

**ECONOMIC ANALYSIS OF CASSAVA STARCH PRODUCTION VIS-A-VIS
STARCH PRODUCTION FROM MAIZE AND POTATOES IN SOUTH AFRICA**

BY

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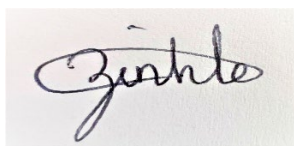
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DECLARATION

I, **Zinhle Zandile Nkosi**, declare that this mini-dissertation, hereby submitted to the University of Limpopo in partial fulfilment of the degree Master of Science in Agricultural Economics, has not been previously submitted by me to this University or any other higher learning institution. It was also prepared and executed by me, and all the material contained therein has been duly acknowledged.

A handwritten signature in black ink on a light-colored background. The signature is cursive and appears to read 'Zinhle'.

18-February-2024

Ms ZZ Nkosi

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DEDICATION

I dedicate this study to Muhluri - it always seems impossible until it is done.

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Psalm 23: *The Lord is my Shepherd, I have everything that I need...* with that said, I would like to thank God for allowing me and blessing me with an opportunity to compile this mini-dissertation. I also thank God for keeping me and giving me the strength to complete it. ***Surely goodness and mercy shall follow me for the rest of my life.***

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ABSTRACT

South Africa is a net importer of cassava starch and its derivatives. Yet, demand for cassava starch is increasing on a global scale. Without a supply and developed value chain, South Africa may continue as a net importer with a consequent unfavourable trade balance and a reduced Gross Domestic Product. Therefore, it is important to explore the economics of locally produced cassava starch and contrast it with currently produced starch (such as maize) in the country, to contribute to decision-making for developing a cassava starch value chain in South Africa.

The study aimed to carry out an economic analysis of starch production from cassava, vis-à-vis starch production from maize and potatoes in South Africa, through the determination of the demand and supply patterns of cassava maize and potato starch, analysis of the profitability of cassava and maize starch production and modelling alternative scenarios of cassava starch production in South Africa whilst determining the costs and benefits. Time series data was extracted from the trade map in the form of yearly imports and exports of cassava, maize and potato starch. The patterns were determined using a graphical analysis, which illustrated that starch imports were significantly higher than maize starch imports. A gross margin analysis was performed to determine the profitability of maize and cassava starch production.

Cassava starch production scenarios in South Africa were modelled using 3 scenarios, which were informed by the extracted starch yield. The cost and benefits of the scenarios were evaluated using Net Present Value, Internal Rate of Returns and Benefit Cost Ratio. These economic indicators revealed that cassava starch production is a viable and worthwhile project. However, one of the scenarios illustrated that the project should be rejected if the extracted starch yield is low. This is because a low extraction efficiency will render cassava starch production unprofitable. Lastly, the study conducted a sensitivity analysis to evaluate the sensitivity of the Net Present Value to the investment cost, discount rate and annual growth rate. It is recommended that the significantly high imports should be used as a driver to develop a cassava value chain in South Africa.

Keywords: Economic Analysis, Cassava starch, Profitability, Cost-Benefit Analysis, Palisade@ risk

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LIST OF ABBREVIATIONS

| | |
|---------|---|
| AFMA | Animal Feed Manufacturing Association |
| APSS | Agro-Processing Support Scheme |
| ARC | Agricultural Research Council |
| BFAP | Bureau For Food And Agricultural Policy |
| CAGR | Compound Annual Growth Rate |
| CBA | Cost-Benefit Analysis |
| DAFF | Department Of Agriculture, Forestry And Fisheries |
| DEAT | Department Of Environmental Affairs And Tourism |
| DTI | The Department Of Trade And Industry |
| FAO | Food And Agriculture Organization |
| FAOSTAT | Food And Agriculture Organization Statistics |
| GDP | Gross Domestic Product |
| GGBL | Guinness Ghana Brewery Limited |
| HQCF | High Quality Cassava Flour |
| IDC | Industrial Development Corporation |
| IFAD | International Fund For Agricultural Development |
| ITAC | International Trade Administration Commission |
| ITC | International Trade Centre |
| MAFAP | Monitoring And Analysing Food And Agricultural Policy |
| NAFRI | National Agriculture And Forestry Research Institute |
| NAMC | National Agricultural Marketing Council |
| OAE | Office Of Agricultural Economics |
| PPD | Post-Harvest Physiological Deterioration |

| | |
|-------|--|
| PRF | Protein Research Foundation |
| SAGIS | South African Grain Information Services |
| SETA | Sector Education And Training Authority |
| SMEs | Small Medium-Sized Enterprises |

CHAPTER ONE: INTRODUCTION

1.1 Background

Food security remains hindered because of diverse constraints such as increasing global population, rising scarcity of agricultural resources and unfavourable climatological variables such as drought (Adigwe *et al.*, 2022). It has been estimated that 815 million people in the world are malnourished with high intensity in developing countries. The world's population is predicted to reach 9 billion people by 2050, and it is projected that there will be a 70% increase in food demand (FAO, 2022). Therefore, it is imperative to cushion the growth of commodities that play a role in enhancing food security. According to Adigwe *et al.* (2022), the starch industry plays a fundamental role in the production of food. It supplies a significant number of ingredients used in multiple food products and animal feed. Additionally, starches are essential in a wide variety of products apart from food.

Starch is a polymer that is cheap, renewable and biodegradable (Visakh and Yu, 2016). Moreover, its derivatives are used in the pharmaceutical, textile, cosmetics, food, beverage, paper and animal feed sectors, indicating the significance of starch (Padi *et al.*, 2022). According to a comprehensive field investigation conducted by Urban-Economics (2017) on the starch industry in South Africa, the local starch industry is primarily dependent on maize and only to a small extent on wheat, potatoes and rice. According to the Bureau for Food and Agricultural Policy (2015), maize is the source of about 95% of the local starch produced in South Africa. Thus, this puts a strain on the maize industry which serves a variety of purposes with 37.4%, 39.8%, 17.9 % and 4.9% used for food, feed, export and industrial purposes respectively (BFAP, 2015).

Amelework and Bairu (2022) stated that the local starch industries were unable to fulfil the needs of the nation for starch because of the drought and competition between industries that use maize products. As a result, South Africa imports over 66,000 tons of starch every year. Potatoes also have numerous industrial uses, which limit their potential for starch production. Additionally, potato starch extraction is more expensive when compared to cassava and maize starch extraction (IDC, 2017). Cassava starch can fulfil most of the activities that are currently performed by maize and potato starch, suggesting that it can assist in meeting the demand for starch in the industrial sector while also reducing the supply strain on maize and potatoes (Padi, 2021).

Cassava (*Manihot esculenta crantz*) is a tropical shrub and perennial crop which is largely grown for its carbohydrate-rich tuberous roots (Mabasa, 2007). Tropical areas on continents such as Asia, Africa and Latin America regard cassava as a significant food crop. This crop serves as a staple food for over 800 million people in the tropics (Chisenga *et al.*, 2019). Furthermore, cassava has been transformed from being a poor man's crop to a lucrative industrial crop. The transformation is also supported by the increase in production over the years. In 1961, the total global cassava production was 78.5 million tons, and it surged to 322 million tons in 2017 (FAOSTAT, 2019). The significance of cassava is found in its high adaptability to various ecological conditions (Mutuyaba *et al.*, 2016). It is a drought-tolerant crop and can be grown in soil with low nutrient quality (Cuvaca *et al.*, 2015). Moreover, cassava is estimated to yield 8-10 tons of fresh roots per hectare with minimal inputs (Amelework *et al.*, 2021).

A study by Tonukari (2004) found that cassava starch has various uses in the industrial sector. It is the world's fourth most important source of plant-based starch (Sharma *et al.*, 2016). Cassava's most appealing feature is that it contains 70% starch by dry weight and is also high in carbohydrates, making it an excellent crop for industrial use (Mtunguja *et al.*, 2019). Cassava starch has multiple benefits, including a neutral taste, high purity and great thickening properties. It is also known for its high viscosity, resilience to shear stress and freezing resistance as it is amylose-free (NAMC, 2020).

In light of this, cassava is now manufactured into products such as starch, flour, glucose, ethanol and animal feed. Cassava starch is also used to reduce fluid loss by sealing the walls of boreholes, as well as glue in paper manufacture to achieve brightness and strength (Tonukari, 2004). The starch derived from cassava is said to be the world's most frequently used industrial starch (Amelework and Bairu, 2022). In comparison to maize, potato and wheat starches, cassava starch fetches higher prices on the market (Amelework *et al.*, 2021). A study by Mudombi (2010) found that when compared to maize, turning cassava into starch yields greater returns due to the higher starch content. Therefore, cassava has become a favoured crop for both small-scale and commercial farming because it requires fewer inputs and yields high output (Li *et al.*, 2017). Thus, if cassava can be used as an alternative starch source to meet domestic starch demands, competition amongst staple food commodities will be minimised, as will the amount of imported starch.

1.2 Problem statement

The agricultural potential and economic benefits of cassava production have not been fully exploited in South Africa. Furthermore, the cassava value chain in South Africa is underdeveloped, and this is supported by the lack of comprehensive information about it (NAMC, 2020). Cassava is produced on a small scale which means that there is little and no consistent supply in South Africa. This suggests that the existing supply is insufficient for industrial use, resulting in South Africa being a net importer of cassava starch and its derivatives. Consequently, this creates an unfavourable trade balance and a reduced Gross Domestic Product (GDP) (NAMC, 2020; Uddin and Khanam, 2017). According to Uddin and Khanam (2017), a country can increase its GDP by exporting more and importing less. However, since South Africa is a net importer of cassava starch, this will be an obstacle to improving the country's GDP, which is R1142 billion (Stats SA, 2022).

The volume of international imports and exports trade exhibited a significant decline and fluctuations after the COVID-19 outbreak (Tang *et al.*, 2022). Considering that South Africa's primary source of cassava starch is imported, it makes the country susceptible to value chain disruptions similar to the COVID-19 pandemic. These disruptions result in a trade-inhibitory effect, which weakens the degree of trade liberalisation among countries, resulting in high market access barriers, sharp rises in trade costs, and may even induce trade protectionism (Shahzad *et al.*, 2022). This will subsequently result in a shortage of cassava starch in South African markets. Furthermore, importing retailers will respond with cassava starch derivatives price increments, laying off workers or closing their enterprises. Consequently, it affects economic growth, price stability and full employment.

The market for cassava is being propelled forward by growth in these end-use industries. In future years, the cassava starch market is likely to be driven by rising demand for these derivatives. Projections outline that by 2024 the demand for cassava starch in the world would be above 10 million (Business wire, 2019). The projected rising demand without supply and a developed value chain implies that South Africa will continue being a net importer, which reinforces a vicious cycle. In light of the information above, the study therefore focused on an economic analysis of cassava starch production vis-à-vis starch production from maize and potatoes in South Africa.

1.3 Rationale

South Africa is a water-scarce country with unequal water resource distribution across the country (NAMC, 2020). In 2015-2016, the country experienced the worst protracted drought in a century, with the manufacturing of most food crops plummeting, jeopardising the country's food security position (Knot, 2014). During the 2015-2016 production season, the production of maize reduced drastically by R7.7 million due to the drought faced by the country (IDC, 2017). The 2015-2016 drought not only affected the maize industry, but it also affected the potato industry. The prices of maize and potatoes increased during the drought season (IDC, 2017). Consequently, this affected the supply of maize starches and increased the prices of maize starch in South Africa.

The value chain disruption factors such as drought contribute to the need to investigate different, affordable and effective alternative sources of starches that have high physicochemical and functional qualities, given the rising use of starch in food systems and non-food applications. Cassava is a drought-tolerant crop that produces good yields in marginal land (Cuvaca *et al.*, 2015). When compared to maize and potatoes, cassava has an advantage because it can grow in suboptimal conditions, enabling farmers to use marginal land to increase agricultural output. (Amelework *et al.*, 2021). These characteristics make cassava a potential substitute as well as a complementary crop to produce starch as it will be available even in harsh conditions.

Research pertaining to the improvement of cassava to make it a competitive crop, as compared to crops like maize and potatoes, is limited (Mudombi, 2010). These two crops have a technological advantage over cassava, because of extensive scientific research, which has been conducted regarding them. They have received a lot of scientific attention for their physicochemical and functional qualities (Chisenga *et al.*, 2019). Cassava's prospects are rooted in improving and understanding its supply through research. Therefore, this study contributed to the body of knowledge in terms of cassava starch production economics. This will enable decision-making regarding investment in value chain activities for cassava starch production. The study identified a need for a comparative economic analysis to understand which crop, cassava and maize, would cost-effectively produce the required starch.

1.4 Scope of the study

1.4.1 Aim

The study aimed to carry out an economic analysis of starch production from cassava, vis-à-vis starch production from maize and potatoes in South Africa.

1.4.2 Objectives

- i. To determine the supply and demand patterns of starch produced from cassava, maize and potatoes in South Africa from 2010 to 2021.
- ii. To analyse the profitability of cassava and maize starch production in South Africa.
- iii. To model alternative scenarios of cassava starch production in South Africa and determine the costs and benefits thereof.

1.4.3 Hypotheses that guided the study were as follows:

- i. The production of starch from cassava and maize is profitable.
- ii. Cassava starch production is economically feasible in all the modelled scenarios in South Africa.

1.5 Organisational structure

This mini-dissertation comprises five chapters. Chapter 1 introduces and provides the background of the economics of cassava, maize and potato starch production in South Africa. Additionally, it outlines the research problem and rationale for conducting the current study, objectives and the hypotheses that guide the study. Chapter 2 presents the literature reviewed for this study. It outlines the demand and supply dynamics of cassava, maize and potato starches globally, in Africa and South Africa. Furthermore, chapter 2 reviews the profitability of cassava and maize starch production. Lastly, the chapter reviews the cost and benefits of cassava starch production.

Chapter 3 provides the methods employed in carrying out the study. First, the chapter highlights the study area and outlines the data collection method used for this study. Lastly, it outlines the analytical techniques used to address the objectives of the study. This is followed by Chapter 4, in which the discussion of the results is obtained using the analytical techniques outlined in Chapter 3. Lastly, Chapter 5 presents the summary of the study, the conclusions drawn from the findings, and ends with recommendations that follow the conclusion.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews previous studies conducted both in South Africa and other countries. It takes readers through the detailed value chains for cassava, maize and potatoes. The chapter further presents the supply and demand dynamics at play in cassava, maize, and potato starch production globally, in Africa and South Africa. The reviews and comparison of the profitability of cassava and maize starch production are also presented in this chapter. Lastly, the chapter outlines the findings of other studies in relation to the costs and benefits of cassava starch production.

2.2 Review of previous studies

2.2.1 Cassava starch value chain

The value chain approach is a tool for analysing connections between each actor participating in the process of value addition between the place of production and the product's final markets. This approach contributes to transparency and efficiency in investment planning for agricultural commodities at various points throughout the chain (Adeoye, 2021). The value chain in businesses that produce crops commences with the inputs used to produce the commodity and encompasses everything done up until the time it reaches the consumer (Porter, 1985).

Value chain actors that supply farmers with raw materials and economic resources are found at the beginning of the cassava value chain (Darko-Koomson *et al.*, 2020). These service providers include research institutions such as crop research institutes that provide improved planting materials and agro-input dealers who supply agrochemicals. Agricultural extension agents offer technical advising services, and financial institutions may offer credit facilities to producers and other value chain actors.

A study by Tambunan and Manik (2021) which was conducted in Indonesia found that the value chain of cassava consists of farmers, middlemen, processors, retailers and consumers. However, Manivong *et al.* (2018) and Tanthaphone *et al.* (2020), found that the cassava value chain in Laos constitutes four main parts. These parts are production (farmers), intermediation (traders and collectors), processing (chip and starch factories) and lastly, exportation (cassava collecting companies).

