COMPREHENSIVE CASSAVA STARCH SUPPLY CHAIN MODEL WITH VERTICAL AND HORIZONTAL LINKAGES IN NIGERIA: IMPLICATIONS FOR DOMESTIC AND INTERNATIONAL SHOCKS

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AUGUST, 2025

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (MSc,), IN THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTERNSION SERVICES, FACULTY OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY, BENSON IDAHOSA UNIVERSITY, BENIN CITY, EDO STATE, NIGERIA

AUGUST, 2025

DECLARATION

I, EBUBEDIKE, Cletus Ugochukwu declare that this thesis titled Comprehensive Cassava Starch Supply Chain Model with Vertical and Horizontal Linkages in Nigeria: Implications for Domestic and International Shocks has been written by me and it is a record of my own research work. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

_____ _____

EBUBEDIKE, Cletus Ugochukwu **DATE**

CERTIFICATION

We certify that this research work was carried out by EBUBEDIKE, Cletus Ugochukwu in the department of Agricultural Economics and Extension Services, Faculty of Agriculture and Agricultural Technology, Benson Idahosa University, Benin City, Edo State, Nigeria

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PLAGIARISM ATTESTATION

I certify that this report is my own work, based on my personal research and that I have acknowledged all material and sources used in its preparation, whether they be books, articles, reports, lecture notes, or any document, electronic or personal communication. I also certify that the report has not previously been submitted for assessment elsewhere, and I have not copied in part or whole, otherwise plagiarized the work of other students and/or persons.

NAME: _____ **DATE: _____**

SIGNATURE: _____

DEDICATION

This thesis is dedicated to my wife and best friend, Ogwugwua and my children Ezeugo, Kamsiyochukwu, Agozilim and Olaedo with love. And to all who understands that the biblical Paul was Saul.

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ABSTRACT

This study evaluated the domestic and international implications of a comprehensive cassava starch supply chain model with vertical and horizontal linkages in Nigeria. The model is for expanding Nigeria's annual Cassava Starch production to 400,000 tonnes per year. This quantity on the average will close the gap between the demand and supply which is historically about 320,000 tonnes yearly. The model also provides for an annual export of about 80,000 tonnes of cassava starch. An investment analysis was specifically carried out to establish the economic viability and sustainability of the model. A stakeholder analysis to assess the distributive benefits or loss to the various stakeholders involved in the starch supply chains and also the magnitude of the benefits or losses. The study also conducted a risk analysis to identify the risks associated with the project implementation in order to provide mitigation arrangements to reduce or mitigate the overall risk exposure. A three-stage sampling procedure was used to collect global data for cassava production and consumption, starch production, consumption, import and export identifying the key stakeholders especially those that the proposed model may impact. Nigerian data on cassava production, processing, consumption, starch processing, consumption, import and export were collected. Four (4) states in Nigeria: Edo, Oyo, Benue and Enugu states were selected based on their agroecological comparative advantages. The data were analysed with descriptive statistics, discounted economic analyses, and multiple regression analyses. The result for the entire model showed a benefit cost ratio BCR of 1.43 which is greater than 1, the Net Present Value of ₦6.3 trillion that is positive, and an internal Rate of Returns (IRR) of 35.1% that is greater than the discount rate (cost of capital of 25.5%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. The study recommended that government policies should enable both domestic and foreign direct investments in the model through land provision, favourable interest rates, restrictions on importation of corn starch which was found to be the historical major imported substitute of cassava starch over. Favourable taxation for all segments of the model was also recommended in the study. Further similar supply chain studies were suggested for other agricultural value chains.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Cassava (Manihot esculenta Cranz) is a very important food crop that is capable of providing food security. However, a lot of problems prevent the development and use of modern equipment for its production. Most of the cassava produced still comes from smallholder farmers who depend on manual tools for their field operations and these farmers are instrumental to making Nigeria the world's largest producer of the crop. An increase in production of cassava to sustain the world food security needs improved machinery to allow its continuous cultivation and processing (Oni & Oyebade, 2013).

Output of cassava is growing at well over 3% p.a., almost three times the rate of population growth. Cultivated mainly in the tropical belt and in some of the world's poorest regions, cassava production has doubled over two decades. Once considered a subsistence crop, it is now seen as a commodity and key for value-addition, rural development and poverty alleviation, food security, energy security; and for bringing important macroeconomic benefits. These factors are driving rapid commercialization of this crop and large-scale investments in upscaling the processing of cassava, both which have contributed significantly to its global expansion (FAO 2023).

Cassava is Africa's most important tuberous crop and it is an all-year-round cheap and reliable staple food for millions of Africans, making it vital for food security on the continent (Adebayo Waidi, 2023). However, cassava production in Africa is hindered by a persistent problem of low yield per hectare (Adebayo Waidi, 2023).

According to Mmapatla Preciou et.al (2023), the cassava starch market in Africa is dominated by imports and an insignificant amount of exports. This they further stated makes imports and exports a frame of reference for understanding the nature of the continent's cassava starch market.

The FAO (2023) study suggests that global demand for cassava starch could increase at an annual rate of 3.1%, while regional growth rates are expected to be for Asia 4.2%, Latin America 3.4%, and Africa 2.3%. In some countries almost all starches could be replaced with cassava starch, while in other countries very little imported starch can be replaced. This is because starches, such as glucose and dextrose represent a broad range of products with a multitude of properties.

Cassava starch processing is another success recorded in West Africa. The introduction of cassava starch in the food and non-food industries in Nigeria has transformed the cassava utilization industry. In Nigeria, cassava starch is used as an ingredient in manufactured foods (infant foods, confectionary, glucose, alcohol) and in non-food industries like glues, oil well drilling, adhesives, paper sizing and bonding, textile sizing and strengthening, (Sanni et.al, 2009).

To improve Nigeria's cassava starch competitiveness in world starch markets, further cassava supply chain research is required to increase cassava yields, reduce production costs, broaden the range of starch functional properties and increase the starch content/nutritional value of its cassava tubers.

Also, cassava starch processing efficiency needs to be improved, new processes and products developed, and new markets for cassava-based products identified. This is achievable by the

integration of farm production, processing and marketing, through active collaboration of the various institutions involved, and through an effective partnership between the public and private sectors. Therefore, cassava production and utilization must be given prime attention in food policy.

Cassava has been transformed from being a poor man's crop to a lucrative and industrial crop, (Mmapatla Precious et.al, 2023). 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 application, (Mmapatla Precious et.al, 2023).

The market for cassava is being propelled forward by growth in these end-use industries. In the future years. The cassava starch market is likely to be driven by rising demand these derivatives with the global demand for cassava starch projected to be over 10 million tonnes by 2026 (Business wire, 2019).

Almost all farmers in the main cassava belts of Nigeria's South-Eastern, South-Western and North-Central zones grow cassava, which is typically intercropped as a main or minor crop. Rotation and fallow systems are the traditional systems used by the farmers to maintain soil fertility but population pressure has resulted in reduced fallow, continuous cropping and reduced soil fertility. Farmers are generally aware of the benefit of inorganic fertilizer, but the commodity is scarce and a major constraint in cultivating improved varieties (FAO 2023).

Almost all the cassava produced is used for human consumption and less than 5% is used in industries. As a food crop, cassava fits well into the farming systems of the smallholder farmers in Nigeria because it is available all year round, thus providing household food security. Compared to grains, cassava is more tolerant to low soil fertility and more resistant to drought,

pests and diseases. Furthermore, its roots store well in the ground for months after maturity (FAO, 2015).

Cassava is important, not just as a food crop but even more so as a major source of cash income for producing households. As a cash crop, cassava generates cash income for the largest number of households, in comparison with other staples, contributing positively to poverty alleviation. This necessitates a wholistic cassava starch supply chain model that will create valuable significant source of incomes for the involved farm input suppliers, farm service providers, farming households, haulage companies, industrial cassava starch processors, value-adding firms and traders that deal on the products.

1.2 Problem statement

Nigeria accounts for about 98% of the African Food grade starch consumption market (PwC, 2020).

However, the Nigerian cassava starch value chain is faced with several challenges. These challenges adversely affect the efficiency and growth of the Nigerian cassava starch supply-chain. Despite being the world's leading producer of cassava, Nigeria still imports a lot of starch every year and this appears to be increasing yearly both in the quantity imported and the cost of the imported starch, (PwC, 2020). Annually, the value of imported starch in Nigeria had increased to 83,000Mt worth USS54.8. million in 2021, (International Monetary Fund, 2024). The importation of food grade starch continues to increase every year, and this poses a serious challenge to local production of cassava starch and the upstream and downstream of the cassava starch supply chain, (PwC, 2020).

Internationally, the Nigerian cassava starch production faces stiff competition from more efficient and better equipped global producing countries, fluctuations in demand and supply as well as imposition of trade barriers. It is as such susceptible to the possible shocks in these areas. The main question therefore is whether a comprehensive cassava starch supply chain model with vertical and horizontal Linkages in Nigeria will have implications for domestic and international shocks. It is against this backdrop that this study seeks to provide responses to the following questions:

1. Will a comprehensive cassava starch supply chain model with vertical and horizontal linkages producing sufficient cassava starch up to 400,000Mt annually to plug the current local production gap and export the balance have domestic and international implications?
2. Will an investment towards annually producing 400,000 tonnes of cassava starch be economically viable and sustainable if introduced into Nigeria's starch production chain?
3. How will the stakeholders of the model be impacted?
4. Are there risks associated with the implementation of the proposed model and if there are, can these risks be mitigated against?

1.3 Objectives of the study

The overall objective of this study was to evaluate the domestic and international implications of a comprehensive cassava starch supply chain model with vertical and horizontal linkages in Nigeria for expanding Nigeria's annual cassava starch production by 400,000 tonnes to close the local supply-demand gap and also export the balance.

The specific objectives were to:

1. develop an expansion model for the Nigerian food grade cassava starch supply chain that captures the vertical and horizontal linkages for 400,000 tonnes of cassava starch annually.
2. carry out an investment analysis to determine the economic viability and sustainability of introducing the cassava starch production model into Nigeria's starch production chain.
3. carry out stakeholders' analysis to assess the distributive impacts of the externalities obtained in order to determine the benefits or loss to the various stakeholders involved and the magnitude of the benefit or loss.
4. conduct a risk analysis to identify the risk associated with the project implementation in order to institute appropriate contractual arrangements to reduce or mitigate the overall risk exposure.

1.4 Justification of the study

Despite being among the highest producers of cassava in the world, Nigeria remains a major importer of starch usually corn starch which is a direct substitute of cassava starch, (PwC, 2015). Limited access to improved cassava varieties, agrochemicals and farm mechanization, poor farm productivity, inadequate processing facilities, and poor market structures are internal constraints that weaken the cassava starch supply chain performance, (PwC, 2015). Externally, the starch supply chain may be susceptible to shocks such as fluctuating international prices, demand, competition from better-equipped global producers, and the imposition of trade barriers.

An efficient import-substitution of food grade starch can save Nigeria up to $55,841,380.00 per annum in foreign exchange according the estimation of PwC in 2020. A more efficient food grade cassava starch sector has the potential of creating more jobs along the value chain,

increasing the income and standard of living of the major players and also contributing to Nigeria's gross domestic product. The production efficiencies and profitability of the food grade starch supply chain could only be improved upon if the current supply chain is known and defined. Moreover, the absence of good data about the entire food grade cassava starch supply chain may have prevented prospective large-scale integrators from venturing into this business, (Howeler Reinhardt, 2006).

If cassava can be used as an alternative starch source to satisfy the domestic starch demands, this will reduce competition among staple food commodities and reduce the volume of imported starch. Cassava storage roots contain a starch content that is about 40% higher than rice and 25% more than maize (Tonukari, 2004). Cassava starch is the cheapest and the most preferred known form of industrial starch (Tonukari, 2004).

Majority of literature from researches were on the entire cassava value chains. Comprehensive studies of Nigeria's cassava starch supply chain are not readily available. This necessitated the comprehensive cassava starch specific supply chain modelling.

Therefore, understanding and evaluating the current cassava starch supply chain and building a more efficient comprehensive starch supply chain model with good vertical and horizontal linkages with the attendant technical and economic efficiencies can assist in policy formulation by relevant stakeholders.

This comprehensive study of the cassava starch supply chain, therefore, will generate information that will serve as database for both present and prospective starch processors on the points of technical and economic profitability between the upstream and the downstream of the

supply chain. It will as well as assist the policy-makers in formulating efficiency-based policies with better production plan.

This study will contribute greatly to existing body and knowledge on the cassava starch supply chain with a view to improving the production of food grade starch and serve as a baseline for further research work especially in Nigeria where a few works of this nature has been carried out. It will also be vital in informing priority-setting in policies towards import-substitution and improvement in value-addition.

1.5 Limitations of the study

The study depended on secondary data from various sources and as such the quality of the data is dependent on and may be affected by the integrity of the sources.

CHAPTER TWO

LITERATURE REVIEW

This chapter provides background information on the Nigerian Food Cassava Starch Industry, development in the highly integrated supply chain, impacts of Local Cassava Production and International Corn trade in the raw material costs, advances in the productivity of Food Grade Starch Processors, objectives of the analysis, and organization of the thesis.

2.1 Theoretical Framework

The food industry is undergoing a transformation, resulting in increasingly complex supply chain structures (Hossain & Jahan, 2015). This transformation is leading to the introduction of new technologies, an increased number of supply chain players, and significant shifts in transportation modal. Several studies highlight the importance of analysing and improving supply chain structures in the food industry.

World production and utilization of roots and tubers is projected to increase by about 18% over the next decade between 2023-2032. Production growth in low-income regions could reach 2.6% p.a. while supply in high-income countries should grow at only 0.3% annually. Global land use is projected to increase by 6 million hectares to 71 million hectares, but there will be some regional shifts. African countries are expected to increase their cultivation area, while reductions are projected for Europe and America. Moreover, many farmers in Thailand shifted from Cassava to rice which had better production incentives. Production growth is mainly attributed to investments in yield improvements in Africa and Asia, as well as an intensification of land use in these regions (FAO, 2023).

By 2032, an additional 1.4 kg/capita per year of root crops will enter diets at the global level, driven mostly by consumers in Africa where per capita intake of roots and tubers could surpass 41 kg per year. Biofuel use, albeit from a low basis (3% of use), is expected to grow by 37% over the next ten years driven by the Chinese biofuel industry. Feed and other industrial use will remain significant, albeit with slower growth of about 10% and 15% respectively, over the outlook period (FAO, 2023).

According to FAO (2023), International trade in roots and tubers comprises about 6% of the global market production. Over the medium term, this share is expected to remain constant. Exports from Thailand and Viet Nam are growing and are expected to reach a combined total of 15 Mt, mainly to supply the growing biofuel and starch industries in China.

After a moderate decrease expected in 2023 due to high pressure on cassava markets in Thailand and the shortfall of potato production in Ukraine, prices of roots and tubers are projected to follow a similar path to cereal prices in the medium term given the substitutability between roots and tubers and cereals on food and feed markets; namely, an increase in nominal prices but a decline in real terms (FAO, 2023).

2.2 Empirical Framework

Supply chain vertical linkages refer to the connections and interactions between different stages of the supply chain, such as farmers, distributors, manufacturers, and consumers. These linkages ensure a smooth flow of information, resources, and products throughout the supply chain, ultimately leading to efficient and effective operations. Horizontal linkages, on the other hand, involve collaborations and partnerships between different players within the same stage of the supply chain. These collaborations can lead to economies of scale, improved quality control, and

enhanced market access. For example, in the fresh vegetable supply chain, collaboration between farmers and distributors can streamline the process of getting produce from farms to markets. This collaborative approach can also be applied to other agri-food chains, resulting in similar benefits.

In the Cassava starch value chain, vertical and horizontal linkages play a vital role. Starch industry has progressed into a business that is worth billions of dollars globally, as they have been found useful in the food, textile, biofuel, plastic and the pharmaceutical industries. Nigeria can be the largest producer of starch in the world. Her major sources are roots and tubers (cassava, yam, cocoyam and potato), cereals (maize, sorghum, millet and rice) and fruits (banana, plantain, etc.). Although, all the starch crops are abundantly produced in Nigeria, only less than 1% is processed into high quality starch for industrial processes. This chapter therefore examines the past, the progression and the current state of the starch industry in Nigeria and the roles the government and relevant stakeholders must play to revolutionize the industry in Nigeria.

