agritech initiative as part of its Equity Equivalent Investment Programme (EEIP) strategy with the Department of Trade and Industry (dti). The EEIP allows Microsoft to invest in programmes designed to meet the goals of Broad-Based Black Economic Empowerment (B-BBEE) in key sectors — of which agriculture is one because of its high job absorption capacity and impact on food security in the country.

It is proposed that the creation of a funded Chair in crop precision agriculture at a local university be considered. The Chair must include formal extension training in its mandate in addition to just purely research as has been the case with such Chairs to-date.

12. **Farmer development** and specifically Emerging and smallholder farmer development.

    d) Investigate smallholder farmer engagement models, such as used in Nigeria and East Africa Breweries Limited (EABL). A key consideration of the industry upgrade project is to include marginalized smallholder farmers. EABL and Nigeria seem to have achieved success with such initiatives – what can we learn from them?
    e) Conduct a feasibility study to enhance the feasibility and sustainability of the RED hubs (Rural Enterprise Development Hub) in the Eastern Cape through the addition of sorghum (and grain) extrusion / processing technology. The establishment of small-scale processing facilities such as that provided by CFAM, the South African extrusion cooking technology company, could stimulate rural social upliftment and economic growth and create demand for locally sourced grains (eg sorghum).
    f) The training of officials and establishment of extension services to support small holder farmers, emerging and established farmers with the introduction of precision farming techniques and new cultivars.

13. **VAT Removal**. Support the sorghum industry and specifically the initiatives from UNB to have VAT removed from sorghum and sorghum meal.

14. **Export market development.** The cluster could introduce a detailed logistics and demand study of the East African and Sub-Saharan market for sorghum (all types) in support of the cultivar selection / optimization and germplasm development programme.

15. **End-user market engagement**.

c) Consumer awareness. The establishment of a sorghum promotion programme such as the USA United Sorghum Checkoff program should be an initiative of the Sorghum Cluster. The appropriate vehicle for the establishment of such a programme and its funding could be the responsibility of the Sorghum Forum in collaboration with DSI and other industry players such as the food processing companies.

d) Animal feeds. The increased utilisation of sorghum on the local animal feed industry can be introduced as a separate initiative together with the feed processing companies such as AgriFeeds, Alzu, Epol, RCL etc.

16. **Import tariff.** Investigate whether there is a case for introduction of an import tariff on sorghum as is done with wheat in support of expansion of local production.

The following table provides an indication of potential projects that can be presented to the Sorghum Cluster for key participants to consider.

	Sorghum Cluster	Motivation SARS to remove VAT on sorghum	Equitable excise duty on Pasteurised traditional African beer (TAB)	SADC Sorghum Advanced Germplasm development (Pre-breeding) Programme	University Chair in Crop Precision Agriculture and Extension	Quelea Bird Predation Control	Sorghum RED Hub in the Eastern Cape
Key stakeholders and Roles and Responsibilities	Sorghum Forum – Coordinating body DTIC - Funding Implementation agency to set up Cluster	Sorghum Forum – Coordination and Lead DSI - Advisory	Sorghum Forum – Support from wider sorghum industry and other stakeholders UNB – Lead DSI – Advisory	ARC and ACCI-UKZN – Hosting institutions SANSOR and Commercial seed companies – Oversight and Technical coordination Grain SA - Advisory DSI and DALRRD and SADC Food, Agriculture Natural Resources (FANR) Directorate – Oversight, Obtaining Funding from donors, Technology sharing agreements with ICRISAT and other international organisations	DSI and NRF-Funding and coordination ARC and Grain SA-Advisory Grain SA – Coordination and Implementation Advice	DALRRD – Implementation Grain SA - Coordination	ECRDA, DESTEA, IDC of SA
Timeframe	Establishment – 12 months	12 months to prepare proposal and present it to SARS	12 months to prepare proposal and present it to SARS	Full establishment of the pre-breeding programme	Call for Chairs and Establishment – 12 months Chair duration – Minimum 5 years	Ongoing	12 months for feasibility study
Indicative budget	R3.8 million for establishment only	None – Costs to be met by the individual Forum members	None – Costs to be met by the commercial companies	R3 to 5 million per annum then less once the Programme is fully running.	R 2 million per annum	R3 million for new equipment R2 annually	R3 million for feasibility study

Table 3-3: Sorghum Cluster suggested projects

3.4 Potential Sorghum Cluster stakeholders

Group – interest groups with potential participation in sorghum cluster	Roles and responsibilities	Key players
Support service providers	Provide data analysis and industry overview. Economic analysis	Grain-SA, AgriSA, SAGIS, ARC, DALRRD, University and agricultural training institutions NAMC
Seed producers	Support germplasm development and cultivar selection programmes	SANSOR and major seed companies, e.g. Pannar-Corteva, AGRICOL, AGT Foods,K2, Zamseed,
Farmers and farming organisations	Development of equitable contracting systems with sorghum processing companies	Grain-SA, Black farmers associations
Agritechnology	Promote agritech and precision farming to support commercial and small holder farms.	Microsoft, DTIC, Universities, farmer associations such as Grain-SA and Sorghum Forum. Input suppliers such as seed companies and fertiliser producers (FERTASA)
Processors – alcoholic and non-alcoholic beverages	Development of plan for sustained growth of the traditional African beer industry	Major traditional African beer brewing companies and sorghum maltsters e.g. UNB, AB-InBev, Sorgho, Dannhauser Malt.
Processors – human consumption	Promotion of sorghum as a nutritious and healthy food. Development of equitable contracting systems with sorghum farmers	Major sorghum food processing companies e.g. Tiger Brands, RCL Foods, Pride Milling, Denmar Estates etc.
Processors – animal feeds	Identification of market opportunities for grain sorghum as an animal feed in South Africa	AFMA and major animal feed companies
Retailers	Facilitation of product purchasing from SMEs, Promotion of sorghum as a nutritious and healthy food.	Grocery Manufacturers Association and major retailers
Government departments	Enabling environment and policy formulation as well as funding (seed capital) for research and cluster initiative.	DSI, DTIC, DoA etc

Table 3-4: Sorghum cluster proposed key participants

3.5 Project scoping and basic assessment

The implementation of the various other initiatives can be planned and budgeted for as part of the sorghum cluster establishment program, ie these (and other initiatives) can be tasked to the sorghum cluster to conduct research to scope the projects and conduct basic assessments in terms of the following:

- Proposed project definition and rationale,
- Potential impact in terms of socio-economic impact (employment), industry growth, land use, farmer engagement and growth, etc,
- Key activities and implementation plan,
- Key role players and strategic partners,
- desired outcome and objectives and cost/benefit analysis or financial and non-financial returns,
- Implementation timelines, and
- Implementation budget.

Projects that are accepted for further development and implementation are screened by a panel from the Sorghum Cluster comprising designated representatives from each value chain element and key stakeholders, ie government, industry associations and company representatives. It is conceivable that the sorghum cluster will have various working groups that address specific areas of focus, eg agriculture, processing, marketing etc.