Farmers are responsible for the production of raw cassava using seeds which they get from the input markets (Darko-Koomson *et al.*, 2020). The middlemen act as intermediaries between the farmer and industry or the consumer (Tambunan and Manik, 2021). Smallholder farmers are price takers in markets that are well developed because they rely on traders for market information (Mutayoba *et al.*, 2015). Cassava roots have a limited shelf life after harvest, which significantly restricts their marketability and the benefits they may provide to cassava farmers (Zainuddin *et al.*, 2018). This results in them selling the cassava roots to the middlemen at a very low price because they might have challenges in processing them. To mitigate this, cassava farmers traditionally process cassava into attieke, lafun, fufu and dumbo (Adebayo, 2023).

Cassava processing provides a way to increase crop value while prolonging shelf life, boosting market size and lowering cyanide concentration (Uchechukwu-Agua, *et al.* 2015). Processors are usually found at household level and they hand-process cassava chips using basic machinery for domestic consumption and sell the surplus to retailers (Souvannavong, 2021). However, Daniels *et al.* (2011) found that traditional food products are produced from cassava at household and micro-processing facilities, while enhanced food products and industrial products are produced from cassava in Small Medium-sized Enterprises (SMEs) and large-scale processing facilities. Additionally, the study found that cassava is processed on a small, medium, or large scale using a mortar and pestle, micro-processing facilities, cottage milling and other methods (Daniels *et al.*, 2011).

The cassava processing industry is a significant actor in the value chain (Tambunan and Manik, 2021). The industry processes the cassava produced by farmers into cassava derivatives with higher economic value. According to Ho *et al.* (2015), farmers, processors and other value chain participants such as collectors, middlemen, dealers, wholesalers, retailers, processing units, firms and manufacturers rely mostly on cassava and cassava derivatives for their income. The government in Toba Samosir District Indonesia is not directly involved in the cassava value chain; it plays a role in supporting the improvement of the value chain (Tambunan and Manik 2021).

Government support comes in the form of agricultural services, provision of cassava seeds and provision of equipment and machinery (Tambunan and Manik, 2021).

Cassava value chain actors in African countries are faced with various constraints, which results in the under-utilisation of cassava roots for industrial purposes (Daniels *et al.*, 2014). These constraints are weak links in the supply chain that delay the delivery of cassava to industrial processors and cause insufficient input availability and weak extension services. Additionally, there is limited access to credit for operating and expanding businesses, low processing enterprise efficiency and the non-commercial orientation of many farmers (Daniels *et al.*, 2011). This is in line with Njukwe *et al.* (2014) who found that Cameroon's cassava producing regions frequently lack adequate post-harvest infrastructure, including roadways, communication channels and systems for supplying inputs and farmers themselves are disorganised (Njukwe *et al.*, 2014). These constraints contribute to inadequate participation in the global cassava starch market.

Figure 2.1 depicts the virtual representation of the cassava value chain. The cassava value chain involves glucose and starch production, flour milling, animal feed production and the production of fresh cassava for consumption. Cassava is a significant source of starch used in various industries. Fresh cassava is a key component of local diets due to its carbohydrates and nutrients.

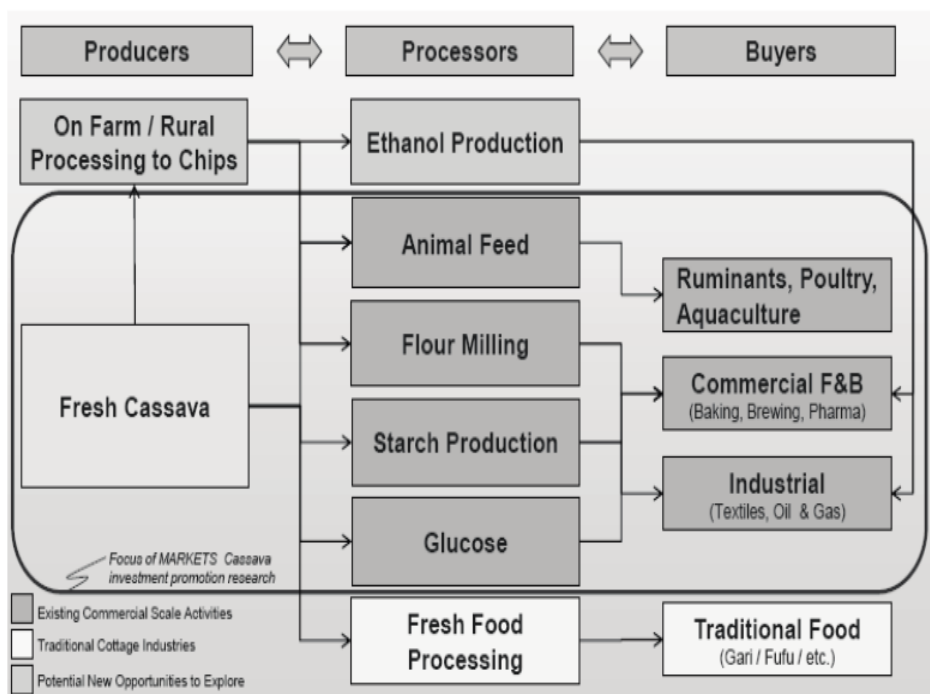


Figure 2.1: Cassava value chain

Source: MAFAP (2013)

Cassava by-products like pulp and peels are often used as animal feed, meeting the nutritional needs of animals, especially in areas where cassava is a primary crop. This is done by processing the roots into pellets or chips. Cassava has also developed into a crucial raw material for the manufacturing of bioethanol and other bio-based compounds due to its low cost and wide availability (El-Sharkawy, 2004). According to Mudombi (2010), ethanol can be utilised as a substitute for conventional energy sources as it is environmentally safe. Additionally, ethanol gel burners have gained momentum in rural areas where there are electricity constraints.

2.2.2 Maize value chain

The maize value chain depicts markets for maize products and the stakeholders involved in the production, processing and marketing of maize. Additionally, it shows their relationship as they move the products from the field to the final market (Fadiji and Aboaba, 2018). The maize value chain can be separated into five components: inputs, production, aggregation, processing and marketing and distribution. A study which aimed to analyse the value chain of maize and maize products in Nigeria purposively selected and interviewed maize farmers, maize processors, maize wholesalers and maize consumers, making them value chain actors (Fadiji and Aboaba, 2020).

The primary, secondary and tertiary sectors make up the maize value chain (Hodge, 2021). Input suppliers are found in the primary sector; they comprise entities that produce and supply seeds, fertiliser, pesticides and farm machinery. Pannar, Pioneer Hybrid International and Monsanto are currently the top three seed companies in South Africa. The number of informal millers has significantly expanded since the introduction of deregulatory measures and the dissolution of the Marketing Board (NAMC, 2004). South Africa consists of millers which are above 190.

The millers are separated into two groups, wet millers for starch production and dry millers for livestock feed and maize meal production. Pioneer Food Group (Pty) Ltd, Premier Foods Ltd, Pride Milling Company (Pty) Ltd, Ruto Mills (Pty) Ltd and Tiger Brands Ltd, as well as some silo owners, are some examples of maize milling companies in South Africa (Hodge, 2021).

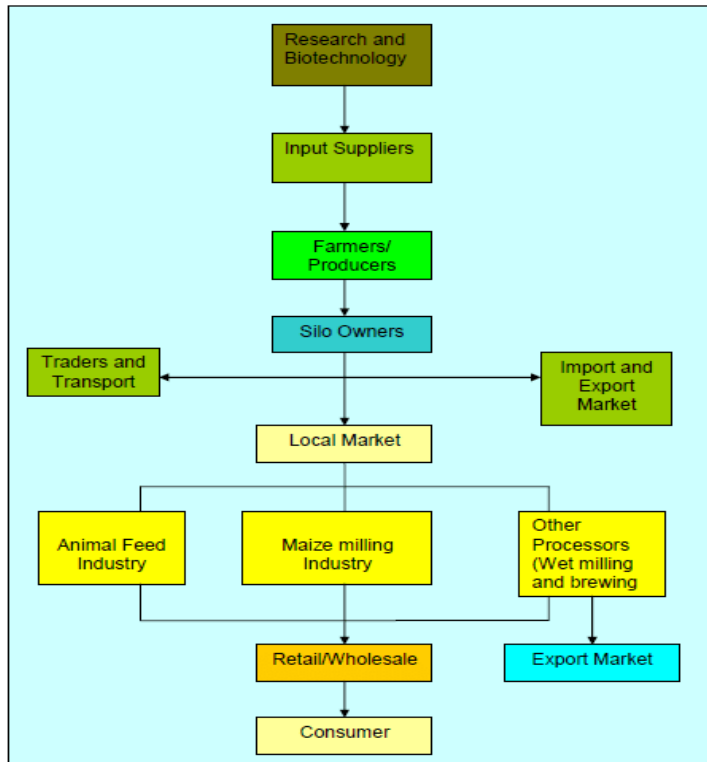


Figure 2.2: Maize value chain

Source: DAFF (2012)

The tertiary sector comprises traders, retailers and transporters that supply the domestic or foreign market. The distribution of maize products from the miller to the final consumer is supported by the retail sector's infrastructure and services. The purpose of transportation is to transport the maize to the relevant value chain actors.

2.2.3 Potato value chain

The potato value chain map emphasises the involvement of several entities who take part in the value chain either directly or indirectly. Indirect actors are those who provide support services, such as credit agencies, government, NGOs, cooperatives, researchers and extension agents (Awoke and Molla, 2018). Direct actors are those involved in commercial activities in the chain (input suppliers, producers, traders and consumers) (Biru and Haji, 2016).

The potato value chain refers to the entire process and network of activities involved in producing, processing, distributing and marketing potatoes, from the farm to the consumer. It encompasses various stages and stakeholders, each adding value to the potato as it moves through the chain (Haggblade *et al.*, 2012). The potato value chain encompasses input suppliers, farmers, collectors, wholesalers, retailers, processors

and final consumers (Wubet *et al.*, 2022). Collectors buy potatoes from the farm gate and re-sell them at a higher price to other value chain actors.

The value addition activities executed by wholesalers involve storing potato tubers they receive from farmers and collectors, cleaning and transporting the potatoes to consumers. The wholesalers normally supply consumers outside their district (Biru and Haji, 2016). Processors are not significant in the Farta District of the South Gondar Zone potato value chain (Wubet *et al.*, 2022). Contrary to the Farta District of South Gondar zone, processors are the main actors in the potato value chain in the Lemo woreda of Hadya zone (Daniso *et al.*, 2021). They are found in the town areas, in hotels and restaurants, cafés and along the roadside. Potato processors convert potatoes into chips, woti and starch which are sold to end consumers (Daniso *et al.*, 2021). Consumers are the last actors in the value chain as they buy the potatoes for final consumption as seen in Figure 2.3 (Wubet *et al.*, 2022).

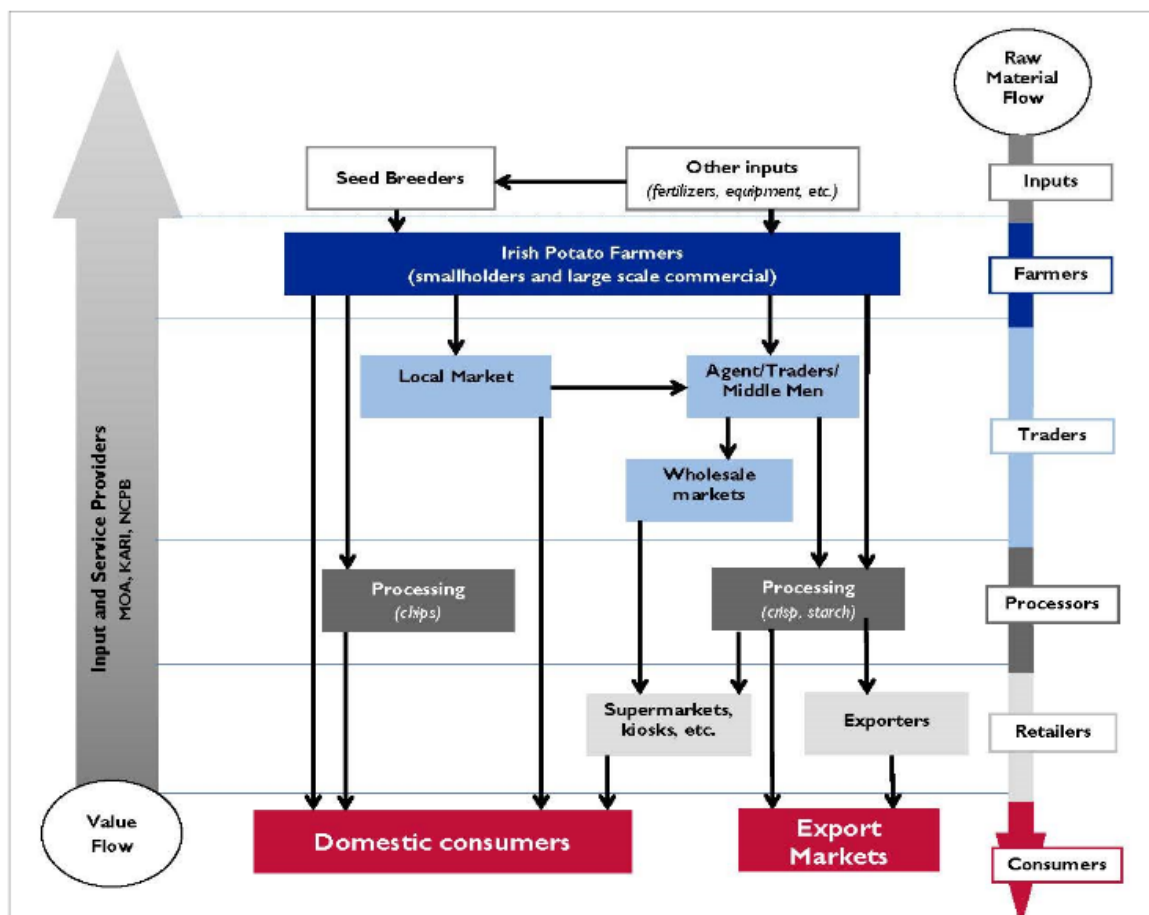


Figure 2.1: Potato value chain

Source: Ministry of Agriculture

2.2.4 Supply and demand dynamics of cassava, maize and potato starches

2.2.4.1 Global supply and demand dynamics of cassava, maize and potato starches

Data Bridge Market Research (2022) found the cassava starch market value to be 4.95 billion USD in 2022. Additionally, it is projected to be worth 7.54 billion USD by 2030. According to the Global Cassava Starch Market (2021), the Asia-Pacific area produces 276 million tons of cassava, which accounts for approximately three-fourths of the global market. Cassava tubers cultivated in Nigeria made up 18% of the total global production.

The global market for maize starch is anticipated to generate 21.13 billion USD in revenue in 2020, reaching a market value of 33.27 billion USD in 2027 (PRNewswire, 2020). Maize starch has dominated world starch production, accounting for 80%, cassava accounting for 10% and potato accounting for 3% (Waterschoot *et al.*, 2014). Cassava contributes about 7% of the world's starch production, which is growing significantly (about 3% yearly) (OECD, 2021). The main areas for potato starch production are Germany, the Netherlands, France, Denmark, Poland, Sweden, Finland, Austria and the Czech Republic. Additionally, these nations produce more than 90% of all the starch in Europe. Farmers and starch processors have worked through long-term contracts to organise starch production (BSAF, 2011).

The European policy to restrict imports of cereal feed grains - which did not apply to pelletised cassava - stimulated the growth of the global trade in cassava products from the 1970s to the late 1980s (Henry and Correa, 1992). Furthermore, the rising demand for cassava starch is a result of its unique qualities, which are particularly appealing to various culinary and non-food businesses. Due to these advantages, the cassava starch market has grown recently and is expected to reach 8.8 million tons of output in 2020 (Wang *et al.*, 2022).