Vertical and horizontal linkages in Cassava starch supply chains are essential for ensuring the efficient flow of information, resources, and products. These linkages facilitate coordination and collaboration between different stakeholders, enabling them to respond effectively to domestic and international shocks. These findings emphasize the importance of developing comprehensive and resilient food grade starch supply chain models that incorporate both vertical and horizontal linkages. By integrating vertical and horizontal linkages, food grade starch supply chains can improve their adaptability and responsiveness to shocks, whether they are domestic or international in nature.

Vertical integration has been widely promoted for offering production, transaction, and market benefits in various agricultural industries. These benefits must be translated into profitability - a proxy of competitive advantage.

2.3 Conceptual Framework

Cassava is the most important root crop in Nigeria. Apart from being a staple crop in both rural and urban household's cassava is a major source of income to cassava farmers and processors in the rural areas.

Cassava alone contributes about forty-five percent (45%) of agricultural GDP in Nigeria for food or domestic purposes, but its industrial processing and utilization has been very limited.

Currently, the country produces about forty (40,000,000) million tonnes of the cassava tubers annually and due to the desire of the federal government to reduce import dependency and conserve of scare foreign exchange, there is national programme aimed at increasing the production of cassava starch as an alternative to corn starch.

Starch is the major constituent of the cassava plant. Its thickening and binding qualities makes it useful in convenience foods and baby foods. Starch makes good adhesives. Dextrin is a modified starch with quality adhesive properties.

Market findings revealed that the product has a lot of industrial applications. It could be used as food in the preparation of bread, macro, noodles, custard, sauce, snacks and Ogi.

Instant noodles are a noodle dish, sold in a precooked and dried noodle block, with flavouring powder and/or seasoning oil.

The flavouring is usually in a separate packet, although in the case of cup noodles the flavouring is often loose in the cup. Some instant noodle products are seal packed; these can be reheated or

eaten straight from the packet/container. Dried noodle blocks are designed to be cooked or soaked in boiling water before eating but can be consumed dry.

The main ingredients used in dried noodles are usually wheat flour, palm oil, and salt. Common ingredients in the flavouring powder are salt, monosodium glutamate, seasoning, and sugar.

Over the years noodles have become an acceptable and domineering food component of most Nigerian homes because of its unique taste and ease of preparation, with the first noodle brand introduced into the country more than twenty (20) years ago. It is a staple food which originated from Asia in the 9th century and then spread to Europe, the far-east and the rest of the world with the major primary ingredient of production being wheat.

In the noodle industry of the country, there are about seventeen (17) players in noodle manufacturing with more than thirty thousand (30,000) people directly employed in the industry and more than two hundred thousand (200,000) distributors employed. This has created a huge avenue for supplies for the flour milling companies, the refineries, the palm oil plantations, the packaging companies and the carton manufacturers with the consumption rate around two hundred and sixty to two hundred and eighty thousand (260,000 to 280,000) tonnes per annum.

One of the challenges faced by the industry is the rising cost and inconsistency in availability of its primary raw material in this case which will be cassava starch. There is a global demand for starch in the international market from the brewing industries, confectionary industries and also competition from the local industry. This places pressure on the commodity subjecting it to erratic price fluctuations.

Cassava starch is a very good substitute for wheat flour in the production of noodles and can be blended with wheat flour to reduce the quantity of wheat required in the production of noodles.

The production plant comprises of Cooling Rack, Noodles Extruder with Dough Mixer, Working Table (S/S), Oven, Blanching Tank, Jacketed boiler with gas burner, Noodles Packaging Machine, Weighing Machine, Accessories, Generator, Project Vehicles and Wood Pallets.

The production capacity of the proposed plant is fifteen (15) tons per day and it would operate at eighty percent (80%) of the installed capacity for three hundred (300) working day producing about three hundred and sixty thousand (360,000) cartons of twenty (20) pieces of five hundred (500) gramme pack of cassava noodles per annum with input output ration of 1:1.5.

This report seeks to examine the financial viability or otherwise of producing instant noodles from High Quality Cassava Starch and Durum Wheat flour in Nigeria.

2.4 Methodological Framework

Cassava is one of the world's three major tuber crops, which is drought-resistant, barren-resistant, widely cultivated in tropical and subtropical regions of more than 100 countries or regions. As one of the three major tuber crops, it is the third-largest food crop in the tropics, and the sixth-largest food crop in the world. Known as the "king of starch", it is the ration of nearly 600 million people in the world. Cassava is a staple food in many developing countries because of its excellent characteristics of being easy to grow, easy to cultivate, high yield, and harvestable in all seasons.

According to the use, cassava can be divided into an edible type and an industrial type. The tuber of edible cassava is rich in starch, therefore it is an important raw material for many pharmaceutical and food industries, as well as for the development of biomass sources. There are more than 2,000 kinds of industrial products of cassava, playing an important role in crop layout, feed production, industrial applications and so on. It has grown widely as the main processed starch and feeds crops. With the development of the cassava industry, the use of cassava starch is

gradually diversified and cassava starch can be used as industrial raw materials for food, medicine, cosmetics, textile, paper, confectionery, beverage, feed, biodegradable materials, adhesives and glues, chemicals, fuel ethanol and so on.

Common raw cassava starch is widely used not only in food recipes such as baked goods but also in the production of extruded small foods and cassava beads. Modified starch or starch derivatives have been used as thickeners, binders, puffers, and stabilizers, and are also the best additive, sweetener, flavour carrier and fat substitute. Foods that use cassava starch include canned foods, frozen foods, dry mixed foods, baked goods, snack foods, condiments, soups, sausages, dairy products, meat products, fish products, and baby foods.

1. Cassava starch sugar

Cassava starch sugar is the general name of glucose, fructose, maltose, and mixture produced by cassava starch as raw material through catalytic hydrolysis of acid or enzyme. The application of deep processing of starch is common in the food, beverage, and health care industry, and the rapid development of the food, beverage, and health care industry also provides a sufficient market for the processing of starch sugar and sugar alcohol production.

2. Cassava modified starch

To improve the performance of starch and expand the range of applications of cassava starch, the food processing industry introduces new functional groups or changes the size of starch molecules by using physical, chemical, and biological enzymatic processing methods that make them more suitable for the requirements of practical applications. This starch that undergoes a secondary process that results in a change in properties is collectively known as modified starch.

Modified starch is widely used in the food industry in the production of starch fudge, beverages, cold food, flour, and so on. Modified starch is widely used in the food processing industry as a

versatile food additive. It gives the food a satisfactory sensory quality and edible quality by improving the ability of thickening, suspension, water retention, and stability of the starch, while also extending the shelf life of the food.

3. Cassava all powder food

The production method of cassava all powder is simple, with low water consumption, high utilization rate, low environmental pollution, and wide use, which can well solve the problem of poor storage and inconvenient transportation of fresh potatoes. Meanwhile, it increases the added value of the industry.

Cassava all powder is widely used in baked food, pastry, and other food fields in two ways: complete main material and incomplete main material (it is used together with other starch food materials), such as cassava all powder fans, cassava cake, cassava biscuit, cassava bread, cassava noodles, cassava steamed buns, yogurt, shrimp slice, macaroni, sweet wine, dumpling skin and so on.

4. Beverages

Modified starch is used as a colloidal stabilizer in beverages containing solid ingredients. In beverages, cassava starch sweeteners are superior to sucrose because the former improves processing and enhances product characteristics, which, in combination with other sweeteners, adequately meet consumer demand. The highly hydrolysed syrup formed by the hydrolysis of cassava starch is an ideal source of readily fermentable sugars in beer brewing.

5. Candy

Raw cassava starch and various modified starch have many applications in confectionery products, such as gelling, thickening, stabilizing system, enhancing foaming, controlling crystallization, bonding, film formation, adding gloss, and so on. Low viscosity cassava starch is

widely used in gelled confectionery such as jelly and chewing gum. The most commonly used is acidolytic starch because of its excellent reversibility and gelling ability, which is even more pronounced with sugar. Dry starch is used as a release agent in candy making. The production of sugar-free chewing gum was achieved with starch-based polysaccharides.

6. Chemicals

Cassava starch-based can be produced at low cost by acidification or enzymatic processes, thus it can be used as a raw material for the production of various chemicals such as sodium glutamate, amino acids, organic acids, ethanol, ketones, vitamins, and antibiotics.

7. Adhesives and glues

Cassava starch dextrins are excellent adhesives for a wide range of applications, including corrugated board, paper bags, plywood, tapes, labels, stamps, and envelopes.

8. Paper-making

Modified starch is used in the paper industry to improve paper quality, productivity, and pulp utilization. Cationic starch is used to flocculate pulp and improve wet dewatering efficiency, which results in higher machine speeds and higher pulp utilization. The starch retained on the finished paper can be used as an internal sizing agent to increase the strength of the paper. Low viscosity starch, such as oxidized starch, can be used as a surface sizing agent to increase paper strength and improve ink absorption during printing and writing.

Modified starch is also used as an adhesive in pigment coating to produce smooth, white, premium paper. Many cassava starch manufacturers' main sales direction is cassava starch export.

9. Textile

In the textile industry, cassava starch is often used as a sizing agent to harden and protect yarns to improve textile efficiency; it is used as a finishing agent to produce fabrics that feel smooth; it is used as a colour enhancer to obtain a clear, wear-resistant printed fabric; for textile applications, lightly boiled starch is more effective.

10. Pharmaceuticals and cosmetics

Cassava raw starch and modified starch are used as binders, increasers, and disintegrants in the production of tablets. Specially modified starch can be used as a carrier for emollients, which are usually mineral oil-based substances. Other modified starches can be used as emulsifiers, sealers (vitamins), styling agents (hair mousse), and thickeners (shampoos).

11. Biodegradable materials

Raw cassava starch and modified starch can be mixed with petroleum-based or synthetic polymer materials to improve the biodegradability of the materials, to minimize the production cost of such environmental protection materials.

CHAPTER THREE

METHODOLOGY

3.1 Area and scope of the study

Nigeria has an area of 923,769 square kilometers made up of 909,890 square kilometres of land area and 13,879 square kilometres of water area, (national Bureau of Statistics, 2011).

It is bordered on the West by Benin Republic and Niger; on the East by the Republic of Cameroon; on the North by Niger and Chad and on the South by the Gulf of Guinea (National Bureau of Statistics, 2011).

Nigeria is located at latitude 9.0820° N, and longitude 8.6753° E. It is part of Africa and the Northern hemisphere. In general, the length of the rainy season decreases from South to North. In the South, the rainy season lasts from March to November, whereas in the far North it lasts only from mid-May to September. A marked interruption in the rains occurs during August in the South, resulting in a short dry season often referred to as the "August break." Precipitation is heavier in the South, especially in the Southeast, which receives more than 120 inches (3,000 mm) of rain a year, compared with about 70 inches (1,800 mm) in the Southwest. Rainfall decreases progressively away from the coast; the far North receives no more than 20 inches (500 mm) a year (Britannica, 2023).

Temperature and humidity remain relatively constant throughout the year in the South, while the seasons vary considerably in the north; during the Northern dry season the daily temperature range becomes great as well (Britannica, 2023).

According to Worldometer (2024) in their analysis of United Nation's data, the current population of Nigeria is 234,730,395 as of Wednesday, December 4, 2024, based on Worldometer's elaboration of the latest United Nations data[1]. Nigeria 2024 population is estimated at 232,679,478 people at mid-year. Nigeria population is equivalent to 2.85% of the total world population and Nigeria ranks number six in

the list of countries by population. The population density in Nigeria is 255 per square Km and 53.9 % of the population is urban (125,447,884 people in 2024) and the median age in Nigeria is 17.9 years.

Nigeria is divided into six geopolitical zones, commonly just called zones. They are a type of administrative division grouping the country's States. Nigerian economic, political, and educational resources are often shared across the zones. These Zones are:

North-Central (also known as Middle Belt): Consisting of Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau States, as well as the Federal Capital Territory.

North-East: Consisting of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe States.

North-West: Consisting of Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara States.

South-East: Consisting of Abia, Anambra, Ebonyi, Enugu, and Imo States.

South-South (also known as Niger Delta region): Consisting of Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States.

South-West: Consisting of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo States.

(Britannica, 2023)

3.2 Sources of data

Data were obtained from secondary sources and annual data from the government reports and databases of various institutions which included production, consumption, prices and trade data. Historical data on cassava production and consumption, industrial starch production, consumption and importation were obtained from records of relevant institutions like National Bureau of Statistics, World Bank, International Monetary Fund, Food and Agriculture Organisation (FAO), International Institute of Tropical Agriculture (IITA) and others.

3.3 Sampling procedure and data collection

Three-stage sampling procedure was used. Stage one involved collection of secondary data on the global cassava production and consumption, starch production, consumption, import and export identifying the key stakeholders especially those that the proposed model may impact. Stage two involved the collection of secondary data on Nigeria's cassava production, processing, consumption, starch processing, consumption, import and export. The third and final stage involved the selection of four (4) States for the model. The States were selected based on their agroecological comparative advantage for cassava cultivation. The suitability classification of Nigeria was done by FAO in research with the Federal Ministry of Agriculture and Rural Development (see map below). The zones as shown in the map were classified as:

1. Least Suitable
2. Average
3. Above Average
4. Most Suitable

The States were selected based on their comparative advantage for cassava production and as such only States within the most suitable zones were picked. They include; Benue, Edo, Enugu and Oyo States.

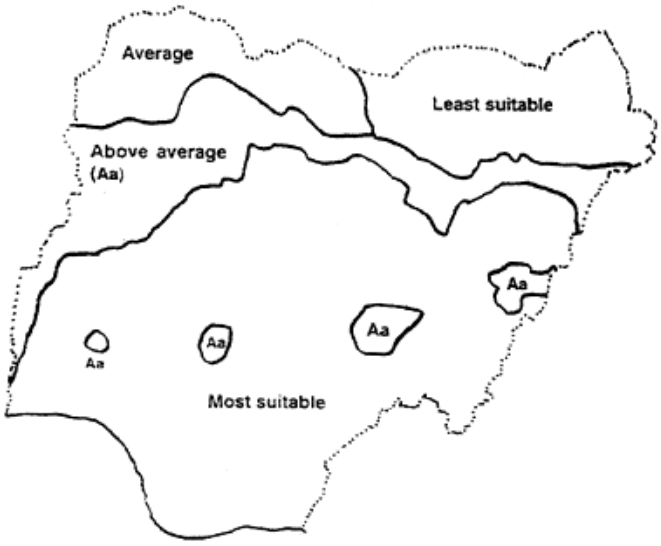


Figure 1 Agro-ecological suitability zones for the cultivation of cassava, based on combined data for soils, mean rainfall, mean temperature, temperature range and the length of growing season in Nigeria (Source: FAO, 2015)

3.4 Analytical techniques

Data collected was analysed according to objectives.

1. To develop the expansion model, the analysis for the various segments of the model for the Nigerian Food grade Cassava Starch supply chain that captured the vertical and horizontal linkages was done. These are explained in turn below.

1.1 Farm inputs and services segment**:** the residual supply of select cassava varieties SS, the residual supply of agrochemical, SA, and the residual supply of fertilisers and limes, SF are represented as reduced-form supply functions as proxy for supply functions of cassava and starch as used by Hakan Unveren (2019).

These are given as:

$$SS = \psi s\ Ps\ \varepsilon s \quad (1)$$

where

SS = the residual supply of select varieties of cassava stems.

Ps = prices of select high-yielding varieties of cassava stems.

ψs = Supply scale parameter for stems.

εs = Elasticity

$$SA = \psi A\ PA\ \varepsilon A \quad (2)$$

where

SA = the residual supply of agrochemicals.

PA = prices of agrochemicals (herbicides, insecticides, fungicides)

ψA = Supply scale parameter for agrochemicals

εA = Elasticity

$$SF = \psi F\ PA\ \varepsilon F \quad (3)$$

where

SF = the residual supply of fertilizers and limes.

PF = prices of fertilizers and limes

ΨF = Supply scale parameter for fertilizers and limes

εF = Elasticity

1.2 Tractor Services Segment: the profit maximisation of the tractor services segment was obtained using the profit maximisation function as used by Hakan Unveren (2019) in profit maximization for breeders.

The profit maximization function for tractor service Π^{TS} is given as:

$$\Pi^{TS} = \rho^{TS} Q^{TS} - C^{TS}\ p^{op}.\ Q^{TS} \quad (4)$$

Where:

ρTS = the transfer price of mechanization operations done

Q^{TS} = the area of operations done.

p^{op} = cost of owning and operating the tractors

C^{Ts} = is the cost function for performing the mechanization operations

1.3 Cassava tuber haulage segment: the profit maximisation of the tubers' haulage segment was obtained using the profit maximisation function as used by Hakan Unveren (2019) in profit maximization for hatcheries.