Africa, Asia and Latin America are the main producers of cassava and their demand is driven by the domestic consumption of raw cassava roots. However, Thailand, Vietnam and Cambodia export a significant amount of value-added cassava in the form of chips pellets and starch, when compared to domestic consumption. Furthermore, due to its domestic consumption being significantly less than other countries, Thailand manages to be the largest cassava starch exporter in the global

market (OAE, 2012). From 2014 to 2017, the total export quantities were approximately 11 million tons, but they started to decline in 2018 and peaked at 7.14 million tons in 2020 (Pannakkong, 2022). The value of the world's exports of cassava and its derivatives (fresh cassava roots, chips, pellets and starch) declined by 5.08% annually from 2013 to 2017. This was because of a policy implemented by China that supported the release of low-price maize stocks. As a result, the alcohol industry switched to using maize as a raw material instead of importing cassava chips from Vietnam and Thailand.

2.2.4.2 African supply and demand dynamics of cassava, maize and potato starches

North African nations including Egypt, Algeria, and Morocco are among the continent's top producers of potatoes. Within Sub-Saharan Africa (SSA), the majority of potatoes are grown in eastern Africa (71%), with the remaining portions coming from southern and west Africa (21% and 8%, respectively (Muthoni and Shimelis, 2023). According to statistics, Nigeria produces the fourth most potatoes in West Africa and the seventh most in the continent. Over 80% of it is consumed as food, hence little effort is made to promote it for industrial application this is true for most (Adigwe *et al.*, 2022). A study by Desta and Tigabu, (2015) found that the current demand for potato production is estimated at 1768 tonnes per annum. The study projected that potato starch demand in Ethiopia will increase from approximately 1.8 million kg by 2016 to 1.9 million kg by 2017 and 2.1 million kg by 2018. Furthermore, the demand will reach at a level of 4.2 million kg by the year 2030.

In Nigeria maize is a staple food and the most important component in food manufacturing. Maize is consumed in Nigeria as maize meal, roasted, boiled, or made into porridge. The household consumption amounts to 10-15% of the overall consumption. The remaining 80-85% is used for food manufacturing. In Nigeria cassava is preferred when comparing it with maize starch.

The total production of cassava was about 170 million tons in Africa, which is 56% of world production (FAOSTAT, 2019). Nigeria, Ghana, the Democratic Republic of Congo, Tanzania, Mozambique and Malawi are the biggest producers of cassava. Cassava and its by-products are produced on three different scales namely, small-scale for traditional foods, medium-scale for enhanced foods and large-scale for

industrial goods (Daniels *et al.*, 2011). The traditional market is saturated and allows little room for expansion. According to Daniels *et al.* (2011), industrially processed products still have significant growth potential provided the correct dynamics can be created in terms of supply-demand, manufacturing costs, transportation and infrastructure.

Nigeria produced about 60 million tons of cassava, which contributed to the 170 million tons produced in Africa (FAOSTAT, 2019). However, even though Nigeria is the largest producer of cassava, it still has not harnessed the full economic potential of the crop and the country is not an active participant in cassava trade in international markets (Ani *et al.*, 2019). This is because 90% of the cassava produced in Nigeria is consumed locally, which means that a large percentage goes to domestic consumption and a small percentage is for industrial use, whereas a higher proportion can be allocated for industrial use (Denton *et al.*, 2004; Ikuemonisan *et al.*, 2020).

In Nigeria, there are two types of markets for cassava namely, the traditional food orientated market, which has limited risk and is not capital intensive and the new emerging market for cassava derivatives, which is capital intensive and has not yet found its way to the market (Ikuemonisani *et al.*, 2020). The local business owners have built medium sized companies which process cassava into High Quality Cassava Flour (HQCF), starch and high grade fufu. Businesses in this category are Peak Products Ltd in Abeokuta, Vesa Farms Ltd and Deladder Investment in Benin City. Major industrial scale processors include Matna Starch and Nigerian Starch Mills in Ihiala, Ondo State and are the leading starch industries supplying high grade refined products to manufacturing industries such as Cadbury and Nestlé Plc (Sanni *et al.*, 2009).

Nonetheless, Nigeria is still a net importer of cassava starch, and this is due to the under-utilisation of the existing resources. Investors are discouraged from investing in Nigeria's cassava production due to the issue with the land tenure system and other difficulties that hinder the ease of doing business, despite the increasing value of cassava in the global market (Ikuemonisan *et al.*, 2020).

Ghana is the second largest producer in Africa and ranks sixth globally, with a production of 17.8 million MT in 2016 (FAOSTAT, 2016). Cassava cultivation and value addition revenues account for around one-fifth of Ghana's agricultural GDP

(Kleih *et al.*, 2013). In Ghana, two major companies, Guinness Ghana Brewery Limited (GGBL) and Accra Breweries Limited, extract starch from cassava to make beer. As a result, the government has an excise break policy for the brewing sector in Ghana to encourage the use of locally sourced ingredients in beers (Darko-Koomson *et al.*, 2020).

Despite the prospects that exist in the global cassava market, most nations in Sub-Saharan Africa (SSA) still participate minimally in the market (IFAD, 2000; Prakash, 2008; Ikuemonisan *et al.*, 2020). Moreover, the conventional processing methods that predominate in Africa limit the continent's economic potential since they are characterised by inefficient mass and energy conversions and capacity limitations (Westby, 2002; Padi, 2021).

Small and medium-sized farmers in Africa are unable to increase the value chain's efficiency and the profitability of their cassava businesses due to a lack of professional support. Consequently, this makes it harder for processors to make a transition from manual, low capacity, inefficient and unprofitable processing enterprises to mechanical, high capacity, efficient and profitable processing enterprises. This results in many farmers failing to manage cassava production as a business (Abass *et al.*, 2014). Hence, this makes the cassava industries in Africa less competitive on a worldwide scale. Therefore, industrialising cassava processing is essential to maximising its agricultural and commercial potential as well as its ability to compete globally (Padi, 2021).

2.2.4.3 South African supply and demand dynamics of cassava, maize starch and potato starch

South Africa sources cassava starch from Asia, Europe and America at a high economic cost (IDC, 2017). The total value of imported and exported cassava starch and cassava starch derivatives in 2021 was approximately R94 782 000 and R1195 000 respectively (ITC, 2021). Over time, there has been an increase in domestic demand which has led to an increase in import volume and related expenses. Irrespective of these high imports, considerable starch exports also prevail (Padi, 2021). Given the wide range of imported goods, cassava starch is the second most popular commodity (Urban-Econs, 2017).

Maize starch and derivatives make up the majority of exported goods, which may be attributable to the local industry's dominating producers of maize starch and nominal

derivative processors in the local industry. The local industry producers include Tongaat Hulett Starch, which is the leading company in the maize starch market, producing about 99.5% of all starch produced domestically. The remaining 0.5% is produced in the nation by five other smaller producers of starch (WFM Starch Products, Natal Starch, Top Products, Charka, and Noukloof Store) (IDC, 2017). Genetically modified maize is used in the processes of South Africa's smaller starch producers. Starch yields have significantly increased as a result of the use of genetically modified maize and other technological advancements. But only non-genetically modified maize is used to create the majority of the starch made from it in South Africa (Tongaat Hulett, 2017).

The Department of Agriculture, Forestry and Fisheries (2010) reported local production of 20 000 tons of cassava starch annually. This was based on full capacity (60 tons starch/day) projections for a cassava starch facility in Dendron as of 1999 (Payne, 1999). However, it ceased to operate due to crop infestations by leaf mosaic virus and bacterial wilt diseases, resulting in a lack of raw material supply (Okudoh *et al.*, 2014; Amelework *et al.*, 2021). Nationally, cassava is traded informally, creating raw material scarcity. This is a result of the underdeveloped cassava value chain, a lack of well-established marketing channels, substandard infrastructure and inadequate information about the market (NAMC, 2020).

Mudombi (2010) found that cassava starch is mostly consumed in South Africa by businesses in the paper, food and textile industries. The paper milling company Mondi South Africa has acknowledged the prospects for commercial cassava cultivation. This is because they managed to produce 15 tons of cassava starch annually (Amelework, 2021). A company that utilises cassava starch in South Africa is Enterprise Foods. Its sausages are bound together with cassava starch. Compared to sausages manufactured with maize, potatoes and wheat starch, these sausages are six times more durable, allowing the firm to produce its products at a lower cost (Mudombi, 2010).

The sauces for tinned fish at Lucky Star are thickened with cassava starch. Lucky Star supplies approximately 800 000 cans of Lucky Star daily, serving over 3 million people. This contributes to food security because tinned fish is affordable and convenient to store. In Africa, Tongaat Hulett intends to explore cassava starch as a raw material to

harness potential cost saving benefits due to cassava starch's unique functional properties (Tongaat Hulett, 2018).

The frozen French fries' and snack (crisp) businesses are the two most leading sectors in the potato processing industry. According to NAMC (2017), McCain, Lamberts Bay Foods, and Natures Choice are the companies with the biggest market shares in the frozen fries' sector. In the Delmas, Mpumalanga region, a manufacturer of potato starch has been located. In the food industry, this producer of potato starch caters to a specialized market (IDC, 2017).

Maize, potatoes and other cereals which dominate the starch market, are significantly preferred by South African consumers. Post-colonial government policies favouring maize over cassava were another reason causing cassava to lag in South Africa. However, there is a significant market growth potential for cassava starch because of the industry's need for less expensive alternatives to maize and potatoes, as well as the expanding need for starch-based applications in the culinary and industrial sectors.

2.2.5 Profitability of cassava and maize starch production

According to Itam *et al.* (2014), profitability is a measure of the relationship between the levels of profits generated during an accounting period and the number of resources employed to generate those profits. It links the level of profits to sales or the effectiveness with which different types of resources are managed. Profitability is determined by the difference between expenses and returns per unit of production and the quantity of units sold. Tijani *et al.* (2010) stated that profitability is a vital factor which directs the flow of capital. Moreover, farmers should be aware of factors affecting profitability.

To examine the profitability of cassava production, Awerije and Rahman (2014) employed a standard gross margin analysis and imputed the costs supplied to inputs with market prices. Based on ANOVA analysis, Awerije and Rahman (2014) found that cassava production was profitable with significant differences in overall profit margin of 19.93 across all farm size categories and regions. Tam *et al.* (2014) findings were in line with Awerije and Rahman's (2014) results, which showed that cassava production is profitable. According to Itam *et al.* (2014), profitability analysis showed that the gross margin per hectare was ₦9 520.66 (R405.26). Furthermore, the total revenue was 46% more than the costs incurred.

The analysis of maize producers' gross margins revealed that those with farms of less than 2 hectares had the highest net profits. The analysis of wholesalers' and processors' marketing margins revealed that the marketing and processing of maize is profitable and the analysis of value addition revealed that wholesalers add more value to maize than processors (Fadiji and Aboaba, 2018). There was a net profit of ₦32 893.6 (R1 224,10) from the cultivation of less than two hectares of maize, a net profit of ₦9,868.1 (R373,08) from the cultivation of 2-4 hectares of maize, and a net profit of ₦6,578.7 (R248,72) from the cultivation of more than 4 hectares. These results indicate that maize farmers with less than two hectares of maize farm have the highest net profits. Farmers with less than two hectares have fewer operational expenses as compared to farmers with more than two hectares.

Marketers, consumers, farmers and processors may all benefit from cassava, making it a competitive commercial agricultural crop. (Ani *et al.*, 2019). According to Oruonye *et al.* (2021), based on operating profit, cassava was ranked third behind rice and maize in the value chain analysis of cassava, cotton, maize, rice, soybeans and sugarcane. In comparison to maize (R29 514) and potatoes (R32 400), cassava generates the maximum income from starch per hectare (R74 250) (Mudombi, 2010). Additionally, research has shown that adding value to cassava results in higher profits as compared to selling raw cassava tubers (Abass *et al.*, 2014; Manganyi *et al.*, 2023). According to a study by Mudombi (2010), processors generate more profits from cassava as compared to farmers because they add value to cassava. As a result, farmers in South Africa became discouraged from growing cassava, which decreased the availability of raw cassava. This resulted in the shutting down of the cassava starch factory which had been opened by African Products in South Africa because of the shortage of raw materials.

2.2.6 Costs and benefits of cassava starch production

The costs and advantages to society as a whole are examined in a social cost-benefit analysis. It aims to ascertain whether the project will benefit or harm society. According to Sriroth *et al.* (2007), the cultivation of cassava benefits society. Benefits include employment creation, income generation across the full system of production, processing, trading and export revenues, as well as a variety of healthy diets.

A social cost-benefit looks at the costs and benefits to society as a whole. It aims to ascertain whether the project will benefit or harm society. According to Siroth *et al.* (2007), the cultivation of cassava benefits society. Benefits include employment creation, income generation across the full system of production, processing, trading and export revenues, as well as a variety of adequate diets.

Cassava can be produced without significant use of inputs (Mbanjo *et al.*, 2021). As a result, it can be grown by small-scale resource-constrained farmers who lack the funds to purchase agrochemicals (Costa and Delgado, 2019). Cassava fresh root yields for smallholder farmers have been calculated to range between 1-10t ha⁻¹. However, by using high-yielding cultivars and enhanced crop management techniques, fresh root yields might reach 75-80t ha⁻¹ (Anikwe and Ikenganyia, 2017). This means that the use of enhanced crop management techniques such as agrochemical application can improve the productivity of the farmer. Consequently, this can enhance the benefits received by the farmer producing cassava.

Like any other economic activity, cassava production and value addition have associated costs. A study by Sanusi *et al.* (2020) in Nigeria found that cassava farmers in their sample size incurred variable costs, which amounted to ₦17980.66 (R731.67) per hectare. The variable costs consisted of planting operations ₦4510.76 (R183.60), fertilisers ₦5 932.49 (R241.47), herbicides ₦1 490.62 (R60.67), fungicides ₦1 021.00 (R41.56), hired labour ₦3 070.66 (R124.99), family labour ₦954.05 (R38.82) and transportation ₦1 001.08 (R40.75) (Sanusi *et al.*, 2020). The farmers invested mostly in agrochemicals because this accounted for 47.21% of the variable costs. This suggests that agrochemicals constituted the most significant variable cost. However, fertiliser costs accounted for 33% of the farmer's agrochemicals costs. This highlights the importance of fertiliser application in the production of cassava. Planting operation and labour costs accounted for 25.09% and 22.3% respectively. The lowest costs were transportation costs, which were 5.4% of the variable costs. The farmers managed to produce cassava yields at the value of ₦42729.94 (R1731.63) per hectare (Sanusi *et al.*, 2020). Furthermore, the benefit costs ratio for this enterprise was 1.38. This suggests that for every R1 the farmers put into the production of cassava, R0.38 was returned to them.

In Cambodia, research findings suggested the cost of production for cassava increased from 464.80 USD (R8 339.33) in 2007 to 981.25 USD (R17 611.18) per hectare in 2013 (Hing and Thun, 2009; Ou *et al.*, 2016). Production costs increased further in 2017 to 996.76 USD (R17 889.25) (Sopheak, 2017). They further increased to 1085.19 USD (R18 790.86) in 2021 (Peuo *et al.*, 2021). The expenditure for hired labour, hired services and land rental accounted for 494.25 (R8 782, 23) of their income and the imputed cost of family labour. The cost of services by the farmer's own fixed capital was 312.59 USD (R5 554.35). Labour cost represented 21.16% of the farmer's total revenue. Farm machinery depreciation amounts to 21.33 USD (R378.92) per year of cassava farming, including tractors, trucks, equipment for spraying herbicides and weed cutters. The total expenditure was 745.59 USD (R13 235.34), excluding the amount that was imputed (Peuo *et al.*, 2021).

Despite all of these expenses, cassava is still a profitable crop that increases farmer income and provides job opportunities for people in rural areas. According to Peuo *et al.* (2021), the average price of cassava was 61.53 USD (R1 092, 65) per ton, while the average production per hectare was 24.16 tons. This implies that the farmer produced revenue of (1 486.58 USD) R26 388. 43 per hectare for cassava. The study found that farmers share an imputed cost of 312.59 USD (R5 554.99). The return on investment represented R1.40, meaning that for every R1 invested in Cassava farming, the farmer will get R0.40 (Peuo *et al.*, 2021).

Cassava starch extraction is a capital-intensive multi-step process. Soesilowati *et al.* (2020) found that the initial investment costs of running a cassava starch and derivatives business are buying various assets and business equipment. Cassava production consists of a cassava washing machine, crushing machine, fine fibre sieve, de-sanding cyclone, de-silting cyclone, starch hydro-cyclone, vacuum filter, airflow flash dryer and packaging machine (Good way solution, 2018).

According to Soesilowati *et al.* (2020), manufacturing machinery accounts for over half of the overall investment expenditure. Investing in cassava starch processing machinery is essential for adequate value addition that maintains nutritional content. Soesilowati *et al.* (2020) found that the initial investment was worth IDR 120 800 000 (R129 744. 82) and the depreciation value IDR 8 053 000 (R8 646. 58) per year. A study by Kathiravan *et al.* (2017) found that a cassava starch processing plant with a

production scale of 1701 tons has a total variable cost of Rs 845.640 lakh (R17 127 110.55) and labour costs accounted for R2 459 591.67. The labour costs are the second highest costs after cassava roots, which accounted for Rs 550 lakh (R 11 121 786.50) of total variable costs.

Cassava starch processing operations are dependent on electricity and fuels. (Ntiamoah, 2017). Cassava has a high water content and is bulky in nature; this contributes to the energy intensiveness of processing it (Ajiboshin *et al.*, 2011; Padi, 2021). A study by Siroth *et al.* (2000), found that processing one ton of cassava starch requires thermal energy and electricity of 1600-2500 MJ and 170-250 kWh, respectively. According to Pingmuanglek *et al.* (2017), drying operations for cassava starch contributed approximately 69% of the production's overall energy 2008 MJ/ton. Modern energy is, therefore, essential for industrialisation of cassava processing.

In the processing of starch, it is critical to complete the entire process in the shortest amount of time feasible without the disturbances of power cuts such as load shedding. This is because enzymatic processes begin shortly after the cassava tubers are harvested, as well as throughout each of the subsequent phases of manufacture, compromising the ultimate product's quality (Krishnakumar *et al.*, 2021).

The industrialisation of cassava processing in Africa is threatened by the dominance of unstable modern energy sources (Brew-Hammond and Kemausuor, 2009). The profitability of the industrialised processes is affected by an increase or instability in the pricing of these energies in the area (Kleih, 2013). For instance, energy contributes to the cost of producing cassava starch in Thailand at a rate of around 14% (Chavalparit and Ongwandee, 2009). It contributes at a rate of 20-25% in Nigeria, whereas the processing activities are similar (Nang'ayo *et al.*, 2005). This demonstrates the significance of energy to the economic sustainability of cassava starch production in Africa (Padi, 2021).

According to Omolara (2017), the value addition of cassava has various economic benefits. This is in line with Adrien's (2008) study, which asserted that adding value to cassava provides significant benefits such as an increase in income generation for rural producers. Omolara (2017) found that the contributions of cassava derivatives to socioeconomic development support economic growth by supplying food to the world's growing population, especially in urban areas. Cassava derivatives can be kept in

storage to avoid rotting and wastage and then used locally or exported to boost the country's foreign exchange profits. Omolara (2017) found that the total costs of production amounted to ₦147 509.5890 (R5 476.81) and the benefit-cost ratio (BCR) was 1.35. This means that for every R1.00 invested in cassava flour production, R0.35 is returned. The cassava flour processors are encouraged to increase their investments in the company because this shows that it is a worthwhile venture (Omolara, 2017).

The agronomic benefits of cassava include drought tolerance, high starch content and favourable biomass yields as compared to maize and potatoes (Marx and Nquma, 2013). Therefore, cassava has been suggested as a potential food, industrial and bioenergy security crop for South Africa, which can reduce the effects of ongoing droughts and depleting agricultural resources like arable land (Okudoh *et al.*, 2014). Additionally, it can also promote socio-economic empowerment, which can improve livelihood and support for farmers (Coulibaly *et al.*, 2014). The cassava industry's significance lies in its potential to create employment (Krishnakumar *et al.*, 2021). This is consistent with Olajide's (2007) study, which found that Nigerian cassava starch was valued at 456 USD per ton and generated roughly 150,000 jobs annually, with a market value of 22.6 million USD. In South Africa, it would contribute to welfare by possibly reducing the unemployment rate, which is at 32.7% (Stats SA, 2022). Therefore, strategically advancing cassava might aid in reducing rural poverty and boosting food security, which could be accomplished by enlarging its industrial applications and distribution channels.

Cassava starch generated locally could be a good alternative to imported maize starch, enhancing profits for local businesses, and lowering starch costs by avoiding importation costs (Bennesi *et al.*, 2006; Mufumbo *et al.*, 2011; Olunkunle, 2013; Mtunguja *et al.*, 2015). Cassava marketing would be expensive because it would require educating people about a new product and then generating interest in it. This is because most investments favour maize-based products, and the current market situation may make it difficult for cassava derivatives to gain traction.

Having access to financial resources and developing a strategy that capitalises on current demand, looks into alternative distribution options and highlights the advantages of consuming cassava products over those made from maize would be

necessary for the introduction of cassava products into this type of market. Cassava starch production has benefits that could change the state in which South Africa finds itself. However, because exploring this market can be capital-intensive and South Africa has limited resources, it might not be viable. Rome was not built in a day - this implies that with proper policies such as the New Growth Path together with the National Development Plan, the Industrial Policy Action Plan (IPAP) and the South Africa Trade Policy and Strategic Framework, the cassava market can be developed over time and it will be beneficial to South Africa. These policies acknowledge agro-processing as one of the significant sectors for industrialisation (ITAC, 2016).

2.3 Summary of literature

The literature illustrates that the cassava value chain is significant and enabling its growth can greatly contribute to the economy. This is demonstrated by Thailand as it managed to continue producing cassava starch whilst experiencing challenges, which highlights the importance of cushioning a cassava value chain. However, African countries have not mastered the art of exploiting the maximum economic benefits of cassava starch production. This is seen in their performance in the global cassava starch market that is dominated by the Asia-Pacific region. This suggests that there is room for growth in African countries which could improve their status in the global cassava starch market.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter outlines the research methodology employed in conducting the current study. It initially gives a detailed description of the study area. This is followed by the data collection methods, which were utilised to obtain the data for this study. It also describes the analytical tools that were employed to obtain the results of the study.

3.2 Study area

The study was conducted in South Africa, which is located on the Southern tip of the African continent and covers an area of 1 219 090 square kilometres (Stats SA, 1996). It has coastlines on both the Atlantic Ocean and the Indian Ocean. South Africa has 9 provinces, namely Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, North West and Western Cape. It is bordered by the following countries: Namibia, Botswana, Zimbabwe and Mozambique. South Africa is home to approximately 60.6 million people (Stats SA, 2022).



Figure 3.1: Map of South Africa

Source: Stats SA (2020)

3.3 Data collection

The study used publicly available secondary data, which was gathered mostly through internet searches and an examination of existing papers in South Africa and other countries. It was also collected on established international organisations' websites, reports and databases, such as the Trade Map, Department of Trade and Industry (DTI), National Agricultural Marketing Council (NAMC), Agricultural Research Council (ARC), Industrial Development Corporation (IDC) as well as from the internet and existing physical documents.

3.4 Analytical tools

3.4.1 Market Assessment

A market assessment is a useful tool which enables the assessment of supply and demand patterns (IDC, 2017). It is a quick picture of what goods and services are available, as well as an indication of how satisfied customers are with the items and services offered in a certain market. A market assessment also identifies goods that are in demand by consumers but that the existing supply does not meet (Forcier, 2013). It is important to do a market assessment before launching a good or service. A market assessment involves assessing the characteristics of the market, which are the market size, the locally traded volumes and values, import and export volumes and values of a commodity.

The cassava starch market in South Africa is dominated by imports and a insignificant number of exports. This makes imports and exports a frame of reference for understanding the nature of the cassava starch market. Therefore, a market assessment was performed for cassava, maize and potato starches in South Africa from 2010 to 2021, utilising import and export data from the trade map. This was done to evaluate the demand and supply dynamics of the three commodities and was illustrated through graphs.

3.4.2 Profitability Analysis

Profitability studies focused on budgetary analysis, which included gross margin and return on investment evaluations among farming firms from various value chains in various nations. The financial indicators refer to the farm enterprise's profitability, liquidity (short-term financial stability) and solvency (long-term financial stability). Profit is a major factor in all investments; thus, it is an indicator of whether participation will

be encouraged or discouraged. The sustainability of agricultural technologies depends on profitability (Piedra-Muñoz *et al.*, 2016).

Gross margin analysis is a simple model for calculating the financial returns of the manufacturing process for a year or a production season (Djokoto and Zigah, 2021). It is a post-implementation evaluation tool that aids in the identification of more profitable enterprises, the calculation of break-even price or yield and the construction of the enterprise's budgets (Stephenson, 2019). Gross margin is used across the agricultural value chain, including input supply, processing and marketing (Nuraeni, 2019).

Partial budgeting has been used to analyse profitability in previous studies and it measures the anticipated changes in the net benefits of an enterprise (Ngare, 2004). It solely takes into consideration changes in returns and expenses which result from changes in the way a technology or alternative is implemented. The unaffected income and expenses are ignored and not included when formulating a partial budget.

Literature shows that gross margin analysis is an effective tool used to compare the profitability of similar or different enterprises (Heard *et al.*, 2013). This is because it is not affected by the size or kind of enterprise, making it possible to compare the operations of different enterprises (Semerci *et al.*, 2014). Thus, this study used a gross margin analysis to compare and analyse the profitability of cassava and maize starch production. In order to assess and analyse the economics of producing cassava and maize starch, this study performed a gross margin analysis. An analysis of gross margins does not account for potential social and environmental effects that might result from the adoption of a new technology. In this instance, the social and environmental effects of the production of cassava and maize starch were not taken into account in the gross margin analysis. To account for the social benefits the study also used a cost-benefit analysis.

Economic studies have utilised gross margin analysis to determine the profitability of output. It is one of the simplest and earliest analytical techniques used in farm management (Choumbou *et al.*, 2015). A study by Bime *et al.* (2014) used a gross margin analysis to evaluate the profitability of rice in the Menchum River Valley of the North West Region of Cameroon. They determined a gross margin of R3 443.13/ha

(134484.9 fcfa/ha) and they concluded that rice production was profitable. Another study by Wango (2016), analysed the profitability of agro-ecological intensification techniques (AEI) in Yatta Sub-County, Kenya`Virginiiah. The findings of the gross margin analysis showed that farmers practicing the AEI technique increased their yield and attained higher profits than farmers without it (Wango, 2016).

The gross margin is calculated by subtracting variable expenses from enterprise outputs (Fani *et al.*, 2015). Fixed costs exist only in the short term since, in the long run, all costs become variable as situations may require changing all production elements. Variable costs, on the other hand, are the short-term expenses of resources that are used within a year (Olukos and Ogungbile, 1982). There is no requirement for a distribution of fixed expenses to the enterprise operations, which is a substantial advantage in the gross margin analysis. When the difficulties of distributing fixed expenses are examined, the benefits of gross margin analysis become clearer (Inan, 2008).

A study by Ramirez *et al.* (2008), which evaluated the engineering process and cost model for a conventional corn wet milling facility, found that fixed costs mainly come from facility and hardware costs. The variable costs consisted of raw materials (corn, sulphur and water), depreciation, facility-related costs, utilities (natural gas, steam and electricity) and operations labour (Ramirez *et al.*, 2008). An economic feasibility analysis of soybean oil production by hexane extraction study carried out by Cheng and Rosentrater (2017) found that the main sources of variable costs are material, labour, facility maintenance and utility expenditures. Material expenses included soybeans, hexane and water needed in extraction and degumming procedures. Electricity was the primary source of energy for facilities, with steam and natural gas serving as heat transfer agents. Agricultural machine operators, extraction workers and hazardous material employees account for most labour costs (Cheng and Rosentrater, 2017).

The study aimed to compare the costs incurred when producing cassava and maize starches with a focus on the starch extraction process. An analysis of the costs incurred in primary production was not carried out. However, a review of cassava and maize primary production was undertaken, focusing on the costs incurred by farmers in Nigeria and South Africa. The study relied mostly on studies from Nigeria as it is the

leading producer of cassava in the world. This would give a picture of what cassava production might look like in South Africa. However, it would not represent exactly what would happen, but what could be anticipated by potential cassava farmers in South Africa. The gross margin analysis for starch extraction was performed using the formula below.

According to Jatto (2012), mathematical notation for gross margin was presented as:

$$GM = TR - TVC$$

Where:

$$GM = \text{Gross Margin (R)}$$

$$TR = \text{Total Revenue (R)}$$

$$TVC = \text{Total Variable Costs (R)}$$

Cassava starch

$$GM_c = (\text{cassava starch} \times \text{price/ton}) - (\text{cassava} + \text{electricity} + \text{water} + \text{labour} + \text{insurance} + \text{depreciation})$$

Maize starch

$$GM_M = (\text{maize starch} \times \text{price/ton}) - (\text{Maize} + \text{Sulphur} + \text{water} + \text{natural gas} + \text{steam} + \text{electricity} + \text{labour} + \text{insurance})$$

3.4.3 Cost-benefit analysis

The cost-benefit analysis (CBA) methodology symbolises a framework of project benefits in which costs are identified, valued and compared to a variety of optimality criteria on an ex-ante basis (Anandajaysekeram *et al.*, 2004). It uses the economic shadow pricing method to focus on direct benefits and costs. Multiplier effects, secondary impacts and connections are all taken into consideration in the analysis. To evaluate the appropriate course of action, the cost-benefit technique takes into account quantifiable benefits and costs. It can be used to estimate the current and future effects of a planned technological introduction (Mudombi, 2010).

Cost-benefit analysis is a technique for evaluating projects and selecting the best choice. The evaluation and rankings are made based on anticipated economic costs and benefits. A project should be pursued if the lifetime benefits are anticipated to outweigh the costs (Gittinger, 1995). The art of the analysis process is in the quantification of these effects, as well as their adjustment for market failure, time, income distribution, incomplete information and potentially irreversible consequences (DEAT, 2004).

The CBA uses discounted measurements of project worth tools like the Net Present Value (NPV), Internal Rate of Returns (IRR) and Benefit Costs Ratio (BCR) when computing a monetary valuation. Net Present Value is the present net value of cash flows (Gittinger, 1995; Mudombi, 2010). This is done by calculating the present value with the expected results based on the specified discount rate. The formula used to compute NPV mathematically is as follows:

$$NPV = \sum_{t=0}^n \frac{B_t - C_t}{(1 + i)^t}$$

B_t and C_t are costs, t is the time period, n is the number of years and i is the interest (discount) rate. Benefits and expenses with no monetary worth are usually overlooked or approximated. The selection criteria for NPV when measuring project worth are as follows: if the NPV obtained is positive, it means that the project can be accepted, and if the NPV obtained is negative then the project should be rejected.