The profit maximization function for tuber haulage Πth is

$$\Pi^{th} = pth\ Qth - Cth\ pG, Qth \quad (5)$$

Where;

Πth = Profit maximization function for tubers haulage

pth = Average price of tuber haulage

Qth = Quantity of tubes hauled in tonnes

Cth = Cost function of tubers haulage

1.4 Starch Processing Segment: the profit maximisation of starch processing segment was obtained using the profit maximisation function as used by Hakan Unveren (2019) in profit maximization for processing plant.

The profit maximization function for the cassava starch Π^{cs} is given as:

$$\Pi cs = pcs\ Qcs - Ccs\ pcs, Qcs \quad (6)$$

Where;

Pcs = price per Mt of Cassava Starch

Qcs = number of Mt of cassava starch produced.

Ccs = the cost function of Cassava Starch:

1.5 Value-added segment: like as used by Hakan Unveren (2019) in profit maximization in value-adding plants, Profit maximization function will be used for value-added plants Π^{VA} thus:

$$\Pi^{VA} = p^{VA}Q^{VA} - C^{VA}\ \ \rho^{PV}, Q^{VA}\ \ , \qquad (7)$$

where;

p^{VA} = price of Value-added products

Q^{VA} = the quantity value-added products.

C^{VA} = the cost function for value-added .

2. To carry out investment analysis to determine the economic viability and sustainability of the cassava starch model proposed, Investment Analysis: as used by Alice Nsenkyire (2015) in Economic analysis of an integrated investment where Net Present Value (NPV), Internal Rate of Return (IRR), Annual Debt Service Coverage Ratio (ADSCR) and Loan Life Coverage Ratio (LLCR) were used. These are explained in the form that follows:

i) Net Present Value:

The value of the net cash flow at time t=0 is called the Net Present Value. In order to get the NPV, one must discount each payment back to time 0 and then sum them all.

Then the NPV is given by:

$$NPV = X_1V^1 + X_2V^2 + X_3V^3 + \ldots + X_nV^n \quad (8)$$

Where:

$$V = \frac{1}{1+i} \quad (9)$$

ii) Internal Rate of Return

The internal rate of return (or the yield) is the interest rate at which the net present value is equal to zero i.e. $NPV_i = 0$ (10)

The IRR can be positive, negative and sometime there may be no solution, a unique solution or there can be multiple solutions.

In order to approximate the net present value, one can use linear interpolation. To use this you must have a positive net present value -and the interest that gives this value- and a negative net present value along with the corresponding interest rate.

where:

- i_* = the interest rate which gives an NPV of zero
- i_1 = the interest rate that gives a positive NPV
- i_2 = the interest rate that gives a negative NPV
- y_1 = positive NPV
- y_2 = negative NPV
- $y_* = 0$

iii) Annual Debt Service Coverage Ratio (ADSCR)

$$ADSCR = \frac{ANCFADS}{ATDS} \quad (11)$$

Where:

ADSCR = Annual Debt Service Coverage Ratio

ANCFADS = Annual Net Cash Flow Available for Debt Service

ATDS = Annual Total Debt Service

The annual debt service coverage ratio (ADSCR) is a financial metric used to assess the ability of a company to meet its annual debt obligations using its operating income. It is an indication of if the earnings are sufficient to cover the loan payments that includes principal and interest.

Interpretation:

- **ADSCR = 1:** The company's income exactly covers its debt obligations.
- **ADSCR > 1:** The company has more than enough income to cover its debt obligations, with a buffer. A higher DSCR indicates a stronger ability to repay debt.
- **ADSCR < 1:** The company's income is not sufficient to cover its debt obligations. This could signal potential financial distress

iv) Loan Life Coverage Ratio

$$\text{LLCR} = \frac{Present\ Value\quad ANCFADS}{Present\ \ value\ ATDS} \qquad (12)$$

Loan Life Coverage Ratio (LLCR) Definition: The Loan Life Coverage Ratio in Project Finance equals the Present Value of All Cash Flow Available for Debt Service (CFADS) in the Remaining Debt Tenor / Current Debt Balance (Wallstreet 2024).

Where:

LLCR = Loan Life Coverage Ratio

Present value ANCFADS = Discounted Annual Net Cash Flow Available for Debt Service

Present value ATDS = Discounted Annual Total Debt Service

3. Objective 3; stakeholder analysis will be done using the Gross margin analysis of every stakeholder in the model.

   $$GM_{stk} = TR_{stk} - TC_{stk}$$

   Where;

   GM_{stk} = Gross Margin for each stakeholder

   $\mathbf{TR}_{stk}$ = Total Revenue for each of the stakeholders

   $\mathbf{TC}_{stk}$ = Total Revenue for each of the stakeholders

4. Objective 4**;** the risks analysis was realized using the SWIFT approach**.** The SWIFT approach, or "structured what-if technique," includes a team-based approach in a workshop environment. This process involves assessing how changes from a newly implemented plan or design may affect a potential project. Using "what if" questions, teams can determine how changes may affect a project or initiative down the road. This will enable sensitivity analysis on all the possible impacts of the model across all the segments of the model.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 The Model

The model aimed at meeting Nigeria's domestic demand for cassava starch and possibly vertical and horizontal integration linkages in the cassava starch supply chain starting from farm input supplies and farm mechanisation services. The Farm Inputs segment guarantees availability and affordability of the required agrochemicals and planting materials while the Farm Mechanisation segment provides the required tractors and implements required to plant 82,000 hectares yearly. The integrators are to be co-owners of this farm input and farm Mechanisation segments.

The Farming segment integrates farms owned by integrators and co-operative farms jointly owned by the integrators and their cooperative societies. Integrator-owned farms will be financed and managed directly by the integrators while the cooperatives-owned farms will be co-financed by the integrators and the cooperatives. While the integrator provides the land, guarantees the farm inputs and farm mechanisation, the cooperatives co-manages the farms with the integrators. The farming mix guarantees the production of 2,000,000 tonnes of cassava tubers yearly without disturbing the other cassava based supply chains.

The model provides for twelve (12) cooperatives each farming 1625 hectares of cassava with each contract farmer under the cooperative farming 8 hectares yearly. With the integrators providing best agricultural practices for the cooperatives and controlling the farm operations planning, a yield average of 25 tonnes per hectare is guaranteed. Side-selling problems usually associated with less integrator-controlled contract farming is eliminated by the integrators

owning the land, having firm presence on the cooperative farms and better structured farming contracts.

The haulage challenges associated with haulage of bulky cassava tubers from the farms to the cassava starch processing factories are handled in the model by the integration of the cassava Chips mills, and the Haulage segments. The cassava chips mills are owned by the cooperatives and are located at the satellite cooperative farms. Cassava chips production reduces the waste haulage from the farms to the factories. The chips production also enables the cooperative farms plough back the peels and other cassava chipping wastes back to the fields as such helping in improving soil fertility usually depleted by tubers harvesting. With the size reduction between the tubers and the chips, the haulage cost of feedstock for the cassava starch mills is drastically reduced. With fresh tubers sometimes containing as high as 60-70% of water, efficient chipping plants will reduce bulk for haulage by about 75% with tubers chips conversion ratio of 4:1 with good chipping and drying systems.

The Haulage segment in the model uses longer trucks capable of hauling between 45 – 50 tonnes of raw material per trip. The trucks are proposed to run on the more efficient compressed natural gas (CNG) as against the more popular diesel guarantees lower fuel costs, reduced emissions and energy security reduced dependence on diesel. The Haulage segment is comprised sub business units owned by the integrators to reduce the uncertainties, inconsistencies and higher costs that comes with third-party haulage companies. The haulage segment also takes care of the logistics of produced cassava starch.

The cassava starch production segment produces 400,000 tonnes of cassava starch annually from the 2,000,000 tonnes of cassava tubers from the farming segment. The starch producing segment

in the model comprises of four (4) processing plants with individual producing capacity of 100,000 tonnes of starch yearly.

The crushing points in the starch factories incorporates both hammer mills for crushing cassava chips and raspers for fresh cassava tubers enabling 300 days all year long production.

4.1 The Cassava Starch Supply Chain Model for 400,000Mt cassava starch

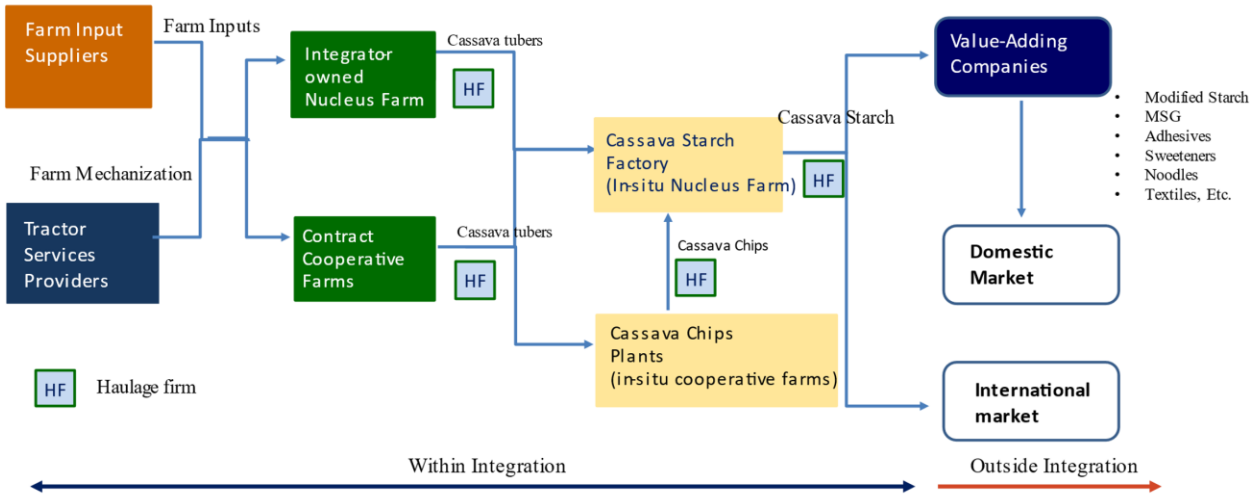


Figure 2 The Model Proposed Comprehensive Cassava Starch Supply Chain Model

Source: Researcher Analysis and Modelling (2024)

The model seeks not just to bridge the demand gap of cassava starch but also aims at substituting the importation of corn starch and becoming a player in the international market of cassava starch through exportation of the excess of the produced cassava starch.

The model proposes that the production be split across four States in Nigeria with each of the selected States lying within the belts where cassava production can be maximised. The States were seen to have land size to meet the land requirements alongside having the population to meet the labour requirements of the model.

The proposed model will run in a 10-year project that will start in 2026 and run till the end of 2035 and will interface with the domestic markets, and the international markets for corn starch and cassava starch respectively.

Benue, Edo, Enugu and Oyo States were selected for the model as shown in Figure 3 below.

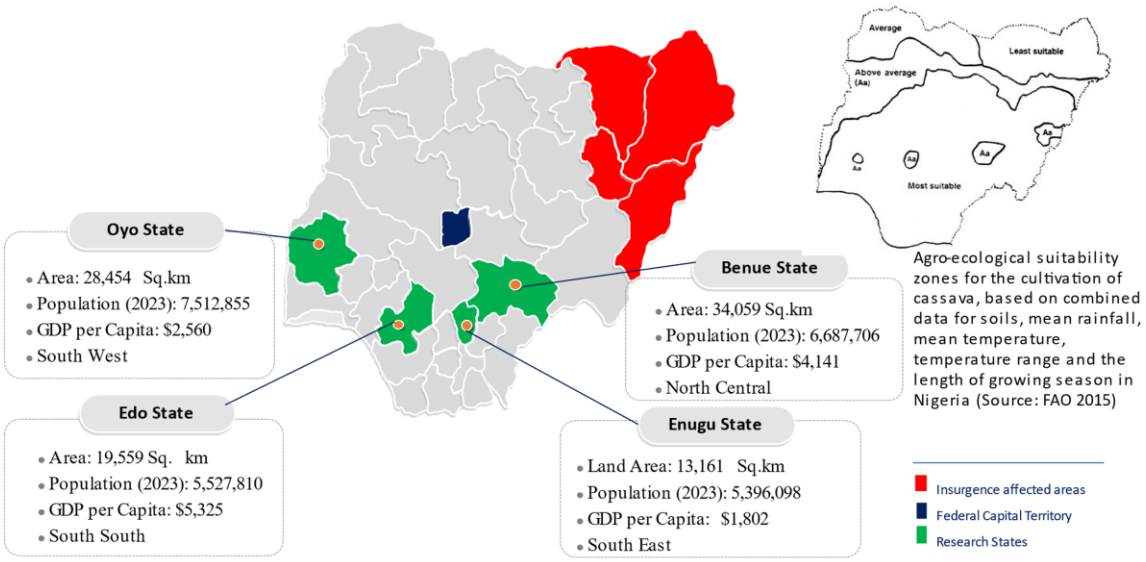


Figure 3 The selected States for the model

Sources: Data from world bank and Wikipedia (2024) and Researcher Analysis (2025)

4.1.1 The States and Distribution of the Model

The model covers four (4) out of the six (6) geo-political zones in Nigeria which is 66.67% of the zones, four (4) out of the 36 States representing 11.11% of the States, covering 10.12% of the nation's land size and within 10.9% of the country's population as presented in Table 4.1. It can be adjudged that the model is representative enough while allowing for the development of other value chains in other parts of the country according to the respective comparative advantages in production.

The GDP per capita of the proposed States were also shown and was used to compare those of the participating populace in the model.

Table 4.1: The States, Land Sizes, Population and GDP Per Capita

Geopolitical Zone	State	Land Area	Population (2023)	Density (per km²)	GDP Per Capita
North Central	Benue	34,059 Sq.Km	6,687,706	196.34	$4,141
South South	Edo	19,559 Sq.Km	5,527,810	289.89	$5,325
South East	Enugu	13,161 Sq.Km	5,396,098	753.71	$1,802
South West	Oyo	28,454 Sq.Km	7,512,855	264.08	$2,560
4 Zones	**4 States**	**95,233 Sq.Km**	**25,124,469**	**376**	**$3,457.00**
Nigeria 6 Zones	**36 States**	**941,092 Sq.Km**	**230,501,935**	**502**	**$1,621.12**
Research Coverage					
66.67%	**11.11%**	**10.12%**	**10.90%**	**74.96%**	

Source; Data from Wikipedia, World bank (2024) and Researcher Analysis (2024)

Table 4.2: The States and the Model

Model Variables	Edo	Oyo	Benue	Enugu	Entire Model
Land Contribution	20,500.00 Ha	20,500.00 Ha	20,500.00 Ha	20,500.00 Ha	82,000.00 Ha
For Farming	20,000.00 Ha	20,000.00 Ha	20,000.00 Ha	20,000.00 Ha	80,000.00 Ha
For Processing & Structures	500.00 Ha	500.00 Ha	500.00 Ha	500.00 Ha	2,000.00 Ha
Yearly Cassava Production	500,000.00Mt	500,000.00Mt	500,000.00Mt	500,000.00Mt	2,000,000.00Mt
Yearly Cassava Starch Production	100,000.00Mt	100,000.00Mt	100,000.00Mt	100,000.00Mt	50,000.00Mt
Number of Integrating Businesses	1 Integrator	1 Integrator	1 Integrator	1 Integrator	4 Integrators
Farm Area per Integrator Nucleus (ha)	7,000.00 Ha per integrator	7,000.00 Ha per integrator	7,000.00 Ha per integrator	7,000.00 Ha per integrator	28,000.00 Ha per integrator
Farm Area per Contract Farmer (ha)	8.00 Ha per farmer	8.00 Ha per farmer	8.00 Ha per farmer	8.00 Ha per farmer	8.00 Ha per farmer
Number of participating Farmers	1625 Farmers	1625 Farmers	1625 Farmers	1625 Farmers	6500 Farmers
Projected Average Tuber Yield	25Mt per Ha	25Mt per Ha	25Mt per Ha	25Mt per Ha	25Mt per Ha
Yearly Cassava Production per Farmer	200.00Mt per farmer	200.00Mt per farmer	200.00Mt per farmer	200.00Mt per farmer	200.00Mt per farmer

Sources: Researcher Data Analysis, (2025)

As shown in Table 4.2, the model proposes that each of the four States will have an integrator with total land per State proposed at 20,500 hectares to actualise a total of 82,200 hectares required for the model. Of the area mapped out for the model, 80,000 will be directly cultivated with cassava yearly while 2,000 hectares are planned for structural development including factories, roads and buildings.