The IRR is sometimes known as the hurdle rate because it is usually the lowest acceptable rate of return. It is a useful tool to decision makers because it accounts for the time value of money and it includes all the cash flow related to a project. IRR discounts all the cashback in addition to giving zero NPV during the investment life of a project (Malek *et al.*, 2017). The formula used to compute it mathematically is as follows:

$$NPV = \sum_{t=0}^n \frac{C_t}{(1+IRR)^t}$$

The Benefit-Cost Ratio offers a way of ranking projects. The BCR is computed theoretically as the present value of the benefit stream divided by the present value of the cost stream and is mathematically presented as follows:

$$BCR = \frac{\sum_{t=1}^n \frac{B_t}{(1+i)^t}}{\sum_{t=1}^n \frac{C_t}{(1+i)^t}}$$

In BCR the ratio of discounted benefits to costs should be higher than one, the higher the ratio of benefits to costs, the better the project meaning the project will be economically more viable (Gittinger, 1995; Mudombi, 2010).

The study performed a cost-benefit analysis to evaluate whether cassava starch processing would be economically worthwhile. This was achieved through 2 performance indicators which are explained above. According to Konstantinov (2015), the lifespan of a manufacturing plant is between 10-15 years. Hence, the study used a 10-year discounted cash flow to run simulations of cassava starch production. The built-in @Risk discounted cash flow model with changing growth rates was used to simulate the cash flows on the created enterprise budgets. The simulation process involved choosing suitable discount and annual growth rates as well as a standard deviation. The average yield on bonds issued by the government employer is one of the best substitutes for the discount rate (Bui and Randazzo, 2015; Mdlulwa *et al.*, 2018). Given that the average South African Treasury bond yield for the years 1993 to 2018 was 10.76% (FRED, 2018), this study used a 10% discount rate for analysis. Agriculture-specific growth rates have been substituted with the GDP growth rate because they are not stable over time. The 3% annual growth rate was used since South Africa's GDP rate from 1993 to 2018 averaged 2.82% (Trading Economics, 2018). A market risk premium was utilised as a stand-in for standard deviation because there is a chance that processors will not produce the expected returns from the manufacturing of cassava starch due to various factors. A market risk premium is the additional amount that investors expect over the risk-free rate in exchange for taking on an average risk investment. Thus, a 6% standard deviation was chosen based on the market risk premium for South Africa in 2016 (Fernandez *et al.*, 2016).

Benefits are frequently harder to measure than costs. The majority of benefits are non-economic and an economic analysis seeks to translate these benefits into monetary terms. This may be problematic as it can bias the analysis. Cost-benefit analysis often

includes subjective assumptions regarding non-economic values. Therefore, this method contains a large margin for error because economists must often make assumptions regarding the financial value of the costs and benefits (DEAT, 2004). It can oversimplify the complex cause and effect linkages to a single number like the NPV or BCR. Ensuring that the sensitivity analysis performed captures the effects of variations in important variables such as discount rates can help mitigate this potential issue. Therefore, the study conducted a sensitivity analysis to evaluate the sensitivity of the Net Present Value to the investment cost, discount rate and annual growth rate. This was achieved through the Monte Carlo simulation approach which is a built-in sensitivity analysis function developed in @Risk software for Excel version 7.5 (Palisade Corporation, Newfield, NY, USA).

3.4.3.1 Scenario building

According to Ratcliffe (2000), scenarios are experiments in thinking about how an enterprise will function under a variety of future possibilities. Furthermore, scenarios are not predictions or forecasts, they are projections of a potential future. Hence, the study developed possible scenarios for cassava starch production in South Africa. These scenarios were guided by the starch that can be extracted from cassava tubers in the process of cassava starch production. Starch yield is the amount of starch that can be physically extracted from cassava roots (Hasmadi *et al.*, 2021).

According to Kayode *et al.* (2021), cassava starch extracted from different cultivars and locations varies in its properties. A study conducted by Hasmadi *et al.* (2021) found that cassava grown in Semporna had a high extraction yield compared to cassava starch grown in Tawau. Sampson *et al.* (2022) discovered that the Tanganyika, Mweulu and Banguerlu regions had a considerably higher cassava starch content of 62.7%, 63.6% and 63.6%, respectively. The high starch content is suitable for industrial applications (Sampson *et al.*, 2022).

The physiochemical properties of cassava cultivars are a determining factor of the root quality attributes, which are essential for processing and consumption. Since 1995, high starch content and high yield have emerged as the most important breeding goals due to the rapid growth of the cassava processing industry. Hence, cultivars like SC8002, SC 6 and SC 8013, which have starch levels of up to 35% and a high production of over 75 tons/ha, are readily accessible.

Different elements such as the technology used for starch extraction, the kind and growth of the cassava and the environment, have an impact on the quality and yield of cassava starches (Wang *et al.*, 2022). Hence, this study focused on evaluating how different cassava starch extracted yields affect the economic indicators of cassava starch production. Therefore, the 3 scenarios were based on different cassava starch extracted in the process of cassava starch production.

Scenario 1

The baseline scenario is a reference point for comparison or measurement. It offers a standard to evaluate the development, significance or effectiveness of a specific project, policy or intervention. The baseline scenario for South Africa's cassava starch production was developed based on the following:

Cassava raw material influences the starch yield that can be extracted from cassava. Henan Jinrui Food Engineering Co., Ltd (n.d.) found that Africa's cassava starch content is approximately 23%-25% and 4 tons of raw cassava can produce 1 ton of cassava starch. The study assumes South African processors will extract 1 ton of cassava starch from 4 tons of cassava. The processing technology and machinery utilised in the production of cassava starch also influences the starch yield that can be extracted from the raw cassava. The DTI has supported agro-processing industries through various incentive schemes such as the Agro-Processing Support Scheme (APSS), which aims to create and foster the use of modernised machinery and equipment and improve productivity (DTI, n.d.). Thus, the assumption is that South Africa will utilise improved processing technology in the extraction of cassava starch. The operation of the technology also influences the extractable cassava starch yield. The skills that the operators have become an important factor, because if they are not well skilled, they will not produce cassava starch efficiently. Hence, the study assumes that the processors in South Africa will be able to carry out the production process efficiently. This is because South Africa has 21 Sector Education and Training Authorities (SETAs) which are responsible for skills development. SETAs such as merSETA, which encompasses Manufacturing, Engineering and Related Services and AgriSETA covers the agricultural sector and will contribute to the development of cassava starch production skills needed by the processors (South African government, n.d.). Therefore, in this scenario, the assumption is that South Africa will produce 1 ton

of cassava starch from 4 tons of raw cassava. Furthermore, there will not be production losses associated with technical know-how and poor machinery.

Scenario 2

Considering that cassava is not a popular crop in South Africa and limited research has been done on the crop, the possibility of using inferior cultivar arises. Additionally, cassava starch production will be new in the country, therefore there is potential for error in the extraction process. Regarding the limited knowledge of cassava starch processing, a scenario in which cassava starch extraction yield was deflated by 20% from the baseline was create. The assumption in this scenario which is regarded as the worst case scenario is that the processors will be able to extract 0.8 tons of cassava starch from 4 tons of cassava tubers.

Scenario 3

The ARC collaborated with stakeholders to design a cassava R&D plan. The focus areas included germplasm acquisition, evaluation, conservation and breeding, agronomy, crop protection, socioeconomics, food science, postharvest and storage, mechanisation and agro-processing (Amelework *et al.*,2021). Therefore, the possibility of mastering cassava starch production in South Africa exists because of the research that focuses on the advancement of the cassava value chain. The best case scenario occurs when the conversion rate is assumed to be 20% more than the baseline scenario, which implies that the processor will achieve 1.2 tons of cassava starch from 4 tons of raw cassava. The assumption is that processors will utilise improved cultivars and improved machinery and the skills will have been successfully transferred.

3.5 Limitations of the study

Cassava starch production is limited in South Africa, which means that production data is not easily accessible. However, the holistic objective of the study was to conduct an economic analysis of cassava, maize and potato starch production in South Africa. To achieve these objectives, assumptions and adjustments were made. The supply and demand dynamics of cassava and maize starches were evaluated using import and export data only. This is because that is the only recorded data on cassava starch and for the sake of uniformity, this type of data was also used for maize and potato starches.

Literature shows that potato production in South Africa is limited as one potato starch production company was identified by IDC, (2017) in Mpumalanga. This made finding data and literature on potato starch to be challenging. However, potato starch could not be entirely left out of study because the study was initially interested in Cassava, maize and potato starch production. Cassava was the main crop of interest; maize was a crop of interest because maize starch production is popular in South Africa. Potato starch was a crop of interest because the starch production process of cassava and potatoes are similar since they are both tubers (IDC, 2017). Additionally, in South Africa potatoes are regarded as largest vegetable produce as well as an important crop (NAMC, 2017). However, due to data limitations and time constraints the study only performed to a graphical analysis of potato starch imports and exports.

A research method that involves assessing data and information provided in written documents and existing literature is known as content analysis, often known as desk research (Pershing, 2007). This is a desktop study, so it relied mostly on other published studies as cassava is not a popular crop in South Africa. The data used to analyse profitability was sourced from various studies and adjusted to the value of the South African Rand in 2021. The operational cost for maize starch production were sourced from a study conducted in USA. This is because data on operational cost for maize starch production was not accessible. The study also used data from cassava starch machine capacity to determine the costs of the inputs required to process cassava starch.

3.6 Summary of methodology

This study was conducted in South Africa utilising secondary data that was sourced from established international organisations' websites, reports and databases. The execution of the study encountered data constraints and limitations. However, the study managed to assess the market for cassava, maize and potato starches through a graphical analysis of imports and exports. The study also examined the profitability of cassava and maize starches through a gross margin analysis. A cost-benefit analysis was also carried out, which included determining the NPV and BCR of cassava starch production. Additionally, a sensitivity analysis was executed as part of the CBA using Palisade @Risk software.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

The study aimed to carry out an economic analysis of starch production from cassava, vis-à-vis starch production from maize and potatoes in South Africa. This chapter presents and discusses the empirical results found when data sourced was analysed to achieve the objectives of the study. It also outlines the demand and supply dynamics of cassava, maize and potato starch using import and export data, which is illustrated through visual aids. This chapter further summarises the revenues and operating costs of cassava and maize starch production, enabling a comparative analysis of the two as sources of starch. It also discusses the cost-benefit analysis with the calculated NPV, IRR and BCR which were further simulated using palisade @Risk.

4.2 Market assessment of cassava and maize starches in South Africa

4.2.1 Countries supplying South Africa with cassava starch

Figure 4.1 depicts South Africa's primary source of cassava starch as Brazil. It supplies cassava starch to a value which is above R23 498 000. The reason for Brazil being one of the leading suppliers of cassava is that cassava is indigenous to South America. Additionally, the Brazilian Agricultural Research Corporation (Embrapa) and partners have been developing new methods for using and processing cassava after harvest for the past 20 years (Thiele *et al.*, 2022). This gives Brazil an added advantage in terms of production and supply of cassava. India also supplies South Africa with cassava starch to a value which is between R4 699 000 and R9 398 000. India is able to export cassava starch to South Africa because over 60% of the cassava produced in India is used as a raw material for industry, making it a predominantly industrial crop (Prakash *et al.*, 2022). Brazil and India are the leading sources of starch for South Africa, and this could also be influenced by the Brazil, Russia, India and China (BRICS) trade union.

Figure 4.1 also shows that South Africa imports the least cassava starch from China and Nigeria. Cassava is becoming increasingly important as an industrial raw material in China. However, the growth of the cassava sector in China is constrained by a lack of cassava raw materials and the rising demand for cassava in downstream processing industries (Fu *et al.*, 2018). This causes China to supply the least cassava starch to South Africa. Nigeria has not reached its cassava starch-producing capacity, which also leaves little room for it to export. These findings indicate that South Africa's

main source of cassava starch is the foreign market, which consists of 5 countries. There is a high demand for cassava starch in South Africa, which necessitates that the country finds other means to sustain this demand. The high demand also means that domestic production of cassava starch can be successful if proper measures are put in place. The existing demand will, therefore, be a driver for the success of cassava starch production.

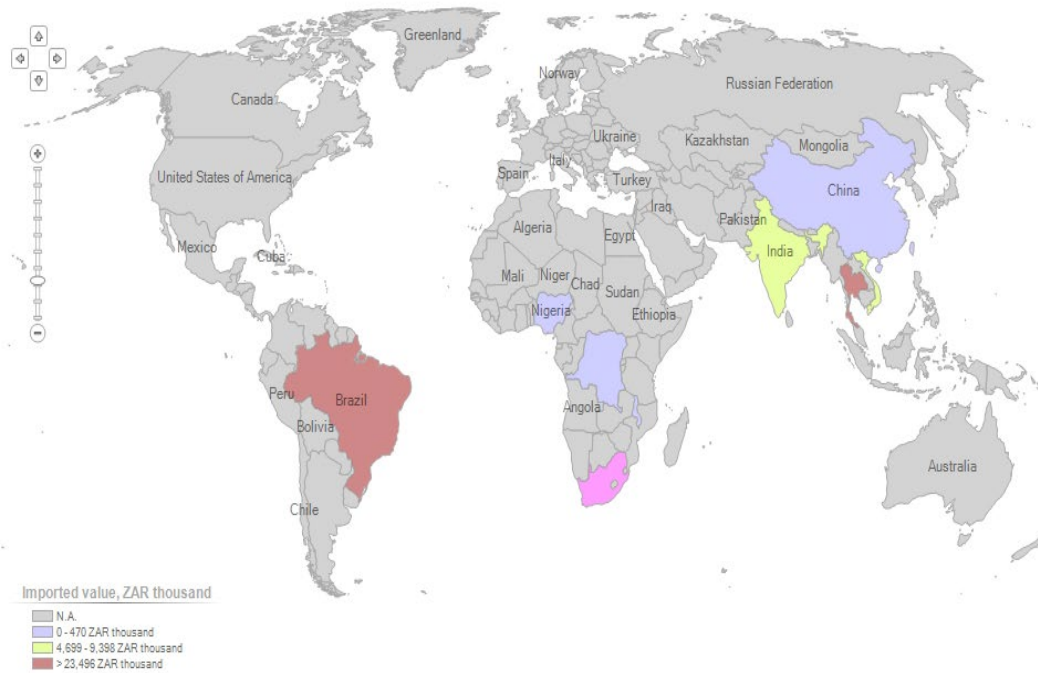


Figure 4.1: Map of countries supplying South Africa with cassava starch

Sources: ITC calculations based on [South African revenue services \(SARS\)](#) statistics 2021

4.2.2 Cassava, Maize and Potatoes starch import and export graphical analysis

A graphical analysis of the primary production of cassava, maize and potatoes was performed, which is presented in Figure 4.2, together with an analysis of the cassava, maize and potato starches imports and exports, which are presented in Figures 4.3 and 4.4. This was done to understand the state of cassava, maize and potato demand and supply dynamics in South Africa. The study found that South Africa does not produce a significant quantity of cassava tubers as a source of starch, but it produces a significant quantity of maize as a source of starch. This is depicted in Figure 4.2 and it is consistent with the available literature on maize production. According to the AFMA (n.d.), approximately 10 to 12 million tons of maize is cultivated annually in

South Africa. Furthermore, averaged over 10 years, maize for human consumption was approximately 4.1 million tons, animal feed about 3.9 million tons, while starch- and glucose-manufacturing industries accounted for 650 000 tons of maize consumed annually.

In South Africa, potatoes are grown in 16 different regions with a variety of soil types and weather conditions. In 2018, the potato industry produced 9.7% of horticultural products and 2.6% of all agricultural products, or around 50% of the total gross value of vegetables produced. Hence, Figure 4.2 below depicts that the production of potatoes from 2010 to 2021 has been steady with minor fluctuations.