Each of the States in the model will produce 500,000 tonnes of tubers yearly to sum up to 2,000,000 tonnes of cassava tubers, and 100,000 tonnes of cassava starch each to actualise the 400,000 tonnes per year objective. Each of the integrator will directly crop 7,000 hectares in their respective nucleus farms for a total of 28,000 hectares integrator-controlled farms in the model. A total of 6,500 cooperative farmers will be aggregated across the four (4) States with 1,625 contract farmers directly involved in the model. Each of the contract farmer will farm eight (8) hectares of cassava yearly producing a total of 200 tonnes yearly at an average yield of 25 tonnes per hectare in conjunction with the cooperative societies and the integrators. The model as such plugs the about 320,000 tonnes cassava starch annual supply gap and provides for 80,000 tonnes of cassava starch export.

4.1.2 Trends of Relevant Rates, Prices and Factors

The cassava starch model spans across 10 years. It will interface with the interface with the international market in sourcing for required machinery and technologies across the supply chain towards improving production efficiencies in the various segments. It will also play in the international market in exportation of the cassava starch excess of the local demand. Corn starch, which is imported in Nigeria currently to buffer the domestic starch requirement as importation of cassava starch is banned, can be substituted by an efficient domestic production of cassava starch the model seeks to achieve. As such relevant rates and prices were studied with projections from historical data applied in the modelling of the proposed supply chain.

The substitution of importation of corn starch and the production to plug the domestic gap in the cassava starch and also the export of the domestic production excess can affect or be affected by changes in certain rates and prices. Establishing the implications of the vertical and horizontal linkages in the cassava starch supply chain for domestic and international shocks necessitated the study of the trends in the exchange rates, interest rates, inflation rates, and the production, trades and prices of cassava and corn starches.

4.1.3 Exchange Rate

The exchange rate is a key macroeconomic variable in the context of general economic policy-making, and of economic reform programmes in particular. (Obadan 2006). According to Obadan 2006, the exchange rate plays a role in connecting the price systems in different countries, thus enabling traders to compare prices directly. With the study looking at implications for international shocks, the trends in exchange between Nigeria Naira and US Dollars and the correlation with other factors along the cassava starch supply chain. This is in compliance with Obadan 2006, changes in exchange rates have a powerful effect on the imports and exports of the countries concerned through effects on relative prices of goods.

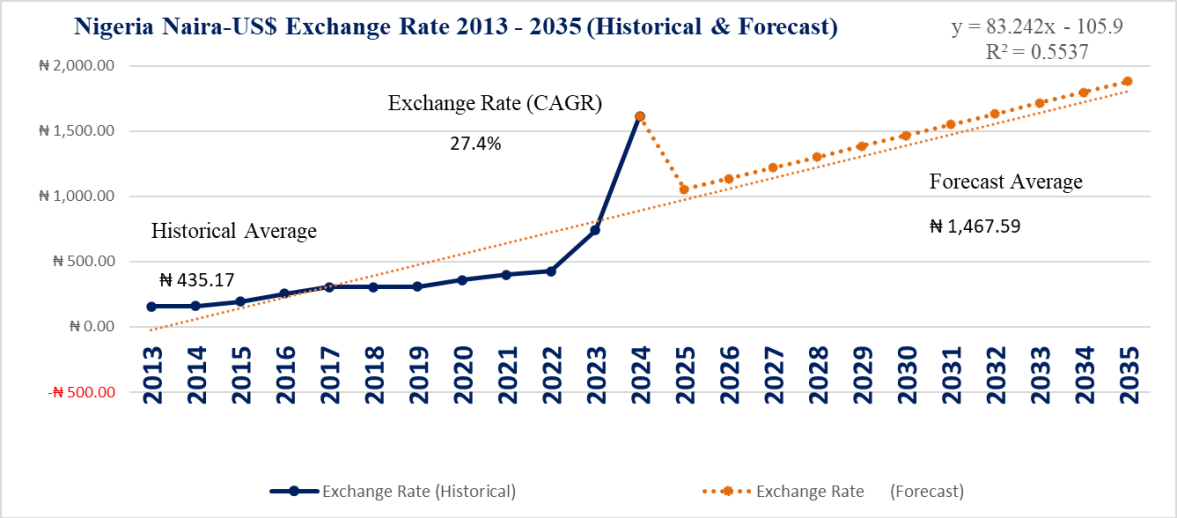


Figure 4 Naira – US Dollars Exchange Rate 2020-2035

Source; Data from World bank (2024) and Researcher's Analysis (2024)

As seen in Figure-4, the Naira exchanged against US$1 at an average ₦435.17 between 2013 and 2023 with a compound annual growth rate of 27.4% between 2013 and 2024, nearly stable between 2017 and 2019 increasing only from ₦305.79 to ₦306.92 , but increased at 118.50% between 2023 and 2024 where it peaked at ₦1,615.91. This saw the exchange rate rise from ₦157.31 per US$ to ₦1,615.91 in 12 years.

The R^2 analysis of the changes in exchange rate in relation to time showed R^2 of 55.37% implying that changes in time(Years) explained 55.37% of the changes in the exchange rate.

The regression line between Exchange rate and Time (years) is:

$$Y = 83.242X - 105.9 + \varepsilon$$

where Y is the Exchange rate,

X is the independent variable Time

ε is the error term that captures the outstanding 44.63% change in the Exchange rate.

The exchange rate trend for the period of the model project 2026 – 2035 was forecast with the average exchange rate at ₦1,467.59 making drastic economic policies and programmes critical. The findings were applied in sensitivity analysis of the model.

4.1.4 Inflation Rate

The profitability of the businesses within the cassava starch supply chain model can be influenced by inflation effects on costs of production, processing and transportation across the upstream, midstream and downstream. According to International Monetary Fund (IMF, 2024), inflation measures how much more expensive a set of goods and services has become over a certain period, usually a year. The IMF further stated that erosion of real income is the single biggest cost of inflation.

The IMF (2024) further stated that most economists now believe that low, stable, and—most important—predictable inflation is good for an economy. If inflation is low and predictable, it is easier to capture it in price-adjustment contracts and interest rates, reducing its distortionary impact. Moreover, knowing that prices will be slightly higher in the future gives consumers an incentive to make purchases sooner, which boosts economic activity, (IMF, 2024).

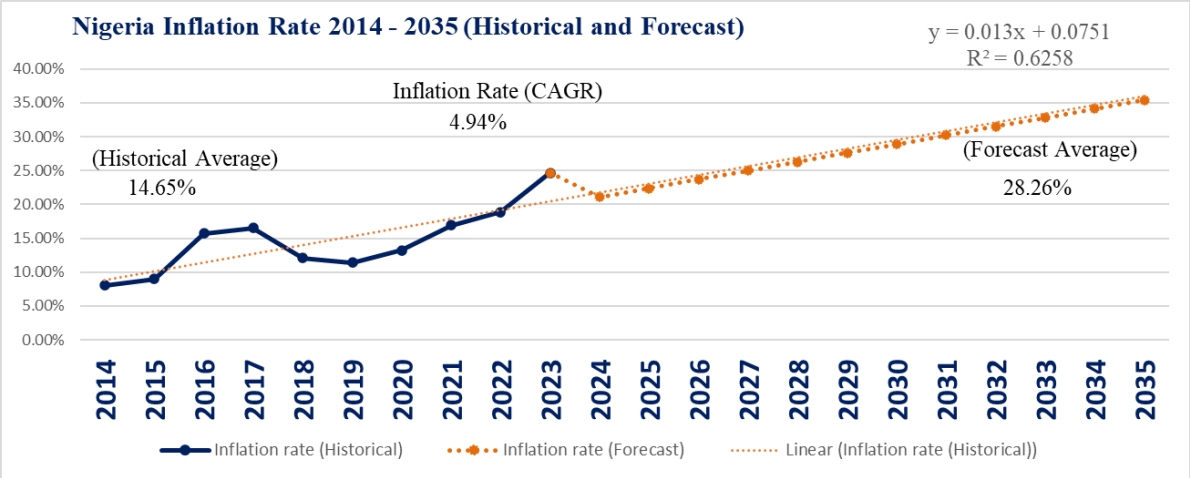


Figure 5 Nigeria's Inflation Rate Trend between 2014-2035

Source; World bank Data from Macrotrends (2024) and Researcher's Analysis (2024)

Figure-5 shows that the historical average in Nigeria's inflation rate was 14.65% between 2014 and 2024. The inflation rate rose from a historical low of 8.05% in 2014 to a historical highest of 24.66% in 2023 growing at a compound annual growth rate of 4.95%.

The relationship between Inflation Rate (Y) and Time (X) is shown by the linear regression equation

$Y = 0.013X - 0.7051 + \varepsilon$

Y depicts the Inflation rate

X depicts the Time

ε representing the error term.

The $\mathbf{R^2}$ of 62.58% implies that 62.58% change in inflation rate in Nigeria depends on time change (Years) with the outstanding explanation due to the error term.

4.1.5 Interest Rate

The proposed cassava starch supply chain model plans for investments in the different segments of the supply chain and these investments will be financed with debt and equity financing that prioritises the

profitability of the businesses. The interest rate is also relevant for the necessary policies that will enable the efficiency of the model. In any economy where the market plays a significant role, interest rates exercise a pervasive influence over economic decisions and performance (International Monetary Fund, 2011). According to IMF (2011), on one hand it affects the willingness to save, on the other hand, they affect the demand for and allocation of borrowed funds.

As such the trend in the interest rates in Nigeria is relevant in the cassava starch supply chain model.

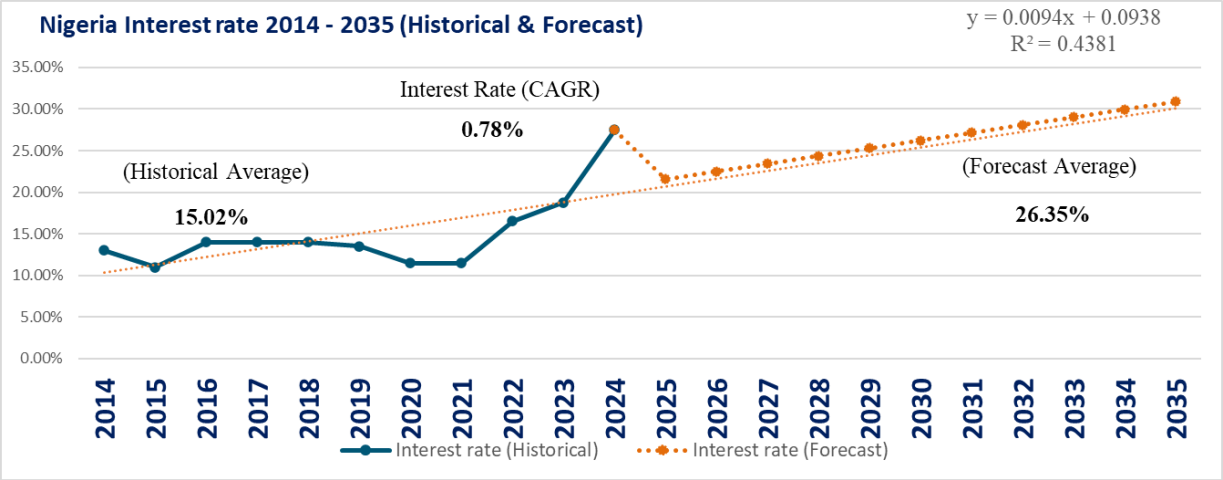


Figure 6 Nigeria's Interest Rate Trend between 2014-2035

Source; World bank data from Focus Economics (2024) and Researcher's Analysis (2024)

In Figure-6 above, Nigeria's historical interest rate between 2014 and 2024 was collected and the data used to forecast interest rates for the period between 2025 and 2035; covering the period of the proposed investment projects in the cassava starch supply chain. Between 2014 and 2024, the average interest rate was 15.02%. The inflation rate grew at a compound annual growth rate (CAGR) of 0.78%. Within the forecast period, the interest rate average would be 26.35% if no special policies are made towards managing it.

The relationship between Interest Rate (Y) and Time (X) is shown by the linear regression equation below

$Y = 0.0094X + 0.0938 + \varepsilon$

Where: **Y** depicts the Interest rate

X is the Time (In Years)

ε is the error term.

The $\mathbf{R^2}$ of 43.81% implies that Time (Years) best explains 43.81% of the changes in the interest rates with the error term explaining the other outstanding independent variables.

4.1.6 Relationship between Interest Rate and Inflation Rate

The conventional view among economists is that higher interest rates lead to lower inflation. According to Fredric Mishkin (2011), The rationale is that higher interest rates increase the cost of borrowing and dampen demand across the economy, resulting in excess supply and lower inflation. In this context, higher interest rates reduce inflation through several channels, including the exchange rate channel, the credit channel, and the bank balance sheet channel (Mishkin, 2011).

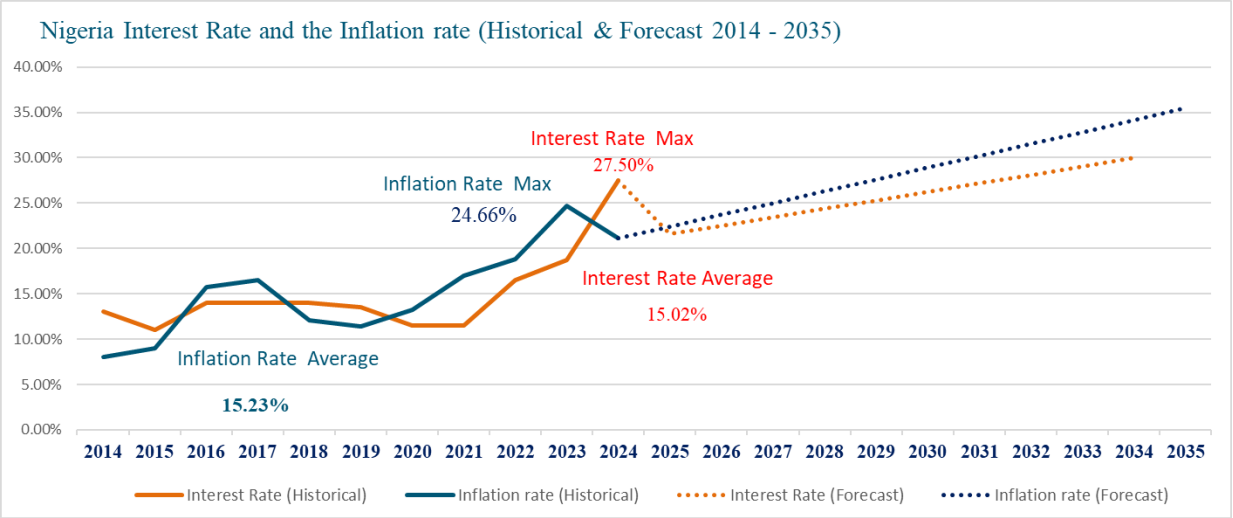


Figure 7: Relationship Trend of Nigeria's Interest Rate and Inflation Rate 2014-2035

Source; World bank data from Focus Economics (2024) and Researcher's Analysis (2024)

From Figure-7 above, the average inflation rate of 15.23% is almost equal to the average interest rate of 15.02% for the period between 2014 and 2024. The maximum inflation rate of 24.66% was in 2024 when the interest rate was also at a maximum of 27.50% suggesting a relationship between the rates as suggested by Fredric Mishkin (2011). The relationship if verified will be applied in the cassava starch supply chain model for investment and policy reasons.

Table 4.3: Relationship between Nigeria's Interest Rate and Inflation Rate 2014-2035

Regression Statistics	
Multiple R	0.840795748
R Square	0.70693749
Adjusted R Square	0.633671863
Standard Error	0.030851152
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.018367646	0.009183823	9.648965212	0.007376342
Residual	8	0.007614349	0.000951794		
Total	10	0.025981995			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-20.85500663	7.895208594	-2.641476332	0.029645328	-39.0613903	-2.648622968
Year	0.010386816	0.003924015	2.646986426	0.029392918	0.00133802	0.019435611
Interest rate	0.241848223	0.276026423	0.876177795	0.406472015	-0.394669851	0.878366297

Source; Data from World bank and Researcher Analysis 2024

Table 4.3 above shows an $\mathbf{R^2}$ of 70.69%. This implies that the total variation in inflation rates explained by the regression line with interest rates and time is 70.69%. As such there is a strong positive relationship between the inflation rate in Nigeria and the interest rates and time under consideration.