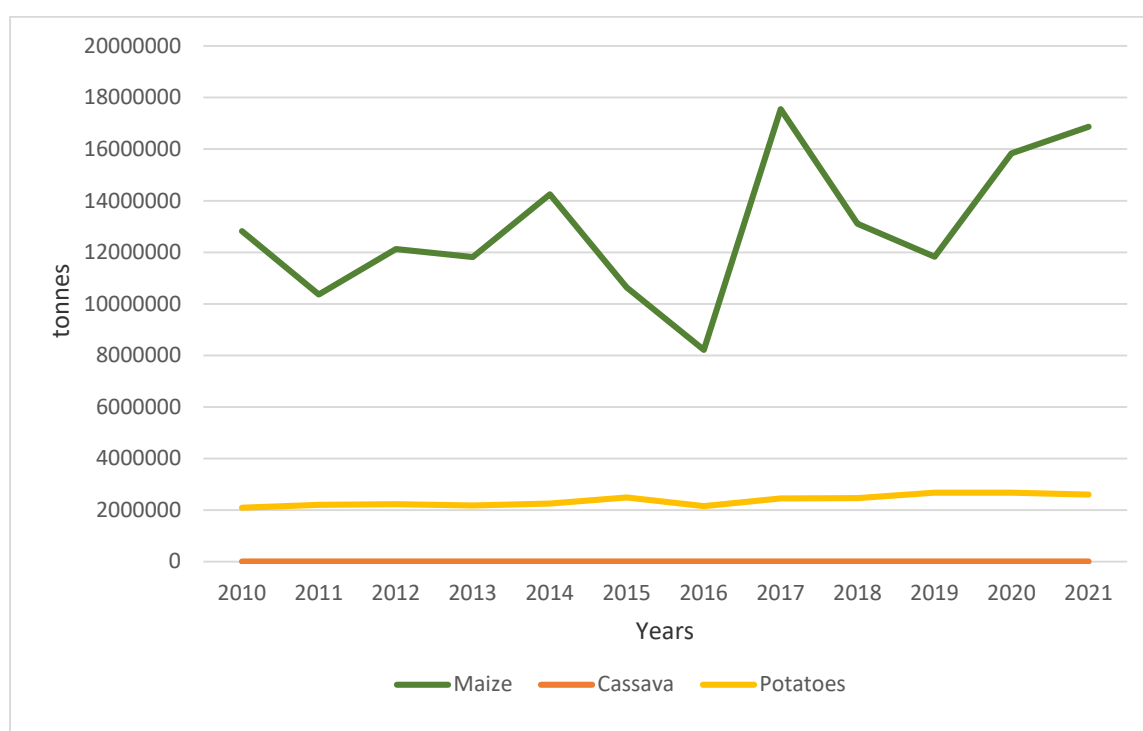


Figure 4.2: Cassava, Maize and Potato Production

Source: ITC, 2022

Cassava starch imports fluctuated from 2010 to 2021 but cassava starch imports were consistently higher than maize and potato starch imports, as depicted in Figure 4.4. However, in 2021 potato starch imports were higher than cassava and maize starch imports. The price of cassava starch increased from 0.43 USD/kg (R6/kg) between 2019 and 2020. It increased to 0.45USD/kg (R6.65/kg) in 2021. Hence, we see a decrease in the cassava starch demand and an increase in potato starch. This is because when prices are high the quantity demanded decreases. The findings of this

study illustrate that the demand for cassava starch in South Africa is higher than maize starch demand. A contributing factor to the significantly high cassava starch import is that there is no local producer or supplier of cassava starch in South Africa.

The study found maize starch exports to be higher than those of cassava starch as portrayed in Figure 4.3. South Africa is self-sufficient in maize starch production as it can supply the local demand and the foreign market. South Africa has a slightly visible footprint of cassava starch export, which is a result of re-exporting. This implies that from the significantly high amount of cassava starch imported, part of it is re-exported. Figures 4.1, 4.3, and 4.4 show that there is a market for cassava starch in South Africa and it further shows that maize starch production in South Africa is doing well.



Figure 4.3: Value of South Africa's starch imports

Source: ITC, 2022

In 2016, Figure 4.3 shows that cassava starch imports amounted to R116 878 000, which was the highest amount of imported cassava starch from 2010-2021.

This also explains why cassava starch exports increased in 2016, which amounted to R2 872 000 as depicted in Figure 4.4. Maize starch exports constantly increased from 2013 to 2016. Maize starch exports were at their highest in 2020 followed by 2016, whereas maize starch imports decreased in 2016. Potato starch imports were at their lowest in 2010 with an amount of R2 380 000 and were at their highest in 2021. Potato starch imports increased from 2010 to 2021 with minimum fluctuations.

The production of maize showed a sharp decrease in 2016 and this was because of the drought that occurred during that production season. A relationship exists between the production of maize and maize starch exported. Figures 4.2 and 4.4 show that after the drought the tons of maize produced decreased, which resulted in an inadequate surplus available for further processing into starch and subsequent export. Thus, we see a decrease in exported maize starch from 2016 in Figure 4.4.

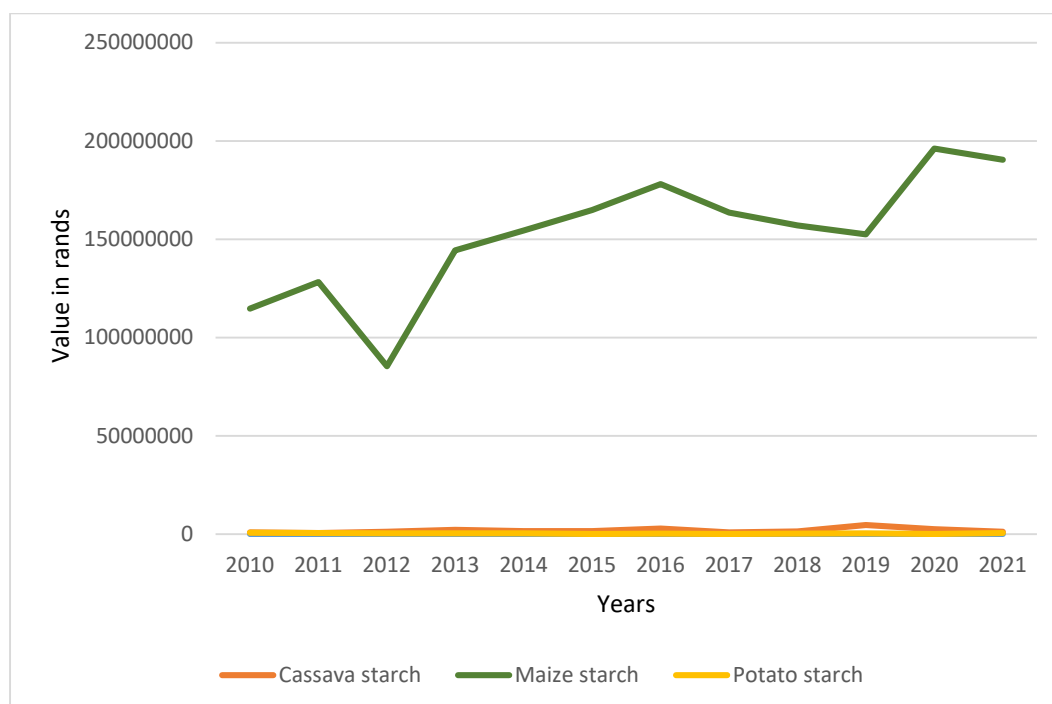


Figure 4.4: Value of South Africa's starch exports

Source: ITC, 2022

The 3 figures (4.2, 4.3, and 4.4) depict 2017 as a challenging year because in 2017 cassava and maize starch imports and exports showed a sharp decrease. Maize and cassava starch exports also decreased in the same year. However, potato starch imports increased in the same year. Following a reported loss of 0.3% in the fourth quarter of 2016, the South African economy entered a recession with a reported

decline of 0.7% in GDP during the first quarter of 2017 (Stats SA, 2022). The recession could be a contributing factor to the decrease in exports and imports.

4.3 Profitability analysis

The profitability of any agricultural crop is heavily influenced by market demand. Both cassava and maize are widely consumed globally and have diverse applications. Maize is a staple food in South Africa and it is also used extensively in animal feed and industrial processes. Cassava, on the other hand, is a versatile crop used for food, animal feed, starch production and biofuel. Understanding the local and global demand for each crop in a specific area is crucial for profitability. Yield potential plays a significant role in determining profitability. In general, maize has a higher potential yield per unit area compared to cassava. Maize is known for its high productivity and faster growth rate, allowing for multiple harvests in a year in some regions (Erenstein *et al.*, 2022). Cassava, on the other hand, has a longer growth cycle and usually provides a single harvest per year (Sanusi *et al.*, 2022). Higher yields generally translate into higher profits. However, it is important to consider the specific conditions of the farming operation.

The profitability of any crop is influenced by input costs, including land, labour, seed, fertilizers, pesticides and machinery. The input costs for both cassava and maize can vary depending on the region and farming practices. The cost of land preparation for cassava cultivation can include clearing, ploughing, harrowing and ridging. The estimated cost for land preparation per hectare can range from ~~₺~~20 000 to ~~₺~~40 000 (R500 – R1000). The cost of cassava stems or cuttings for planting depends on the variety and quality. On average, the cost of planting material per hectare can range from ~~₺~~10 000 to ~~₺~~ 20 000 (R250 to R5000) (Ogunyinka and Oguntuase, 2020; James *et al.*, 2011; Oduntan *et al.*, 2012; Zaknayiba *et al.*, 2014; Kosemani, and Bamgboye, 2018). The cost of maize seed is also influenced by the variety and quality. BFAP *et al.* (2022) found that farmers in KZN spend R3 031 per hectare for seed, which is higher than the costs of cassava cuttings. Maize cultivation typically requires higher inputs, such as fertilizers and pesticides, due to its nutrient demands and susceptibility to pests and diseases. The cost of pest and disease management depends on the prevalence and severity of pests and diseases in the region. Expenses may include the purchase of pesticides and fungicides and hiring labour for spraying activities. According to a report compiled by BFAP *et al.* (2022), maize farmers in KZN incur

R1376 for herbicides, R873 for insecticides, R576 for lime and R4 409 for fertiliser per hectare. According to reports on cassava production in Nigeria, the cost of pest and disease management per hectare can range from ₦10,000 to ₦30,000 N (R250 – R750) (Ogunyinka and Oguntuase 2020; James *et al.*, 2011; Oduntan *et al.* 2012 Zaknayiba *et al.*, 2014; Kosemani and Bamgboye, 2018).

The cost of fertilisers varies based on soil test results and nutrient requirements. However, this can range between ₦30 000 to ₦ 60 000 NGN (R750 -1500). The scale of production and availability of infrastructure influence the cost of harvesting, transportation and post-harvesting activities. The estimated cost for harvesting and post-harvest operations per hectare can range from ₦10 000 to ₦30 000 NGN 250 - 750 (Ogunyinka and Oguntuase 2020; James *et al.*, 2011; Oduntan *et al.*,2012 Zaknayiba *et al.*, 2014; Kosemani and Bamgboye, 2018).

Cassava is generally considered a low-input crop, requiring fewer chemical inputs. However, land preparation for cassava can be labour-intensive due to the need for deep tillage and weed control. Labour costs for various activities such as land preparation, planting, weeding and harvesting contribute significantly to the total cost of cassava production. Labour costs can vary depending on local wage rates and mechanization levels. In Nigeria, the labour costs were approximated to range from ₦40 000 to ₦80 000 NGN per hectare (R1 000 - R2 000).

The report compiled by BFAP *et al.*, (2022) further showed that the farmer's variable costs consisted of crop insurance, fuel and repairs and maintenance costs. These costs were valued at R709, R1 033 and R670 per hectare, respectively. The total variable costs for maize production amounted to R12 922 per hectare, whereas the total variable costs for cassava production on average was R5 500 per hectare (Ogunyinka and Oguntuase 2020; James *et al.*, 2011; Oduntan *et al.*,2012; Zaknayiba *et al.*, 2014; Kosemani, and Bamgboye, 2018).

Cassava is more drought-tolerant, making it suitable for regions with low rainfall or irregular water supply. Maize, on the other hand, requires well-distributed rainfall throughout its growing season. Considering the climate suitability and environmental conditions of the region is important to maximize profitability. The profitability of cassava and maize primary production depends on various factors such as market demand, yield potential, input costs, value-added products and local conditions.

4.3.1 Cassava and maize production process

Figure 4.5 depicts the standard production steps for cassava and maize in a dryland. Cassava and maize have similar steps of production but different processes of production. Cassava production is labour-intensive as compared to maize production due to the nature of the crops. An example would be the harvesting process as cassava has to be dug out underground and maize is removed from the maize stalk.

Post-harvest physiological degradation (PPD) has emerged as one of the main obstacles to the production and usage of commercial cassava; it is caused by the unavoidable physical damage to the roots during harvest (Zainuddin *et al.*, 2018). Consequently, cassava roots need to be processed to reduce these losses (Abong *et al.*, 2016). In producing cassava, a farmer could be at a disadvantage if he does not have access to processing facilities. This indicates that assessing and analysing the processing segment of the cassava value chain is important.

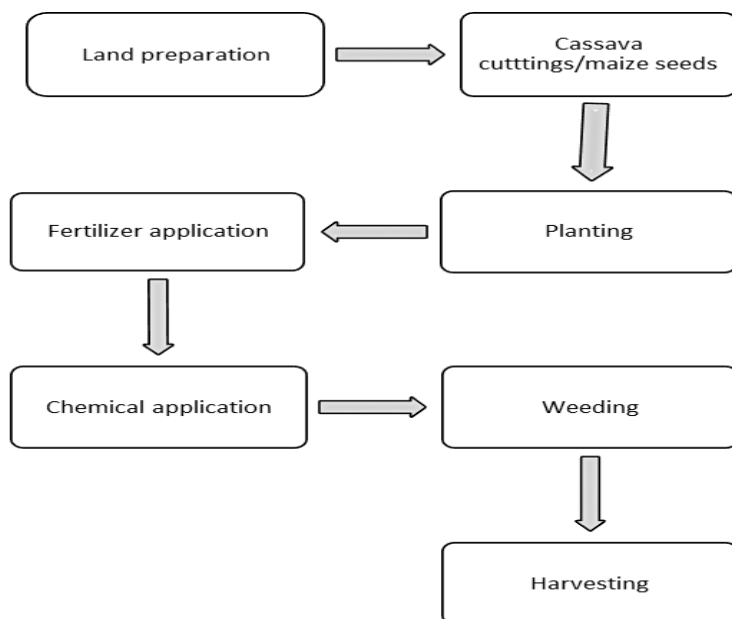


Figure 4.5: Cassava and Maize production process

Source: Author's compilation

Cassava and maize starch extraction

The cassava and maize starch extraction process flow is represented by Figures 4.6 and 4.7, respectively. The cassava starch extraction process steps are shorter than the steps for the maize starch extraction process. This could suggest that the cassava starch extraction process is cheaper than the maize starch extraction process. Traditionally, the grain is chemically pre-treated in a sulphuric acid solution (SO₂ in

water) before wet milling occurs. Steeping corn kernels typically lasts between 24 and 48 hours for maximum starch recovery, consuming approximately 21% of the plant's overall energy and capital expenditures (Yu and Moon, 2021).

This procedure requires a lot of time and energy, suggesting that it is capital-intensive. Additionally, because steeping requires such high levels of sulphur dioxide, it has a severe impact on the environment. This is because sulphur dioxide is listed as a prevalent air pollutant by the Environmental Protection Agency (Ramírez, 2009). Steeping is followed by physical separation of the co-products so that the starch can be isolated. This also contributes to the factors affecting the capital intensiveness of maize starch extraction. According to Zhang *et al.* (2021) and Somavat *et al.* (2021), the traditional wet-milling technique is capital-, time- and energy-intensive. Moreover, it is a water-intensive method because it requires 1.5 m³ of fresh water for every ton of maize (Yu and Moon, 2021).