The relationship between Inflation Rate (Y), interest Rate (X_1) and Time (X_2) is shown by the linear regression equation

$$Y = 0.24184X_1 + 0.00103868X_2 - 20.855006 + \varepsilon$$

Where: Y depicts the Inflation rate

(X_1) is the Interest Rate

(X_2) is Time (Years)

ε represents the error term

4.2 Investment Analysis to show Economic viability

The Investment analysis for model is shown below:

Table 4.4: Investment Analysis of the Entire Model

ECONOMIC ANALYSIS	ENTIRE MODEL
Benefit Cost Ratio (BCR):	1.43
Internal Rate of Returns (IRR):	35.1%
Net Present Value (NPV):	₦6,301,895,140,998.12
Average Annual GDP Contribution:	₦991,748,149,799.50
Additional Yearly Cassava Tuber Production:	2.05 million Mt Yearly
Average Annual Income per Staff	₦86,843,095.43 per Staff
Number of staff (Direct)	11420 workers
Tax Contribution for the period	₦5,190,804,144,294.91

Source; Researcher's Model Analysis, (2025)

4.2.1 Benefit Cost Ratio (BCR) and the Internal Rate of Returns (IRR)

From the Investment analysis for the entire model, the benefit cost ratio BCR is 1.43 which is greater than 1, and an internal Rate of Returns (IRR) of 35.1% that is greater than the discount rate (cost of capital of

25.5%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. According to Pannell, Nguyen, Loncg Chu and Kompas, 2024, a BCR greater than one (1), a positive NPV, and an IRR greater than the cost of borrowing capital suggests that a model should be funded. As such, the proposed cassava starch model should be funded.

4.2.2 Net Present Value (NPV)

The Net Present Value (NPV) of ₦6.3 trillion is a positive NPV. The NPV >0, BCR >1, and IRR > Discount rate (interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded.

4.2.3 Annual debt service coverage ratio (ADSCR)

The annual debt service coverage ratio (ADSCR) is 1.85 this on the average is enough to cover the debt repayment requirements.

4.3 Stakeholder analysis

The direct stakeholders of the model are:

1. Farm Inputs Segment
2. Tractor Services segment
3. Integrator Farming Segment
4. Cooperative Farming Segment
5. Cassava Chips Segment
6. Haulage Segment
7. Cassava Starch Processing Segment

4.3.1 Farm Inputs Segment

The assumptions of the Farm Input segment as shown in Table 4.5, depicting the backward vertical integration of the farm inputs supply of the model by the Integrators (Cassava starch processing companies) aimed at guaranteeing the qualitative and timely supply of the farm inputs to the farming segments. This segment entails blending agrochemicals (herbicides, and other pesticides) and fertilisers to be readily available at the best prices to the farms in the model.

Table 4.5: Assumptions of the Farm Inputs segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN
Proposed Start Year	2026
Business ownership:	Integrators-owned Special Purpose Vehicle
Target Farm Coverage (Integrator & Cooperative Farms)	80,000.00 Hectares
Farm Inputs Trading Businesses	1 Trading SPV
Recommended Equity Model	Integrator-Owned
Equity + Debt Financing	₦66,070,442,384.00
Loan Interest Rate	15.0%
Moratorium (Grace Period)	1 Year
Loan Tenor	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis of the farm Input segment are shown in the table 4.6 below.

Table 4.6: Investment Analysis of the Farm Inputs segment

ECONOMIC ANALYSIS	FARM INPUTS SEGEMENT
Benefit Cost Ratio (BCR):	1.22
Internal Rate of Returns (IRR):	33.0%
Net Present Value (NPV):	₦170,027,760,841.18
Average Annual GDP Contribution:	₦28,973,606,419.32
Average Annual Net Earning of the Input Trading Firm	₦28,973,606,419.32
Average Annual Income per Staff	₦1,772,225.00 per Staff
Number of staff (Direct)	40 Direct Staff
Tax Contribution for the period	₦47,806,450,591.87

Source; Researcher's Model Analysis, (2025)

The results show a Benefit – Cost Ratio (BCR) of 1.22 which is greater than 1, the internal Rate of Returns (IRR) of 33.0% is greater than the cost of capital which is 15% which the historical average of the commercial bank interest rates in the last 10 Years. The Net Present Value of ₦170,027,760,841.18 is positive making the backward integration in the Farm Input segment wort making. This is in order according to Pannell, Nguyen, Loncg Chu and Kompas, 2024 that all projects with NPV >0, BCR >1, and IRR > Discount rate(interest rate) should be funded. With the segment contributing annually an average of ₦28.9 billion to the GDP and a cumulative tax of ₦47.8. billion, the government policies should favour investments like this segment of the cassava starch supply chain.

4.3.2 Tractor Services Segment

The Tractor services segment proposed for integration in the model is recommended to have 4 Special Purposes Vehicles one each for the four(4) States under consideration. The tractor services aim at servicing efficiently and cost – effectively the tractor mechanisation services of the farming segment of the model covering 80,000 hectares with 20,000 in each of the States covered by a Tractor services SPV. The following are the assumptions:

Table 4.7: Assumptions of the Tractor Services Segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Start Year	2026	2026
Business ownership:	Integrators-owned Special Purpose Vehicle	Integrators-owned Special Purpose Vehicl
Total Farm Area Serviced (cooperatives & Integrators):	80,000.00 Hectares	20,000.00 Hectares
Business Type:	4 Tractor Services SPVs	1 Tractor Services SPVs
Recommended Equity Model	Joint Ventures (JV)	Joint Ventures (JV)
Equity + Debt Financing	₦91,098,398,756.00	₦22,774,599,689.00
Loan Interest Rate	27.5%	27.5%
Moratorium (Grace Period)	1 Year	1 Year
Loan Tenor	9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis for the Tractor Services Segment are shown below:

Table 4.8: Investment Analysis of the Tractor Services Segment

ECONOMIC ANALYSIS	TRACTOR SERVICES SEGMENT
Benefit Cost Ratio (BCR):	1.48
Internal Rate of Returns (IRR):	37.6%
Net Present Value (NPV):	₦317,899,434,725.76
Average Annual GDP Contribution:	₦54,696,505,946.73
Average Annual Net Earning of the Firms	₦13,674,126,486.68 per SPV
Average Annual Income per Staff	₦8,245,319.96 per Staff
Number of staff (Direct)	80 staff
Tax Contribution for the period	₦90,249,234,812.10

Source; Researcher's Model Analysis, (2025)

Investment analysis of the Tractor Services segment shows a BCR of 1.48 that is greater than 1, an internal Rate of Returns (IRR) of 37.6% that is greater than the discount rate (cost of capital of 27.5%) which is the forecast average from the historical average of the commercial interest rates in the last 10. The Net Present Value of ₦317,899,434,725.76 is positive and justifies the integration of this segment because the NPV >0, BCR >1, and IRR > Discount rate(interest rate). And Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested that all projects with NPV >0, BCR >1, and IRR > Discount rate(interest rate) should be funded. The Tractor services segment is projected to contribute on the average a GDP of ₦54.6 billion and a project lifelong tax total of ₦90.2 billion, suggesting that the segment should be readily acceptable to the policy makers.

4.3.3 Integrator Farming Segment

The assumptions of the Integrator Farming segment are shown in Table 13 below. It is a backward integration into cassava farming by the cassava starch processing segment, with the processing plant situated on these farms, and as such narrows down the time between harvesting and processing of cassava tubers.

This segment is projected to be integrator-owned and to cover a total of 29, 520 hectares split across the four integrators(States) into 7,380 hectares per integrator. This is proposed to be a Joint Venture(JV) model towards mopping up the equity funding required to compliment a Debt financing to raise the required ₦66 billion take-off funding for the segment.

This segment although a profit-making sub business unit is primarily aimed at avoiding stop gaps in cassava starch processing due to lack of feedstock for processing. The debt financing is assumed to be at 15% interest rate with a 3-year moratorium when only interests will be paid before the repayment of capital and interest begins.

Table 4.9: Assumptions of the Integrator Farming Segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Start Year	2026	2026
Business ownership:	Integrators-owned Special Purpose Vehicle	Integrators-owned SPV
Total Acreage of Inntegrator Farms:	29,520.00 Hectares	7,380.00 Hectares
Number of Integrators	4 Integrators	1 Integrator
Tuber Yield per Hectare	25.00 Tons per Ha	25.00 Tons per Ha
Recommended Equity Model	Joint Ventures (JV)	Joint Ventures (JV)
Equity + Debt Financing	₦66,070,442,384.00	₦16,517,610,596.00
Loan Intereest Rate	15.0%	15.0%
Moratorium (Grace Period)	3 Year	3 Year
Loan Tenor	9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis for the Integrator Segment are in Table 4.10:

Table 4.10: Investment Analysis of the Integrator Farming Segment

ECONOMIC ANALYSIS	INTEGRATORS FARMING SEGMENT
Benefit Cost Ratio (BCR):	1.37
Internal Rate of Returns (IRR):	35.6%
Net Present Value (NPV):	₦448,443,063,423.36
Average Annual GDP Contribution:	₦73,761,261,192.17
Average GDP per Capita:	₦18,440,315,298.04 per Integrator yearly
Additional Yearly Cassava Tuber Production:	0.74 million Mt Yearly
Number of staff (Direct)	1,540 staff
Tax Contribution for the period	₦130,285,934,609.50

Source; Researcher's Model Analysis, (2025)

From the Investment analysis for the Integrator Farming segment, the benefit cost ratio BCR was 1.37 which is greater than 1, the Net Present Value of ₦448,443,063,423.36 that is positive, and an internal Rate of Returns (IRR) of 35.6% that is greater than the discount rate (cost of capital of 15%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. The NPV >0, BCR >1, and IRR > Discount rate(interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded.

The segment also adds 700,000 tonnes of cassava tubers to the national cassava production annually and employs 1,540 direct staff with many more indirect staff. The Integrator cassava farms is projected to contribute on the average a GDP of ₦18.4 billion yearly and a project lifelong tax total of ₦130.3 billion. The domestic impact off the segment is as such significant for policies to be made to suit such.

4.3.4 Cooperative Farming Segment

The Cooperative Farming segment is a key segment in the model. It is a contract farming model with the farmers aggregated into cooperatives to farm on integrator owned lands. These lands are satellite farms and the nucleus farms that cassava starch processing facilities are situated on.

The model proposes that 52,480 hectares be acquired, cleared and demarcated into blocks by the integrating cassava starch processing plants in a manner that every participating farmer is allocated 8 hectares of land to crop yearly.

The contract is to produce cassava tubers as feedstock for only the integrators. With the lands belonging to the integrators and their teams involved in the annual production and harvesting plan to ensure maturity tallies with the target harvest condition and to also ensure good agronomic practices.

Table 4.11 shows the key assumptions of the model.

Table 4.11: Assumptions of the Cooperative Farming Segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Start Year	2026	2026
Business ownership:	Cooperatives-owned	Cooperatives-owned
Total Acreage of Cooperative Farms:	52,480.00 Hectares	13,120.00 Hectares
Acreage Per Participating Farmer	8.00 Hectares per Farmer	8.00 Hectares per Farmer
Number of Farmers	6,560 Farmers	1,640 Farmers
Tuber Yield per Hectare	25.00 Tons per Ha	25.00 Tons per Ha
Loan Intereest Rate	15.0%	15.0%
Moratorium (Grace Period)	3 Year	3 Year
Loan Tenor	9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis for the Cooperative Farming Segment are in Table 4.12:

Table 4.12: Investment Analysis of the Cooperative Farming Segment

ECONOMIC ANALYSIS	COOPERATIVE FARMING SEGMENT
Benefit Cost Ratio (BCR):	1.49
Internal Rate of Returns (IRR):	26.7%
Net Present Value (NPV):	₦1,058,669,309,298.39
Average Annual GDP Contribution:	₦203,583,907,890.16
Average Annual GDP per Capita:	₦31,034,132.30 per Farmer
Additional Yearly Cassava Tuber Production:	1.31 million Mt Yearly
Number of staff (Direct)	8,100 staff
Tax Contribution for the period	₦325,427,195,061.75

Source; Researcher's Model Analysis, (2025)

The benefit cost ratio BCR of the Cooperative Farming segment is 1.49, the Net Present Value NPV is ₦1.05 trillion and an internal Rate of Returns (IRR) of 26.7% which is greater than the discount rate (cost of capital of 15%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. The NPV >0, BCR >1, and IRR > Discount rate (interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded as suggesting that this segment should be funded.

With 8,100 direct staff of the cooperatives, 6,560 of whom are farmers moved from cropping less than 1 hectare of cassava annually to cropping 8 hectares of cassava annually. At a yield average of 25Mt per

hectare, the segment aims at contributing annually an additional 1.31 million tonnes of cassava tubers to the nation's annual cassava production.

With an annual contribution to the nation's Gross Domestic Product of ₦203.5 billion, cumulative tax contribution of ₦325.4 billion, and a per capita earning of each participating farmer projected at ₦31.03 million, the segment deserves detailed and strategic policy making consideration.

4.3.5 Cassava Chips Segment

The cassava chips segment is the horizontal integration segment of the model. It is a value-addition segment aimed at setting up mini-processing plants that will convert cassava tubers into dried cassava chips. The chips segment is assumed to convert 400,000 tonnes of cassava tubers into 100,000 tonnes cassava chips annually. In the model, this segment is owned by the farmers' cooperatives in-situ the satellite farms.

Chipping and drying facilitates bulk-reduction by reducing water content and also enables the supply of the chips instead of fresh cassava tubers in the periods when sourcing of fresh cassava tubers is difficult. The model proposes 4 Special purpose vehicle companies for the chipping plants which are treated as sub business units that procure fresh cassava tubers from the cooperative farming segment, peels, washes, chips, dries and stores for a short while before selling the chips to the cassava starch processing integrators.

Table 4.13 shows the assumptions of the Cassava Chips segment of the model

Table 4.13: Assumptions of the Cassava Chips Segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Establishment Start Year:	2026	2026
Contruction Duration:	1 Year	1 Year
Operations Start Year:	2027	2027
Business ownership:	Farmer Cooperative Owned	Farmer Cooperative Owned
Business Type:	4 Chips Producing SPVs	1 Chips Producing SPVs
Recommended Equity Model	Cooperative	Cooperative
Feedstock (Cassava Tubers) Yearly:	400,000Mt of Cassava Tubers	100,000Mt of Cassava Tubers
Product (Cassava Chips) Yearly:	100,000Mt of Cassava chips	25,000Mt of Cassava chips
Operational Days Yearly	300 days yearly	300 days yearly
Equity + Debt Financing	₦160,918,295,381.11	₦40,229,573,845.28
Loan Intereest Rate	15.0%	15.0%
Moratorium (Grace Period)	3 Year	3 Year
Loan Tenor	9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis for the Cooperative Farming Segment are in Table 4.14 below:

Table 4.14: Investment Analysis of the Cassava Chips Segment

ECONOMIC ANALYSIS	CHIPS PROCESSING SEGMENT
Benefit Cost Ratio (BCR):	1.36
Internal Rate of Returns (IRR):	36.5%
Net Present Value (NPV):	₦554,354,992,604.88
Average Annual GDP Contribution:	₦85,471,542,626.80
Average Annual Net Earning of the Firms	₦21,367,885,656.70 per SPV
Number of staff (Direct)	140 workers
Tax Contribution for the period	₦3,887,820,431,354.10

Source; Researcher's Model Analysis, (2025)

The benefit cost ratio BCR of the Cassava chips segment is 1.36, the Net Present Value NPV is ₦554.3 billion and an internal Rate of Returns (IRR) of 36.5% which is greater than the discount rate (cost of capital of 15%). The NPV >0, BCR >1, and IRR > Discount rate(interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded as suggesting that this segment should be funded.

With 140 direct staff of the cassava chips segment and the segment's average annual contribution of ₦85.5 billion, to the nation's Gross Domestic Product, a total tax contribution of ₦3.8 trillion by the

segment within the lifetime of the project, the horizontal integration of the cassava chipping unit is key in policy making.