The cassava starch extraction process is similar to, but different from, the maize starch extraction process. The cassava roots are prepared by being cleaned, peeled and crushed into a pulpy slurry. At room temperature, starch is then separated. Only 1% of the roots' protein and contaminants are present. The slurry is run through extractors equipped with coarse and fine screens to get rid of both big and tiny molecules in order to eliminate non-starch polysaccharides (Torres-Lozada *et al.*, 2014). The slurry is then centrifuged dry and flash dried. To prevent bacterial development and speed up the process, sulphur dioxide can be introduced in trace amounts to the process (Breuninger *et al.*, 2009). Cassava starch extraction is not as time consuming as maize starch extraction. This gives cassava starch an advantage over maize starch production.

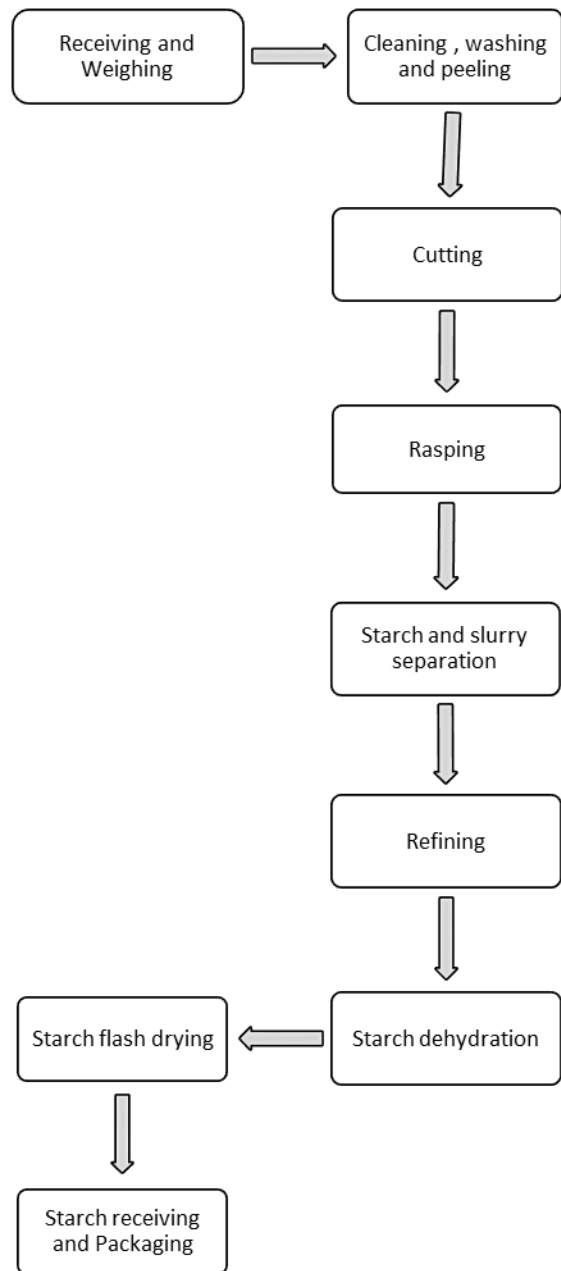


Figure 4.6: Cassava starch extraction process

Source: Wang *et al.*, 2022

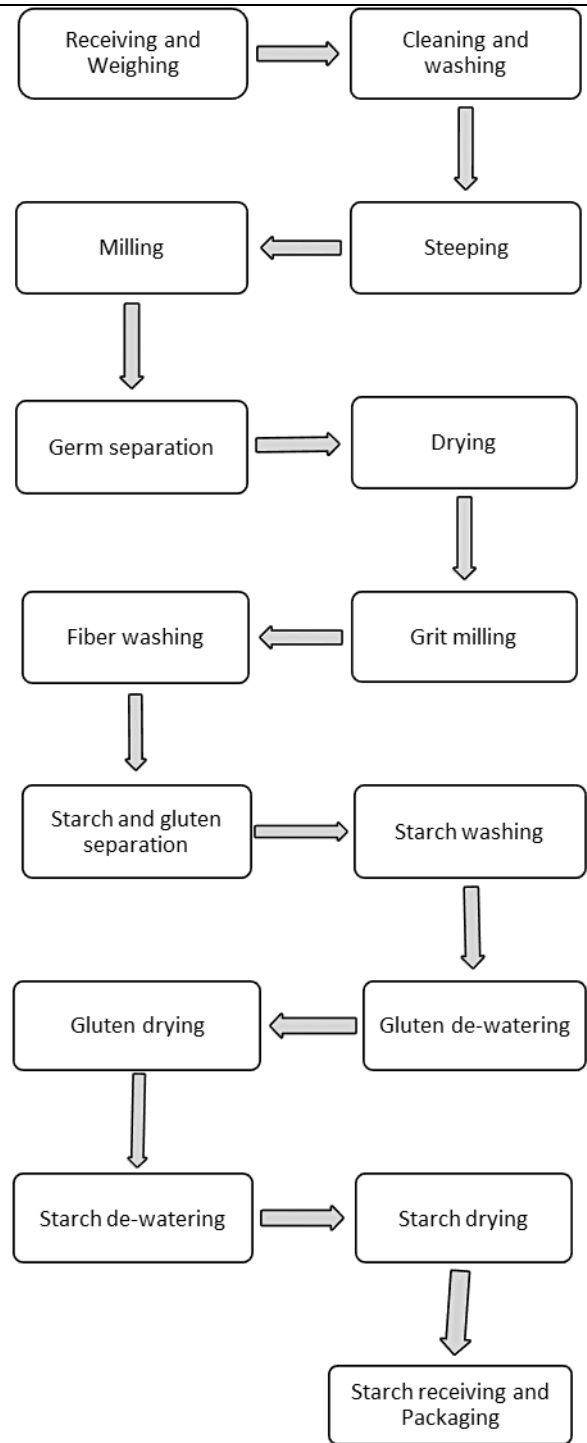


Figure 4.7: Maize starch extraction process

Source: IDC, 2017

4.3.2 Cassava and Maize starch gross margin analysis

The cost estimates in Table 4.1 are based on a 2007 cost model for a traditional maize milling facility in the United States with a daily capacity of 2,540 tons of maize. A study of the market potential for starch production in South Africa utilised the cost estimates in Table 4.1. The variable cost of producing maize starch amounted to R1 274 491 238.4 annually. The annual operating costs to manufacture the starch slurry and its co-products are added together and the annual production costs for producing starch slurry are computed by subtracting this amount from the income from the value of the co-products of the starch production.

The production of maize starch is heavily influenced by the cost of raw materials. The two main raw ingredients, maize and enzymes, account for more than 70% of the total cost of producing corn starch. Other significant cost factors include handling and storing maize, steeping, germ removal, fibre separation, gluten removal and starch washing. The unit cost for producing 1kg of maize starch was approximately 0.193 USD which was equivalent to R3.50 in 2007. However, when the inflation rate is accounted for, the cost of producing 1kg of maize starch in 2021 amounts to R8.26. On average, the cost of 1 ton of maize starch is R5500 - R6500. This makes the costs of maize starch approximately R6.00. This means that the gross margin per unit is - R2.26 per 1kg of maize starch.

Table 4.1: Maize starch Operating costs

| | US Dollar Value in 2007 | Rand in 2021: Exchange Rate R14.2344 |
|----------------------------|--------------------------------|---|
| Operating costs | | |
| <i>Raw materials</i> | | |
| Maize | 111 018 000 | 1 580 274 619.2 |
| Sulphur | 19 000 | 270 453.6 |
| Water | 377 000 | 5 366 368.8 |
| Total raw materials | 111 414 000 | 1 585 911 441.6 |

| | | |
|------------------------|-------------|-----------------|
| Depreciation | 7 933 000 | 112 921 495.2 |
| Facility related costs | 3 467 000 | 49 350 664.8 |
| <i>Utilities</i> | | |
| Natural gas | 6 840 000 | 97 363 296 |
| Steam | 1 695 000 | 24 127 308 |
| Electricity | 4 015 000 | 57 133 450 |
| Total utilities | 12 550 000 | 178 641 720 |
| Operations labour | 1 980 000 | 28 184 112 |
| Total operating costs | 137 344 000 | 1 912 306 233.6 |
| <i>Co-products</i> | | |
| Corn gluten meal | 19,255,000 | 274 083 372 |
| Corn gluten feed | 12,071,000 | 171 823 442.4 |
| Corn germ | 16,482,000 | 234 611 380.8 |
| Total co-products | 47,808,000 | 680 518 195.2 |
| Starch | 89 536 000 | 1 274 491 238.4 |

Source: IDC, 2017¹

Table 4.2 represents the enterprise budget for cassava starch extraction. This processing facility can process 4 tons of cassava tubers per hour. Furthermore, from the 4 tons of raw cassava processed, the output is 1 ton of cassava starch per hour. That has a value of R8 300 which means that the total revenue was R8 300 per ton. The cassava tubers accounted for 65% of the total variable costs. This was followed by electricity, which accounted for 16% of the variable costs, whilst water accounted for 6%. The cassava starch enterprise shows that cassava starch production is profitable as the gross margin per ton was R1 919.80. The cost of producing 1kg of cassava starch is R6.36 and the selling price is R8.30. This means that the gross

¹ Due to data constraints in SA the study used data from USA

margin would be R1.94/1kg of cassava starch. This implies that cassava starch production is more profitable than maize starch production.

Table 4.2 Cassava starch enterprise budget

| | Value/cycle |
|-----------------------------|--------------------|
| Cassava starch | R 8300 |
| Total revenue | R 8300 |
| Variable costs | |
| Cassava tubers | R4713.08 |
| Water | R 413.60 |
| Direct labour | R 185.52 |
| Electricity | R 1060.15 |
| Insurance | R 4.17 |
| Depreciation | R 3.68 |
| Total variable costs | R 6380.20 |
| GM=TR-TVC | R 1919.80 |

Source: Author's compilation

4.4 Cost Benefit Analysis

The study modelled and evaluated the cost and benefits of three cassava starch production scenarios. The cost-benefit analysis technique was applied to select the best investment opportunity from the three scenarios. The results are presented in Table 4.3 and Figures 4.8 to 4.14 below. The study found that raw materials made up 65% of the total variable cost. This suggests that cassava tubers are significant in the production of cassava starch. Evaluating how different cassava cultivars with different starch extractable yields influence cassava starch production is therefore essential. This is because different cultivars have different properties which could affect the amount of starch which can be extracted from the tubers. Hence, the study evaluated

the costs and benefits of cassava starch production under three starch extracted yields.

The baseline scenario is a scenario in which South Africa's processors can extract 1 ton of cassava starch from 4 tons of cassava tubers per hour. The baseline scenario resulted in an NPV of R8 492 770, an IRR of 27% and a BCR of 2.93. This suggests that cassava starch production is a profitable and worthwhile venture, as the 3 economic indicators are positive and above 1. According to (Shou, 2022), investments with a positive NPV are profitable and hence acceptable for consideration, while those with a negative NPV will incur losses and may not be executed.

The second scenario accounted for cassava cultivars with poor starch content. The assumption was that 20% less starch could be extracted from this cultivar than the starch extracted in the baseline scenario. This means that the processors in scenario 2 can extract 0.8 tons of cassava starch from 4 tons of cassava tubers per hour. The study found that when the extracted cassava starch yield is deflated by 20% from the baseline, it results in the project not being profitable. The NPV was –R 13 298 988.37, IRR was -20% and the BCR was -0.04. All the economic indicators strongly suggest that the project should be rejected. The results in scenario 2 show that cultivars with a lower starch content are not desirable for cassava starch production.

The assumption that guided the third scenario was that the cassava cultivars used were superior. They have a high starch content, which is the most favourable condition for cassava starch production. The processors in this scenario are able to extract 20% more starch than the starch from the baseline scenario. This means that they can extract 1.2 tons of cassava starch from 4 tons of cassava tubers per hour. When cassava starch was inflated by 20% the project became profitable. The NPV was R30 763 553, IRR 64% and the BCR was 6.3; this implies that the quality of cassava tuber is important. This is because more revenue is generated when cassava tubers with a higher starch content are utilised.

The scenarios illustrate the importance of a high extractable starch yield suggesting the importance of cassava tubers with a high starch content. This is because in a scenario where the extracted cassava starch yield was inflated, the economic indicators were the highest, as compared to all the evaluated scenarios. The rate at which the investment will yield returns was 64% which is above average. This is a

desirable rate of return on any investment. Since a high extracted starch yield is significant, it is of paramount importance to invest in high starch-yielding cassava cultivars. This will eventually serve as a risk management strategy for the investor. This is because initially investing in tubers that have a higher starch content mitigates the risk of having a possible negative NPV.

Piyachomkwan and Tanticharoen (2011) found that cassava cultivars with a high starch content and improved root quality have contributed to the success of the cassava starch industry in Thailand. Ogunyinka and Oguntuase (2020) found that by cultivating enhanced varieties that yield more and are disease tolerant, farmers can benefit from higher revenues from the sale of fresh cassava roots. This is because cassava tubers with a high starch content achieve higher premium prices from processors. Additionally, processors also benefit from these varieties because they are able to extract a higher starch yield which contributes to profit maximisation (Kim *et al.*, 2008). The literature demonstrates that the economic viability of cassava farming has grown as a result of new, high-yielding cassava varieties and more environmentally friendly production techniques. These findings cement the importance of investing in cultivars with a good starch conversion rate.

Table 4.3 Cassava starch production economic indicators for modelled scenarios

| Economic indicator | Scenario 1 | Scenario 2 | Scenario 3 |
|---------------------------|-------------------|-------------------|-------------------|
| NPV | R8492770 | R-13298988.37 | R30763553.84 |
| IRR | 27% | -20% | 64% |
| BCR | 2.93 | -0.04 | 6.3 |

The simulation results from the baseline scenario are illustrated in Figures 4.8 and 4.9. In Figure 4.8, the NPV ranges between -5.23 and 44.37 million. Additionally, the IRR ranges between -1.1% and 97.1%, which is illustrated in Figure 4.9. The NPV and IRR are positively skewed, which suggests that cassava starch production can be profitable. Furthermore, the probability of acquiring a positive NPV and IRR is higher than the probability of a negative NPV and IRR. This suggests that the probability of accepting cassava starch production in this scenario is higher.

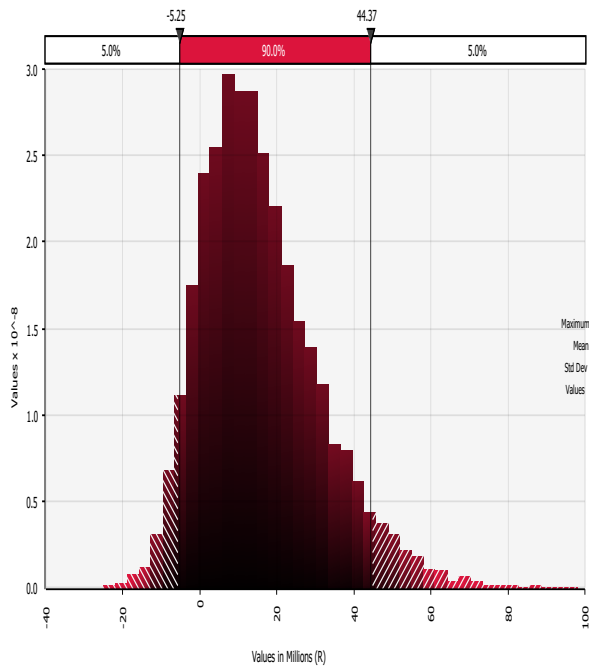


Figure 4.8: Scenario 1 Simulations of NPV
Source: Author's compilation

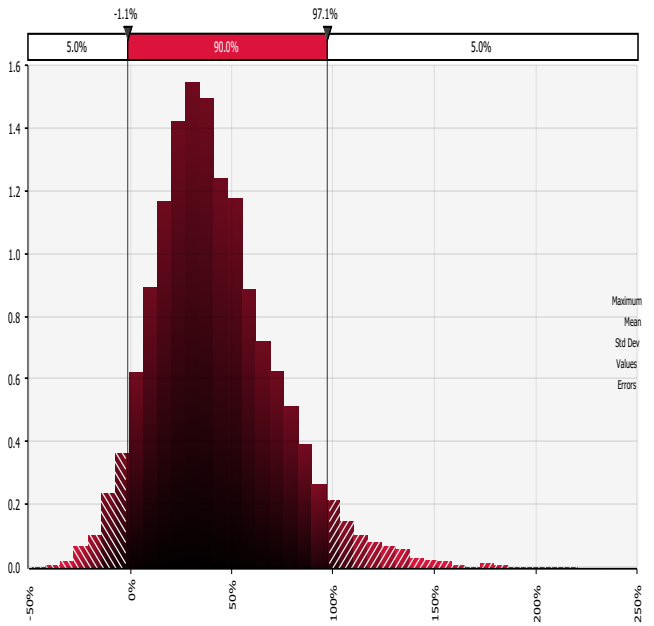


Figure 4.9: Scenario 1 Simulations for IRR
Source: Author's compilation

The simulated results of the economic indicators revealed that in a scenario where cassava tubers have a low starch conversion rate, the NPV ranges between -28.52 million and 5.79 million. Figure 4.10 shows that the possible NPV values are mostly negative. This means that the probability of acquiring a negative NPV is higher than the probability of a positive NPV. The simulations revealed that cassava starch production with a conversion rate of 0.8 should be rejected. This is because the probability of the project being worthwhile is low in scenario 2. The costs of running the projects exceed the benefits of the project. Figure 4.12 illustrates that the IRR ranges between -29.8% and 38.1%.