4.3.6 Haulage Segment

The haulage segment is a horizontal integration segment of the model. It is aimed at eliminating the hassles of transportation of cassava tubers and chips between the satellite cooperative farms and t the integrator cassava starch processing plants. This haulage segment is to annually haul 912,000 tonnes of fresh cassava tubers and 100,000 tonnes of cassava chips across the model.

The detailed assumptions are as listed in Table 4.15.

Table 4.15: Assumptions of the Haulage Segment

ASSUMPTIONS	ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Start Year	2026	2026
Business ownership:	Integrators-owned Special Purpose Vehicle	Integrators-owned Special Purpose Vehicle
Total Farm Area Serviced (cooperatives & Integrators):	80,000.00 Hectares	20,000.00 Hectares
Business Type:	4 Haulage SPVs	1 Haulage SPVs
Recommended Equity Model	Joint Ventures (JV)	Joint Ventures (JV)
Materials Hauled Yearly		
Cassava Chips	100,000Mt yearly	25,000Mt yearly
Cassava Fresh Tubers	912,000Mt yearly	228,000Mt yearly
Operational Days Yearly	300 days yearly	300 days yearly
Equity + Debt Financing	₦10,920,000,000.00	₦2,730,000,000.00
Loan Interest Rate	27.5%	27.5%
Moratorium (Grace Period)	1 Year	1 Year
Loan Tenor	9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

The results of the Investment Analysis for the haulage Segment are in Table 4.16:

Table 4.16: Investment Analysis of the Haulage Segment

ECONOMIC ANALYSIS	HAULAGE SEGMENT
Benefit Cost Ratio (BCR):	1.54
Internal Rate of Returns (IRR):	36.5%
Net Present Value (NPV):	₦170,893,678,379.97
Average Annual GDP Contribution:	₦25,536,297,557.39
Average Annual Net Earning of the Firms	₦6,384,074,389.35 per SPV
Number of staff (Direct)	160 staff
Tax Contribution for the period	₦42,134,890,969.70

Source; Researcher's Model Analysis, (2025)

The benefit cost ratio BCR of the Haulage segment is 1.54, the Net Present Value NPV is ₦170.9 billion and an internal Rate of Returns (IRR) of 36.5% which is greater than the discount rate (cost of capital of 27.5%). The NPV >0, BCR >1, and IRR > Discount rate(interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded as suggesting that this segment should be funded.

With 160 direct staff of the haulage segment and the segment's average annual contribution of ₦25.5 billion, to the nation's Gross Domestic Product, a total tax contribution of ₦42 billion by the segment within the lifetime of the project, the horizontal integration of the cassava chipping unit is key in policy making.

4.3.7 Cassava Starch Processing Segment

The cassava starch processing segment is the core segment of the model. It drives all the other segments in the model. The four(4) special purpose vehicles (SPVs) one per State under consideration in the model are the integrators driving the backward horizontal and vertical integrations.

The horizontal integration segment of the model.

The cassava starch processing segment is projected to produce 400,000Mt of cassava starch, 320,000Mt (80%) is planned to plug the gap between the domestic demand and the domestic supply while 80,000Mt (20%) of the cassava starch processed is planned for the international market. With the domestic gap plugged, the countries that Nigeria used to import corn starch from to plug this gap will have to look for alternative markets that will off-take this quantity previously supplied to Nigeria.

Annually, a total of 2,000,000Mt of fresh cassava tubers, 400,000Mt of which will be converted to 100,000Mt of cassava chips in the chips segment before conversion to cassava starch and 1,600,000Mt that will be converted straight from fresh cassava tubers to cassava starch.

The assumption details are shown in Table 4.17.

Table 4.17: Assumptions of the Cassava Starch Processing Segment

ASSUMPTIONS		ENTIRE SECTOR IN THE VALUE CHAIN	FOR EACH INTEGRATOR (STATE)
Proposed Establishment Start Year:		2026	2026
Contruction Duration:		1 Year	1 Year
Operations Start Year:		2027	2027
Business ownership:		Integrators-owned Special Purpose Vehicle	Integrators-owned Special Purpose Vehicle
Business Type:		4 Processing SPVs	1 Processing SPVs
Recommended Equity Model		Joint Ventures (JV)	Joint Ventures (JV)
Target Annual Production (Cassava Starch):		400,000Mt of Cassava Starch	100,000Mt of Cassava Starch
Domestic Sales (Nigerian Market)	80%	320,000Mt of Cassava Starch	80,000Mt of Cassava Starch
Export Sales (International Market)	20%	80,000Mt of Cassava Starch	20,000Mt of Cassava Starch
Processing Plants Raw Materials Use Ratio:			
Cassava Chips	20%	100,000Mt	20,000Mt
Cassava Fresh Tubers	80%	1,600,000Mt	400,000Mt
Operational Days Yearly		300 days yearly	300 days yearly
Equity + Debt Financing		₦739,442,554,465.97	₦184,860,638,616.49
Loan Intereest Rate		27.5%	27.5%
Moratorium (Grace Period)		3 Year	3 Year
Loan Tenor		9 Year	9 Year

Source; Researcher's Model Analysis, (2025)

Table 4.18: Investment Analysis of the Cassava Starch Processing Segment

ECONOMIC ANALYSIS	
Benefit Cost Ratio (BCR):	1.53
Internal Rate of Returns (IRR):	39.6%
Net Present Value (NPV):	₦3,581,606,901,724.58
Average Annual GDP Contribution:	₦519,725,028,166.93
Average Annual Net Earning of the Firms	₦129,931,257,041.73 per SPV
Average Annual Income per Staff	₦382,150,756.01 per Staff
Number of staff (Direct)	1360 workers
Tax Contribution for the period	₦667,080,006,895.89

Source; Researcher's Model Analysis, (2025)

The segment as the hinge point of the model proposes that four(4) cassava starch processing companies with the full compliments of the integration model will produce 400,000Mt of cassava starch yearly. The segment split across 4 States requires an investment of ₦739.4 billion at cost of capital of 27.5% cumulative average of the forecast interest rate for the 9-year loan tenor.

The segment projected benefit cost ratio BCR is 1.53, with a Net Present Value NPV is ₦3.5 trillion and an internal Rate of Returns (IRR) of 39.6% which is greater than the discount rate (cost of capital of 27.5%). The NPV >0, BCR >1, and IRR > Discount rate(interest rate) matches all the terms of a project

that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded as suggesting that this segment should be funded.

The cassava starch processing segment across the four States is estimated to directly employ 1,360 direct staff and the segment's average annual contribution to the GDP of Nigeria is ₦519.7 billion, with a project cumulative tax contribution of ₦42 billion by the segment within the lifetime of the project, the horizontal integration of the cassava chipping unit is key in policy making.

4.4 Risk and Impact Analysis

Nigeria: Land, Population, Agriculture in the Economy of Nigeria

For the model, it is necessary to ascertain that necessary requirements of land and labour needs can be easily met without distorting the other food value chains.

The model will provide 11,420 direct job opportunities with average annual income of ₦86. Million add an annual production of 2 million tonnes of cassava to the country's annual production and as such help sustain Nigeria ass the top cassava producing nation.

The model help bridge the demand – supply the gap of 320 tonnes of cassava starch yearly and also export 80,000Mt of cassava starch yearly moving Nigeria from an insignificant exporter of cassava starch to a very significant player in the international cassava starch market.

The model will impact the global market of corn starch annually to an annual average of $28,583,907.00 with the import substitution by Nigeria. Turkey will bear 45% of this global impact with their need to find an alternative market for their corn starch annually worth $14,161,102.00 that Nigeria usually imports. India will also bear 15.8% of the impact, China will bear another 15.8% of the impact while Argentina, Egypt, Brazil, Netherlands, Ukraine, Spain, Saudi Arabia and others will bear the outstanding 23.4% of

the impact of Nigeria substituting the import of corn starch with local production of cassava starch as the compressive cassava starch supply chain integration model proposes.

This can stir a price war in the international market prices of both corn starch and cassava starch.

The annual average of $28,583,907.00 Nigeria will save through the model will have an equally significant impact on the country's balance of trade.

4.4.1 Land and Population risks

According to TradingEconomics (2024), Nigeria covers an area of 92.4 million hectares with 82.0 million hectares is cropable representing 88.7% of the lands as shown in Figure 7. And of the cropable lands, only 37.01 million hectares are arable and cropped a utilization of 40.5% leaving 44.99 million Hectares for further development.

The cassava starch supply chain integration model requires 82,000 Hectares of this area not cropped as shown as available in Figure 7 without distorting productions in other value chains. The model seeks to acquire the lands through government support or partnerships and then clear, develop and dedicate the lands to the cassava starch supply chain.

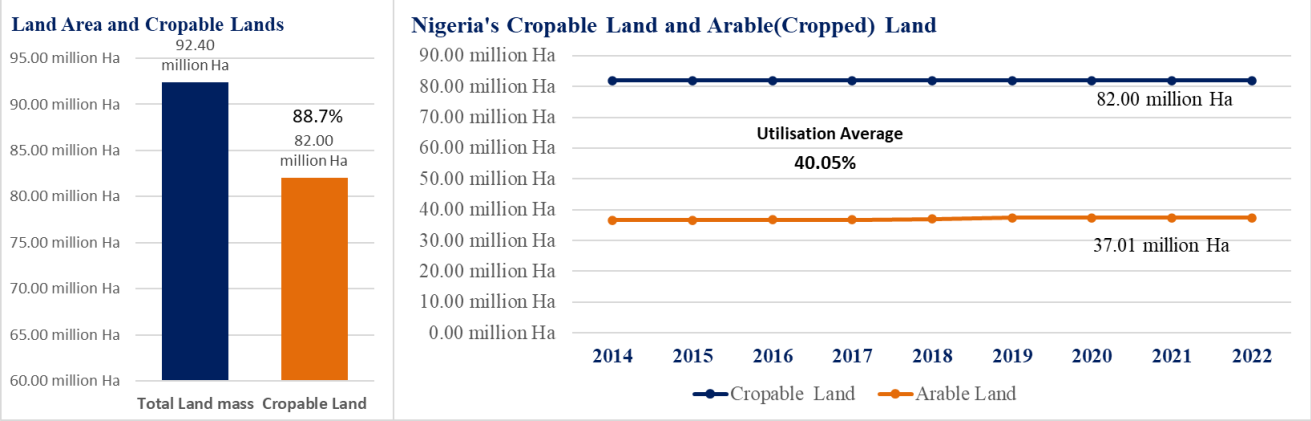


Figure 8: Land Area and Cropable Lands (Historical & Forecast 2014 - 2035)

Source; Trading Economics Data (2024), and Researcher Analysis (2024)

https://tradingeconomics.com/nigeria/arable-land-percent-of-land-area-wb-data.html

According to Worldometer (2024) in their analysis of United Nation's data, the current population of Nigeria is 234,730,395 as of Wednesday, December 4, 2024, based on Worldometer's elaboration of the latest United Nations data[1]. Nigeria population is equivalent to 2.85% of the total world population, Nigeria ranks number 6 in the list of countries by population, and the population density in Nigeria is 255 per Km^2 (662 people per mi^2) with 53.9 % of the population urban (125,447,884 people in 2024) and the median age in Nigeria is 17.9 years (Worldometer 2024).

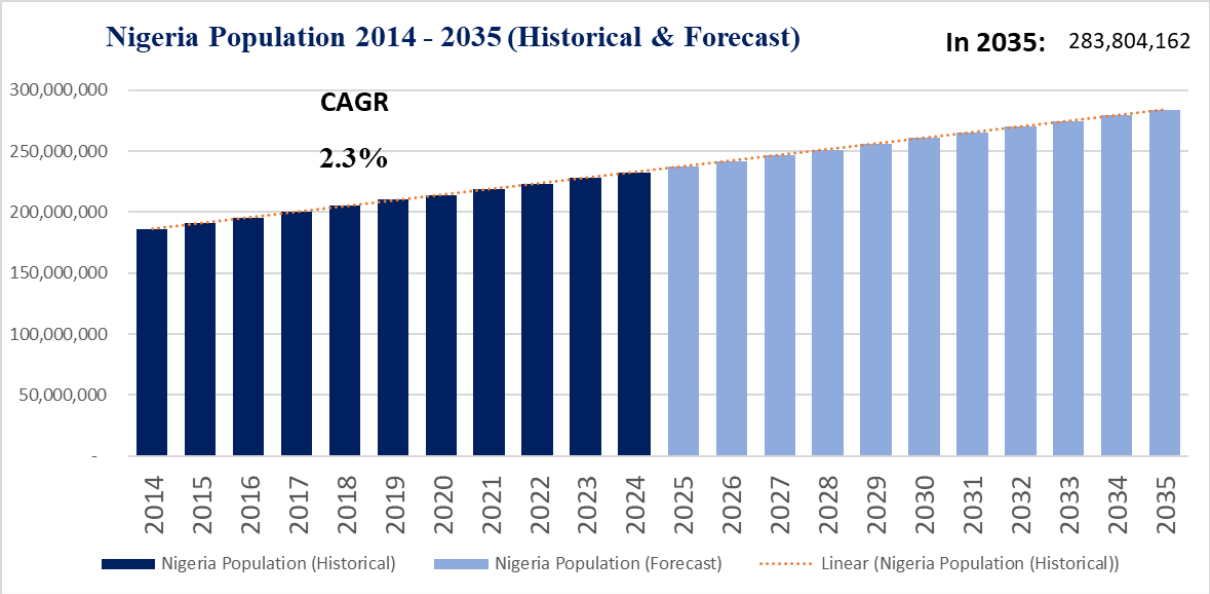


Figure 9: Nigeria's Population (Historical & Forecast 2014 - 2035)

Source; Worldometer United Nations Data (2024), and Researcher's Analysis (2024)

www.Worldometers.info

As shown in Figure 7, the population of Nigeria is increasing at a compounded annual average of 2.3% and the population is forecast to increase to 283,804,162 by 2035.

4.4.2 Agriculture in Nigeria's Economy (GDP)

Agriculture was the mainstay of Nigeria economy before the discovery of crude oil. From 1960 to 1969, the sector contributed an average of 57% of the GDP and generated 64.5% of the export earnings. According to PwC (2020), Agriculture is Nigeria's single largest economic sector and the sector is highly concentrated on crop production, which accounts for 90% of output. Fishery, forestry, and livestock account for the remaining 10%.

Despite several agricultural intervention policies between 2012 and today, the Nigerian agricultural sector is still largely underdeveloped primarily because focus is on production, rather than on enhancing value addition across value chain segments. (PwC, 2020). Also, Nigeria's value chain is characterized by 80% small-holder farmers and a few commercial processors plagued by inadequate inputs, obsolete technology, and poor financing; (Mgbenka & Mbah, 2016).

According to PwC 2020, though agriculture makes up a sizeable portion of economic activities in Nigeria, the sector's impact on government and export revenue is relatively small, accounting for only 4.8% of the total foreign earnings in 2019.

Table 4.19: Nigeria GDP & Agriculture contribution to GDP 2014 - 2024

Year	Agric GDP Contribution (USD Billion)	Nigeria GDP (USD Billion)	Percentage
2014	$107.98	$574.18	20.76%
2015	$114.78	$493.03	19.99%
2016	$101.71	$404.65	20.63%
2017	$84.69	$375.75	20.93%
2018	$78.34	$421.74	20.85%
2019	$89.41	$474.52	21.20%
2020	$103.97	$432.20	21.91%
2021	$104.33	$440.83	24.14%
2022	$102.98	$477.40	23.36%
2023	$113.10	$363.85	23.69%
2024	$82.67	$371.49	22.72%
GDP (CAGR)	**-3.5%**	$439.06	
Agric to GDP (CAGR)	-1.03%	$98.54	
Agric to GDP (Average)	21.83%		

Source; Data From World Bank Records, 2024 Researcher Analysis

https://tradingeconomics.com/nigeria/gdp

https://www.statista.com/statistics/382311/nigeria-gdp-distribution-across-economic-sectors/

From the result of the study the relationship as shown in Table 4, the average contribution of the Agriculture to the Gross Domestic Product of Nigeria between 2014 and 2024 was 21.83%. The compound annual growth(CAGR) in Nigeria's GDP was -3.5% and the compound annual growth(CAGR) of Agricultural sector contribution to the GDP was -1.03%. This can be interpreted that Nigeria's Gross Domestic Product(GDP) is dropping yearly at 3.5% and that the contribution of the agricultural sector to the GDP is dropping yearly by 1.03%.