Contrary to scenario 2, the economic indicators were positive as they revealed that cassava starch production would be a worthwhile project. The simulations from Figure 4.11 illustrate that the NPV would be between 15.67 and 46.77 million. The results suggest that when the conversion rate of cassava starch production is 1.2, the probability of the project failing is non-existent. Figure 4.13 depicts that the IRR will range between 40.3% and 86.9%. This is 30%+ the current returns available from investing in a bank. The highest rate available for an investment is 10.5%, which is offered by an African bank.

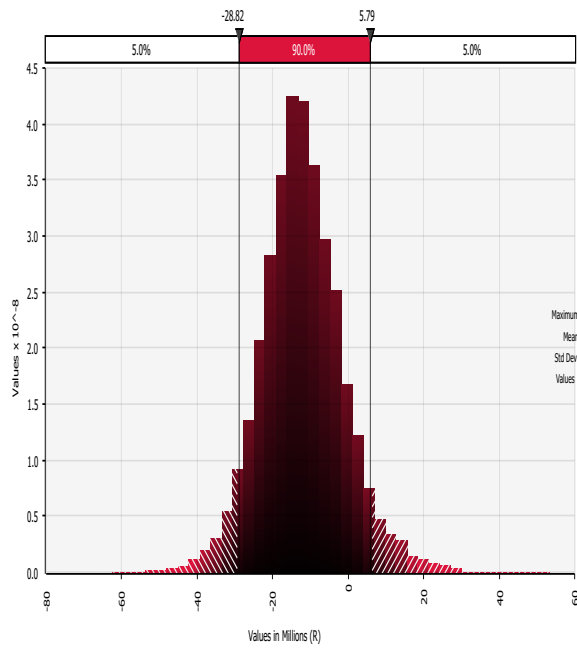


Figure 4.10: Scenario 2 Simulations of NPV
Source: Author's compilation

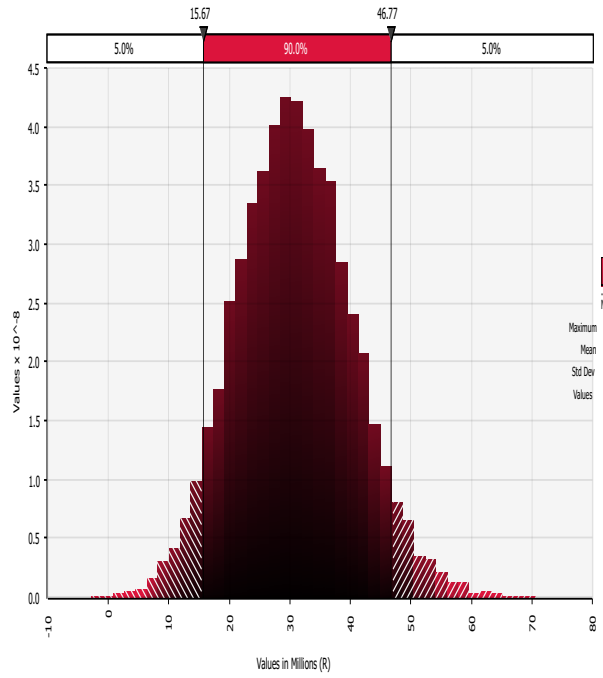


Figure 4.11: Scenario 3 Simulations of NPV
Source: Author's compilation

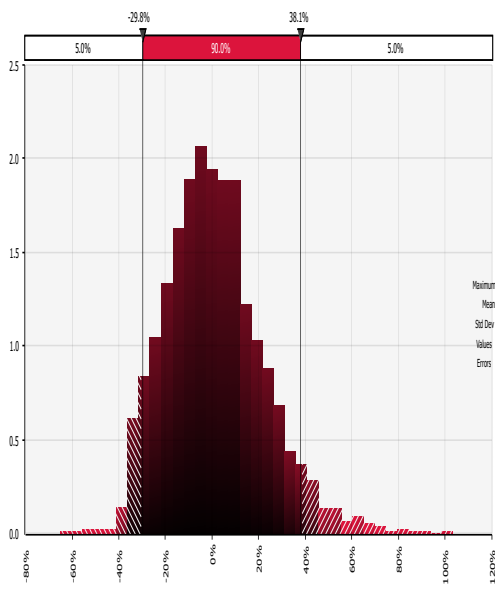


Figure 4.12: Scenario 2 Simulations of IRR
Source: Author's compilation

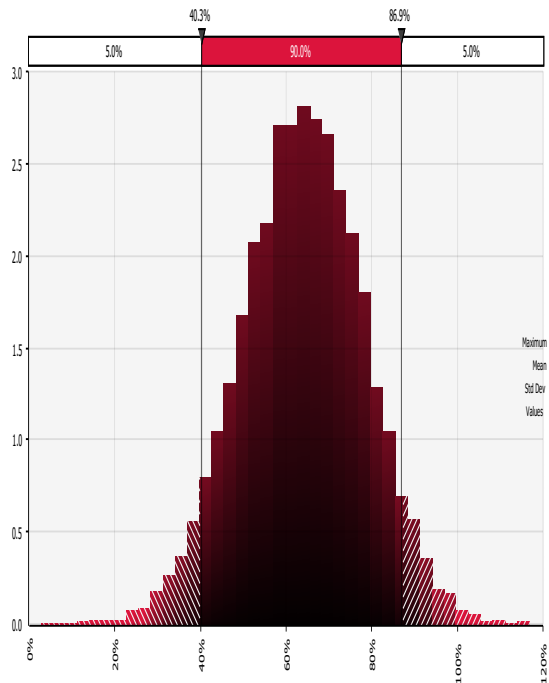


Figure 4.13: Scenario 3 Simulations of IRR
Source: Author's compilation

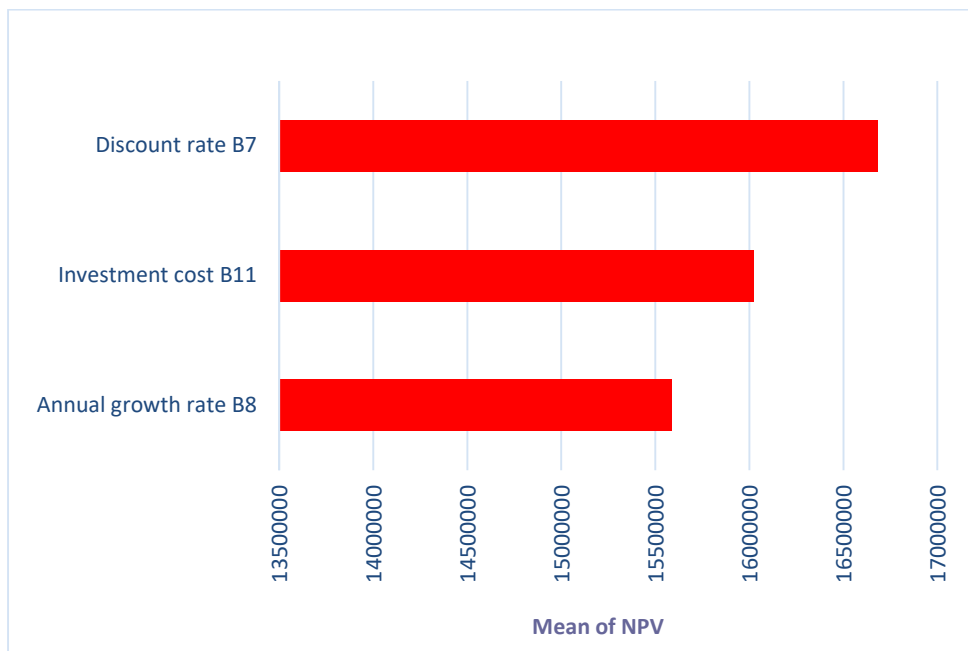


Figure 4.14: NPV Sensitivity tornado

Source: Author's compilation

The sensitivity of the NPV towards discount rate, investment cost and annual growth is represented in Figure 4.14. The tornado graph illustrates that the discount rate has a significant influence on the NPV followed by investment cost and annual growth rate. This suggests that a change in the discount rate will result in a change in the NPV, meaning that the NPV is most sensitive to the change in the discount rate. A change in the investment cost and annual growth rate will have an impact on the NPV. However, it will not be as intense as the change brought upon by a change in the discount rate.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarises the results of the study on the economic analysis of cassava starch production vis-à-vis maize and potato starch production in South Africa. Key results found are also presented. Based on the findings, certain conclusions are drawn. The conclusions and recommendations drawn in this chapter are based on the study's findings.

5.2 Summary

The study aimed to carry out an economic analysis of starch production from cassava, vis-à-vis starch production from maize and potatoes in South Africa. In order to fulfil the economic analysis, the study was guided by three objectives. The first objective was to determine the supply and demand patterns for cassava, maize and potato starches. The study used time series data which was extracted from the trade map. Graphical analysis was used to illustrate the demand and supply patterns of cassava, maize and potato starches.

South Africa demands a high quantity of cassava starch and there is limited supply in the country. Hence, the results showed that cassava starch imports are significantly higher than maize and potato starch imports. The graphical analysis further showed that maize starch exports are higher than cassava and potato starch imports, suggesting that South Africa is self-sufficient in maize starch production.

The second objective was to analyse the economic profitability of cassava and maize starch production in South Africa. The study used a gross margin analysis to determine the profitability of cassava and maize starch production. The study found that cassava and maize production are both profitable. However, the results revealed that cassava starch production is more profitable than starch production from maize. Additionally, the study found that maize starch production is more complex than starch extraction from cassava. This is because the maize starch extraction process consists of extracting 3 co-products.

The third objective was to model alternative scenarios of cassava starch production in South Africa and determine the costs and benefits. The study modelled 3 scenarios which were guided by the cassava starch conversion rate that is influenced by the cultivars. The economic indicators were positive in the first and third scenario, meaning

that the project should be accepted under the first and third's conditions. However, the economic indicators were negative in the second scenario, which implies that the project should be rejected under the second's scenario conditions.

5.3 Conclusion

Cassava starch imports and exports are a frame of reference for understanding the cassava starch market in South Africa. This makes assessing the cassava starch imports and export dynamics significant in developing a sustainable cassava value chain in South Africa. The study found cassava starch imports to be significantly higher than maize starch imports. This suggests that high imports can stimulate the development of a cassava value chain as the demand is currently available. Developing the cassava value chain is essential because it has the potential to improve the country's economy.

A developed cassava value chain will drastically reduce import volumes and possibly increase export volumes. It will generate employment which will enhance the standard of living and contribute to food security. Additionally, the national economy should gain from the indirect job growth and the direct currency savings resulting from the replacement of imported goods and inputs. Given the important role that cassava starch plays in the processing and manufacturing of many other food products in South Africa, understanding the dynamics in the cassava starch markets is essential.

The objectives of the study guided the hypotheses of the study which were tested. The first hypothesis was that the production of cassava and maize starch production is profitable. This hypothesis was rejected because the study found that cassava starch production was profitable whilst maize starch production was not profitable. The second hypothesis was that cassava starch production is economically feasible in all the modelled scenarios in South Africa. This hypothesis was rejected because the economic indicators were negative in the second scenario. This suggests that cassava starch production will not be feasible if the cultivars used for starch production do not have a good conversion rate.

5.5 Recommendations

Cassava's prospects are rooted in improving and understanding its supply and demand through research. Hence, the study recommends that South Africa should develop and follow an effective research strategy that concentrates on meeting the long-term starch demand. Furthermore, the research strategy should be export-oriented as this will assist in fully exploiting the benefits of cassava starch production. The research strategy should be multi-disciplinary as this will allow it to cover all aspects of cassava research including physiology, breeding, agronomy, plant nutrition, diseases, pests, utilisation and economics.

Expanding cassava farming land areas to increase starch production is not a sustainable solution because the world is dealing with resource depletion, land scarcity, urbanisation and rapid population expansion. The creation of high-starch cassava cultivars is a substitute strategy for addressing the demand gap. The results showed that the return on investment is higher when cultivars with a higher starch content are used for cassava starch production. Therefore, institutions such as the Agricultural Research Council (ARC) need to investigate and develop high starch content varieties of cassava and develop technologies for increased efficiency in extraction processes.

A significant sum of money should be allocated to acquiring and breeding improved cassava cultivars which have a high starch content. In order to accelerate the commercialisation of the cassava crop for industrial use, these cultivars should have the necessary physicochemical parameters and functional characteristics. To support the commercialisation of cassava, a mass cassava advertising programme should be put in place. This will create awareness of the product to consumers in all spheres.

South Africa is a developing country which means that there is room for the development of new local and international markets through enhanced efficiency and innovation. This could be fulfilled through investing in cassava agro-processing facilities. The study found that South Africa successfully supplies maize starch to the domestic and foreign markets and that Tongaat Hulett Starch is the largest producer of starch in South Africa, using maize as raw material. The factors which made it a successful entity should be studied and applied in developing a cassava starch business. Furthermore, South Africa should use leading cassava starch producers

such as Thailand and Nigeria as a blueprint for developing a cassava value chain whilst paying attention to country-specific circumstances. The production of cassava in Thailand is mainly for industrial purposes. South Africa should also develop the cassava value chain to maximise the industrialisation of the crop. Policies should be put in place that will cushion the development of the cassava value chain and direct its growth towards industrial purposes.

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7. APPENDICES



07/04/2022

NAME OF STUDENT: Nkosi ZZ
STUDENT NUMBER: 201730826
DEPARTMENT: Agricultural Economics and Animal Production
SCHOOL: Agricultural and Environmental Sciences
QUALIFICATION: MSA02

Dear Ms Nkosi

FACULTY APPROVAL OF PROPOSAL (PROPOSAL NO. 50 OF 2022)

I have pleasure in informing you that your **masters** proposal served at the Faculty Higher Degrees Committee meeting on **09 December 2021** and your title was approved as follows:

"Economic analysis of cassava starch production vis-a-vis starch production from maize and potatoes in South Africa."

Note the following: The study

| Ethical Clearance | Tick One |
|--|----------|
| Requires no ethical clearance Proceed with the study | √ |
| Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate | |
| Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate | |

Yours faithfully

Prof P Masoko
Research Professor: Faculty of Science and Agriculture

CC: Prof MP Senyolo
Prof JJ Hlongwane
Prof TP Mafeo