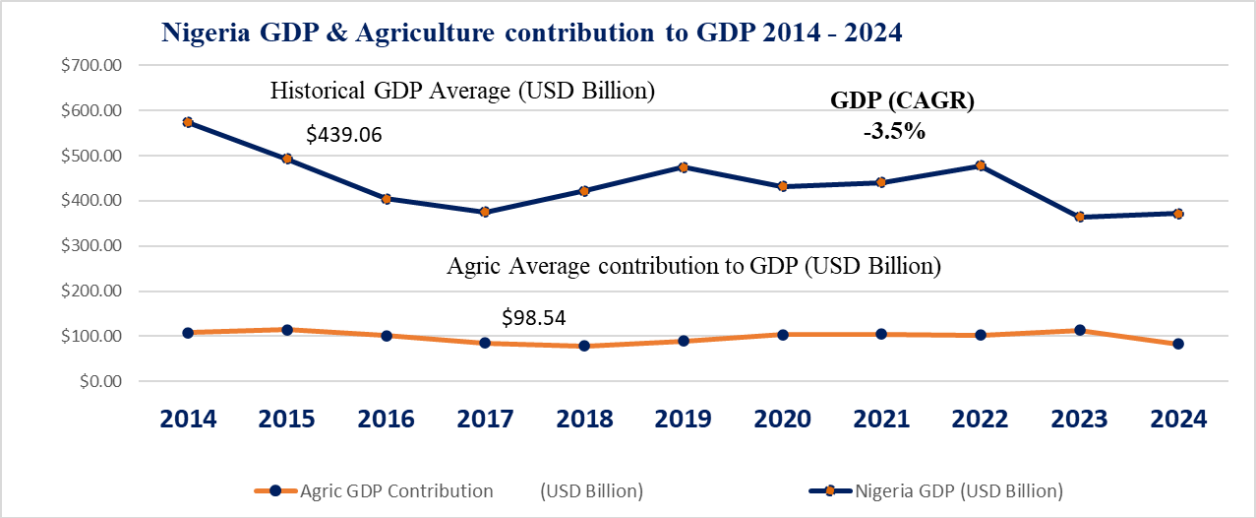


Figure 10: Trend of Nigeria's Agriculture contribution to the GDP (2014 – 2024)

Source; Data from Statista (2024), and Researcher's Analysis (2024)

https://www.statista.com/statistics/382311/nigeria-gdp-distribution-across-economic-sectors/

Table 4.20: Nigeria GDP & Agriculture contribution to GDP 2014 - 2024

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.385798384
R Square	0.148840393
Adjusted R Square	0.054267103
Standard Error	61.2452606
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5903.333045	5903.333045	1.573810039	0.241254421
Residual	9	33758.83752	3750.981947		
Total	10	39662.17056			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	249.3231973	152.3647585	1.636357381	0.136192517	-95.34983259	593.9962272
Agric Contribution to GDP (USD Billion)	1.925435538	1.534803665	1.254515859	0.241254421	-1.546531567	5.397402643

Source; Data from World Bank Records (2024), and Researcher's Analysis (2024)

From Figure 10, between 2014 and 2024, Nigeria's Annual GDP averaged US$439.06 billion while the contribution of the agriculture sector averaged US$98.54 Billion yearly. The decreasing trend in the annual GDP and the contribution by the agriculture sector also shows in Figure 10

With the GDP average contribution of agriculture to the economy at 21.83% between 2014 and 2024 as against the average contribution of 57% between 1960 and 1969, it is clear that a wholistic value chain policy is required to improve the contribution of agriculture sector to the GDP and with it improve the country's GDP. The relationship between Nigeria's GDP and contribution of Agriculture to the GDP is shown from a regression analysis with $\mathbf{R^2}$ of 14.88% implying a 14.88% change in the GDP is explained by Agriculture's contribution to the GDP. The relationship is shown in the regression equation below:

$$Y_{GDP} = 1.9254X_{Agric} + 249.3239 + \varepsilon$$

Where:

$\mathbf{Y_{GDP}}$ is Nigeria's Annual GDP

$\mathbf{X_{Agric}}$ is Agric sector contribution to the GDP

ε represents the error term.

4.4.3 Nigeria's GDP per Capita (Average Income of the Populace)

According to ActionAid Nigeria 2023, 70 million Nigerians live below US$1.9 a day with 89% of the in the rural areas and 11% in urban areas.

The demand for consumer products is a function of the income amongst other factors. The cassava starch is used in many consumer products in foods, textile, pharmaceuticals, paper, and others and the demand may be related to the disposable income of the consumers. The per capita GDP could be applied as the per capita income. The income of the farmers and other stakeholders in the cassava starch supply chain will be compared against the national GDP to see the impact of the model.

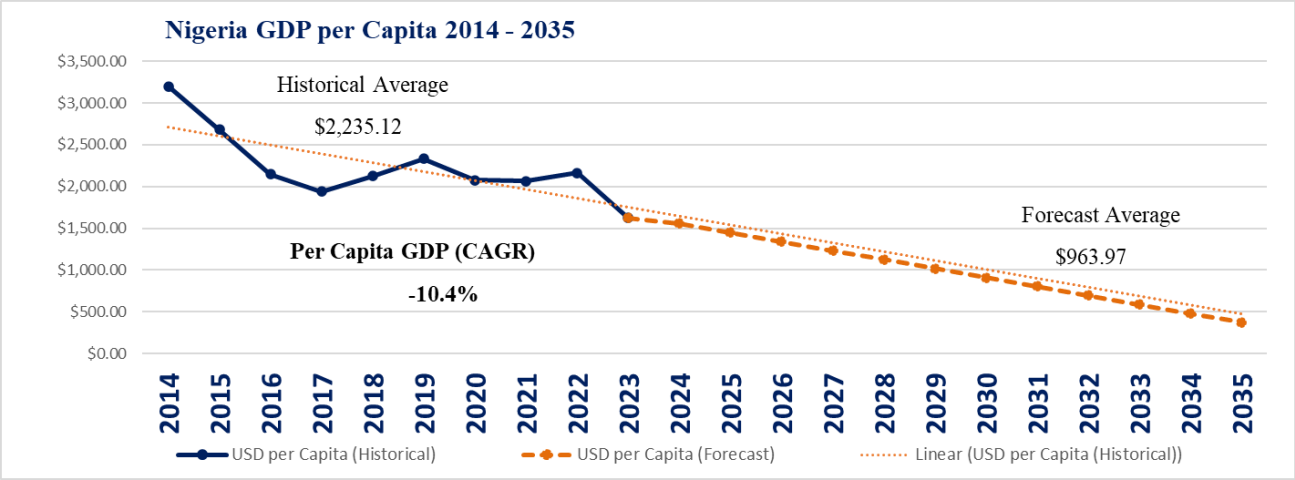


Figure 11: Nigeria's GDP per Capita 2014 - 2024

Source; Data from World Bank Records (2024) and Researcher's Analysis (2024)

www.worldbank.org

From Figure 10, between 2014 and 2024, Nigeria's GDP per Capita averaged US$2,235.12 but dropping from US$3,200.95 in 2014 to US$1,621.12 in 2023 decreasing at 10.4% yearly. A forecast for the period of the proposed cassava starch model showed that the GDP average between 2025 and 2035 will be about US$963.97 with the GDP by 2035 as low as US$372.95. This calls for a drastic macroeconomic action.

Table 4.21: GDP per Capita with Population, Time, Inflation, Exchange Rate & GDP

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999566268
R Square	0.999132724
Adjusted R Square	0.998048629
Standard Error	19.10205399
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1681457.867	336291.5734	921.628399	3.28788E-06
Residual	4	1459.553867	364.8884667		
Total	9	1682917.421			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	105527.9401	236542.3824	0.446126986	0.678590413	-551218.9997	762274.8798
Year	-51.98790111	119.8045934	-0.433939131	0.686712382	-384.6187781	280.6429758
Nigeria Population	-4.56467E-06	2.54446E-05	-0.179396116	0.866347466	-7.52103E-05	6.60809E-05
Inflation rate	-0.859545005	271.307642	-0.003168156	0.997623888	-754.1303196	752.4112296
Exchange Rate	0.416367575	0.099159647	4.198961854	0.013707253	0.141056259	0.691678891
GDP USD Billion	5.487745318	0.134764676	40.7209476	2.17338E-06	5.113578592	5.861912043

Source; Data from World Bank Records (2024) and Researcher's Analysis (2024)

From Table 4.21, a regression analysis with $\mathbf{R^2}$ of 99.91% implies that Time (in Years), Population, Inflation rate, Exchange rate and the National GDP are responsible for 99.91% change in the GDP per capita of Nigeria.

The regression relationship is shown in the regression equation below:

$$\mathbf{Y_{GDP\ per\ Capita} = 5.4877X_{GDP} - 4.56466E\text{-}06\ X_{Po} - 51.9879\,X_{Ti} - 0.8595\,X_{In} + 0.4164\,X_{Exc} + 0.4164 + 105527.94 + \varepsilon}$$

Where:

$\mathbf{Y_{GDP\ per\ Capita}}$ is Nigeria's GDP per capita

$\mathbf{X_{GDP}}$ is the GDP

$\mathbf{X_{Po}}$ is Nigeria's Population

$\mathbf{X_{Ti}}$ is Time (in Years)

$\mathbf{X_{In}}$ is the Inflation Rate

$\mathbf{X_{Exc}}$ is Exchange Rate US$ to Naira

$\boldsymbol{\varepsilon}$ represents the error term.

4.5 Nigeria in Global Cassava and Cassava Starch

The demand for cassava and its constituents is high in the domestic economy. Unfortunately, the supply has not been able to meet the huge demand, PwC 2020. Ordinarily a country producing cassava is expected to be producing the derivatives of cassava in a relatively equal measure given that cassava tubers are the major feedstock in cassava derivatives industry.

According to PwC 2020, Nigeria has the economic potentials to generate US$427.2 million from domestic value addition and derive income of US$2.98 billion in agricultural exports of cassava. Furthermore, the local value addition to cassava via local manufacturing and processing could potentially unlock about US$16 million in taxes to the government.

4.5.1 Nigeria's Cassava Production in the Global Production

Nigeria is a significant player in the global production of cassava.

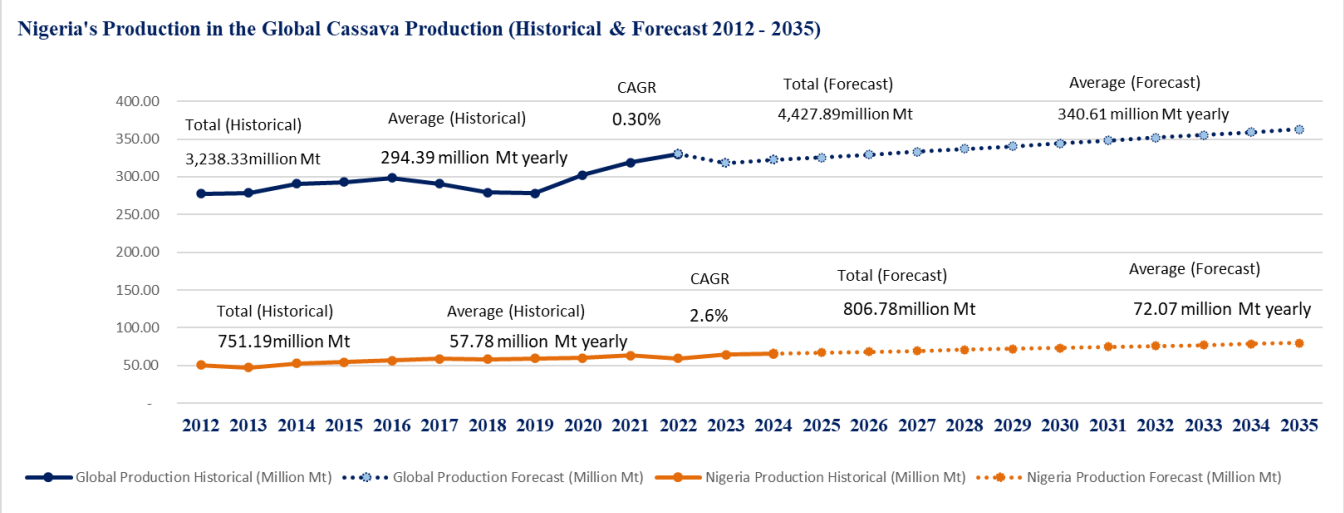


Figure 12: Nigeria's Annual Cassava Starch Demand vs Supply 2020

Source; FAO (2020), World Bank (2024) and Researcher's Analysis (2024)

From the Figure 12, it can be seen that between 2012 and 2024, the global production of cassava was 3,238.33 million tonnes at an annual average of 294.39 million tonnes yearly with a compound annual growth rate of 0.3% while Nigeria produced 751.19 million tonnes at an annual average of 57.78 million tonnes yearly at a compound annual growth rate of 2.6%.

Between 2025 and 2035, the world production is forecast to be an annual average of 340.61 million Mt yearly while Nigeria is forecast to produce an average of 72.07 million tonnes of cassava yearly.

Nigeria appears as such to be a significant producer of cassava tubers hence a regression analysis to see the corelation between Nigeria's cassava production and the Global production of cassava as shown in Table 4.22.

Table 4.22: Relationship between the Global and Nigeria's Cassava Production (2012 -2024)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.707896776
R Square	0.501117846
Adjusted R Square	0.455764923
Standard Error	13726598.61
Observations	13

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.0819E+15	2.0819E+15	11.04929543	0.006782439
Residual	11	2.07261E+15	1.8842E+14		
Total	12	4.15452E+15			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	156438802.2	42866280.71	3.649460593	0.003824335	62090754.51	250786849.9
Nigeria Cassava Production	2.456167183	0.738908447	3.324048049	0.006782439	0.829840656	4.08249371

Source; World Bank Data (2024) and Researcher's Analysis (2024)

https://wits.worldbank.org/trade/comtrade/en/country/NGA/year/2012/tradeflow/Imports/partner/ALL/product/110812

Within the period, an $\mathbf{R^2}$ of 50.11% showed a strong positive relationship between Time (Years) and the average price of corn starch imported by Nigeria with the regression equation below

$$\mathbf{Y = 2.45617X + 156438802.21 + \varepsilon}$$

Where:

Y is Nigeria's Average Import Price per Mt

X is Time (Years)

ε represents the error term.

4.5.2 Nigeria's Domestic Demand and Supply of Cassava Starch

The cassava starch supply chain model is targets ensuring that Nigeria is self-sufficient in cassava starch given the country's leading position in cassava production. Nigeria's corn starch import was summarized from the world bank corn starch trade records between 2014 and 2023 to

It also aims at Nigeria becoming a significant player in the global cassava starch export trade.

Establishing the current domestic market status in terms of equilibrium or imbalance between domestic cassava starch supply and the demand is necessary.

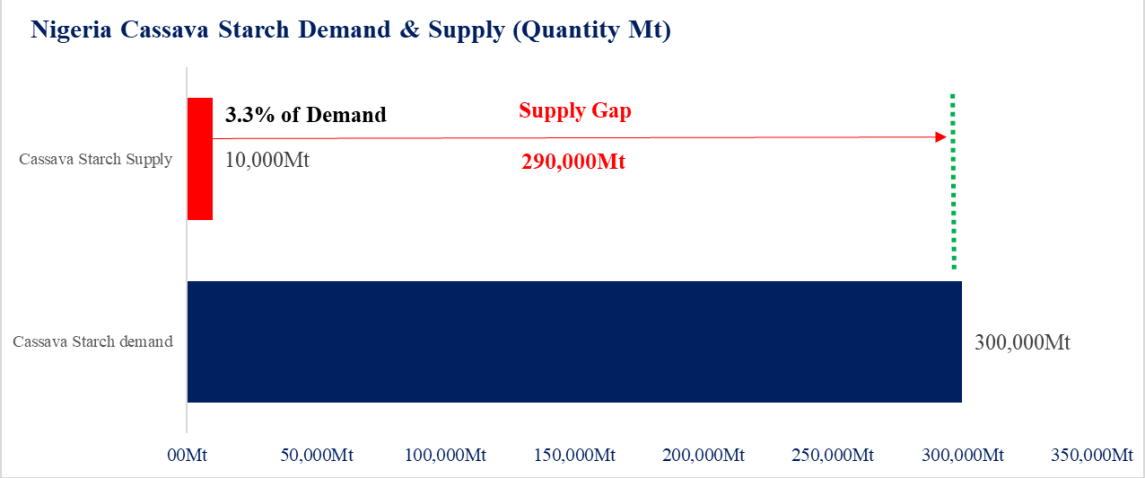


Figure 13: Nigeria's Annual Cassava Starch Demand vs Supply 2020

Source; PwC Data (2020) and Researcher Analysis (2024)

As shown in Figure 13, the annual average cassava starch demand by the dependent industries is 300,000 tonnes while the local supply of cassava starch is 10,000 tonnes meeting only 3.3% of the local demand.

This leaves the dependent industries which include sweeteners: glucose, fructose and sorbitol(in toothpastes), modified starch: animal feed, cationic (paper and textiles), foods and glues.

These industries resort to importation in efforts to breach the gap and as such import corn starch instead with the ban on importation of cassava starch.

The cassava starch supply chain model proposed is aimed at closing this 290,000 tonnes gap between the demand and supply of cassava starch without distorting the local direct local consumption of cassava as food , substituting the importation of corn starch and exporting cassava starch. It is therefore important to explore the potentials of Nigeria in the cassava starch supply chain and the opportunities that can accrue to an efficient supply chain.

4.6 Nigeria's Corn Starch Import as substitute of Domestic Demand Cassava Starch

The starch-dependent domestic industries resort to importation to buffer the supply – demand gap and as such import corn starch with the importation of cassava starch banned in Nigeria. For the impact of the cassava starch model on international shocks, the corn starch importation was evaluated.

Table 4.23: Nigeria's Corn Starch Import History (2014-2023)

Year	Corn Starch Price	Quantity(Mt)	Trade Value (US$)	Trade Value (Naira)
2014	$651.61 per Mt	44,104.26Mt	$28,738,720.00	₦4,556,524,056.00
2015	$507.60 per Mt	32,876.81Mt	$16,688,170.00	₦3,211,471,434.80
2016	$525.95 per Mt	46,611.71Mt	$24,515,390.00	₦6,214,406,211.10
2017	$489.45 per Mt	61,260.40Mt	$29,983,670.00	₦9,168,706,449.30
2018	$448.41 per Mt	39,297.82Mt	$17,621,590.00	₦5,393,616,267.20
2019	$430.91 per Mt	75,089.62Mt	$32,356,760.00	₦9,930,936,779.20
2020	$558.07 per Mt	100,790.78Mt	$56,248,180.00	₦20,182,409,465.80
2021	$660.32 per Mt	83,052.36Mt	$54,841,380.00	₦21,999,619,587.00
2022	$878.14 per Mt	36,299.39Mt	$31,876,120.00	₦13,578,589,597.60
2023	$685.26 per Mt	31,452.25Mt	$21,553,000.00	₦15,940,814,330.00
		Import (Quantity)	**Import Trade Value (US$)**	**Import Trade Value (US$)**
	Total Import:	550,835.40Mt	$314,422,980.00	₦110,177,094,178.00
	Annual Import Average:	55,083.54Mt yearly	$31,442,298.00 Yearly	₦11,017,709,417.80 Yearly
	Corn Starch Import Price Average:	$583.57 per Mt		

Source; World Bank Data (2024) and Researcher's Analysis (2024)

https://wits.worldbank.org/trade/comtrade/en/country/NGA/year/2012/tradeflow/Imports/partner/ALL/product/110812

4.6.1 Nigeria's Import Price of Corn Starch (Historical & Forecast 2014-2035)

In Table 4.23, the historical annual average prices for imported corn starch in Nigeria between 2014 and 2024 showed an average price of $583.57 per metric ton with a maximum of $878.14 per Mt in 2022 and a minimum of $430.91 per Mt in 2019.

Within the historical period, an $\mathbf{R^2}$ of 99.72% showed a strong positive relationship between Time (Years) and the average price of corn starch imported by Nigeria with the regression equation below

$$\mathbf{Y = 23.246X + 466.96 + \varepsilon}$$

Where:

Y is Nigeria's Average Import Price per Mt

X is Time (Years)

ε represents the error term.

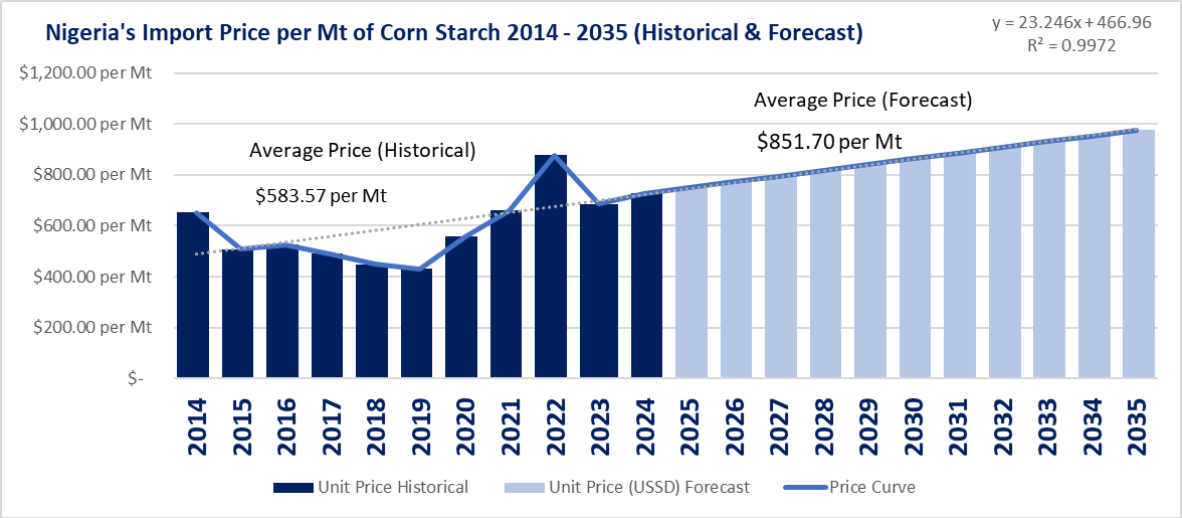


Figure 14: Nigeria's Import Price of Corn Starch (Historical & Forecast 2014-2035)

Source; World Bank Data (2024) and Researcher's Analysis (2024)

A linear forecast of the average import price of corn starch for the Investment Project period of the cassava starch supply chain integration model showed that Nigeria will import corn starch at an average

price of $851.7 per metric ton between 2025 and 2035. If Nigeria does not substitute the importation of corn starch within the period, the country will be left with importing corn starch at this average price.

4.6.2 Nigeria's Import Price of Corn Starch vs Global Export Market Average

Figure 15 compares the annual average price at which Nigeria imported corn starch as against the Global annual average price of corn starch. The market price of corn starch globally appeared to vary between each trade partnership between the trading countries. Between 2014 and 2024, the international market average price was $519.83 per metric ton while Nigeria imported at an average of $583.57 which is higher than the global average by $63.75 per metric ton.

Through the period, Nigeria imported corn starch at a price higher than the global market average except in 2018, 2019 and 2024 when the country imported at near global average and in 2023 the only period when Nigeria imported at an average price lower than the global average.

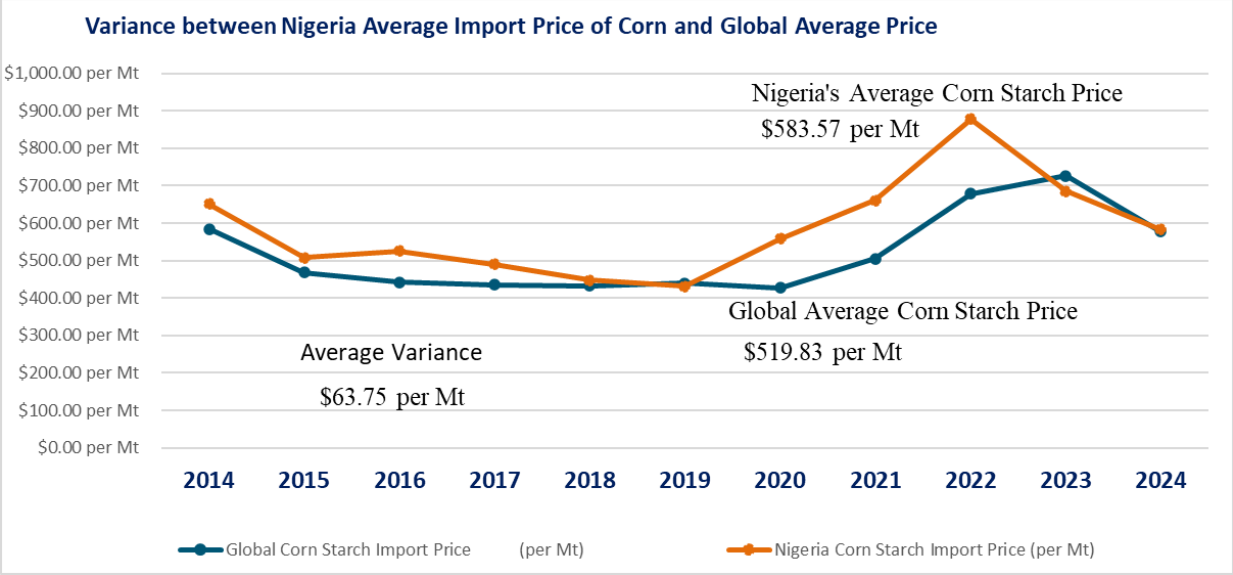


Figure 15: Nigeria's Import Price of Corn Starch vs International Market Average Price (2014-2023)

Source; World Bank Data (2024) and Researcher's Analysis (2024)

This shows that the importing firms in Nigeria were willing within that period to import at higher average price per ton and that the corn starch trade partnering countries were only willing to sell to Nigerian importers at averages above the global average prices.

4.6.3 Nigeria's Corn Starch Import Quantity and Trade Value (Demand)

Figure 16 and Figure 17 show the historical quantities and trade values of corn starch imported by Nigeria between 2014 and 2024 and the forecast corn starch import quantities and trade values between 2025 and 2035 based on the historical data and covering the project life of the proposed Investment model in the cassava starch supply chain.

Given that the corn starch is imported as a substitute to cassava starch with the importation of the later banned in Nigeria, it is necessary to establish the corn starch import quantities and the trade values of the import over time, forecast the import quantities and the respective trade values to establish the quantities and values of cassava starch that the proposed model will produce to completely substitute the importation of corn starch.

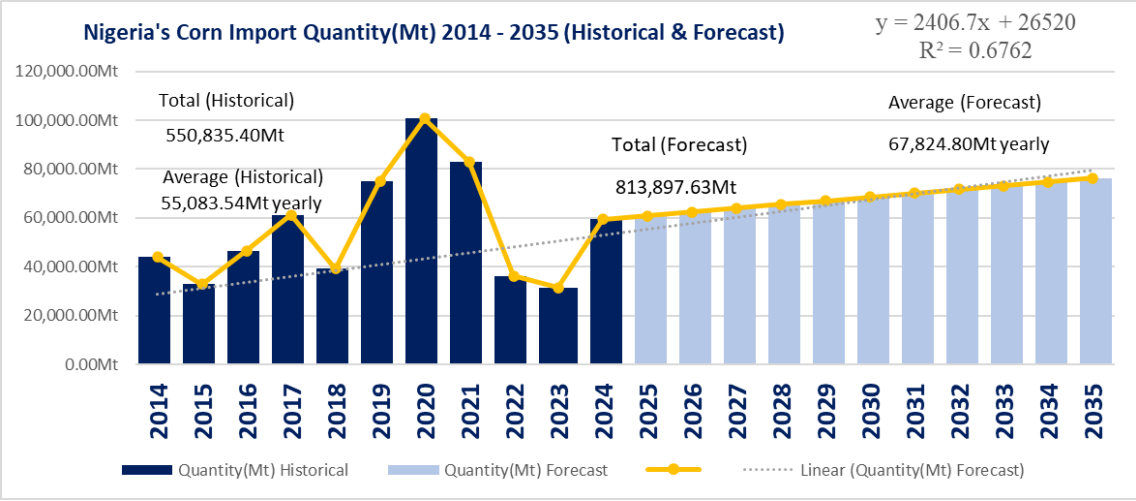


Figure 16: Nigeria's Corn Starch Import Quantity (History & Forecast 2014-2023)

Source; World Bank Data (2024) and Researcher's Analysis (2024)

https://wits.worldbank.org/trade/comtrade/en/country/NGA/year/2012/tradeflow/Imports/partner/ALL/product/110812

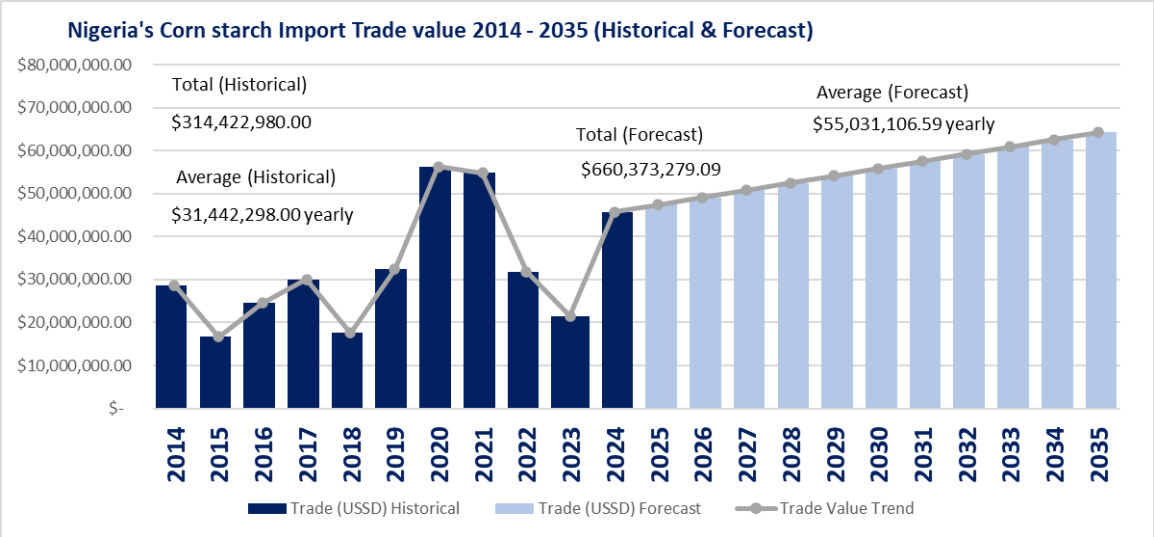


Figure 17: Nigeria's Corn Starch Import Trade Value (History & Forecast 2014-2023)

Source; World Bank Data (2024) and Researcher's Analysis (2024)

https://wits.worldbank.org/trade/comtrade/en/country/NGA/year/2012/tradeflow/Imports/partner/ALL/product/110812

From Figure 16 and Figure 17 above, a total of 550,835Mt of corn starch worth $314,422,980 was imported between 2014 and 2024 with an average annual import of 55,083Mt per annum year at an average trade value of $31,442,298 per year. A forecast based on this historical data shows that Nigeria will import a total of 813,897.63 tonnes of corn starch projected to be worth $660,373,279.09 an average of $55,031,106.59 between 2025 and 2035.

This necessitates a sound corn starch import substitution policy for Nigeria. The policy will be such that should completely substitute corn starch importation with domestic cassava starch production making a total ban of corn starch possible.

A strong positive relationship between time (in years) and Nigeria's corn starch importation was seen from a regression analysis with $\mathbf{R^2}$ of 67.62% with the regression equation below:

$$\mathbf{Y_{import} = 2406.7X_{time} + 26520 + \varepsilon}$$

Where: $\mathbf{Y_{import}}$ is Nigeria's Average annual Corn starch Import

$\mathbf{X_{time}}$ is Time (Years)

$\boldsymbol{\varepsilon}$ represents the error term.

4.6.4 Nigeria's Major Corn Starch Import Partners (Sources)

Nigeria's corn starch import was summarized from the world bank corn starch trade records between 2014 and 2023 to isolate the countries which are sources of the corn starch imported by Nigeria. Figure 18 shows that the bulk of corn starch imported by Nigeria within the period were from Turkey (45%), India (15.8%), China (15.8%), Argentina (4.6%), Egypt (3.2%), Brazil (2.7%), Netherlands (2.6%) Ukraine (2.3%), Spain (2.2%), South Africa (1.6%) and (4.1%) from other countries.

Replacing the imported corn starch with cassava starch produced domestically will imply that these countries will have to look for alternative export destination for their corn starch or devise domestic consumption for the corn starch.

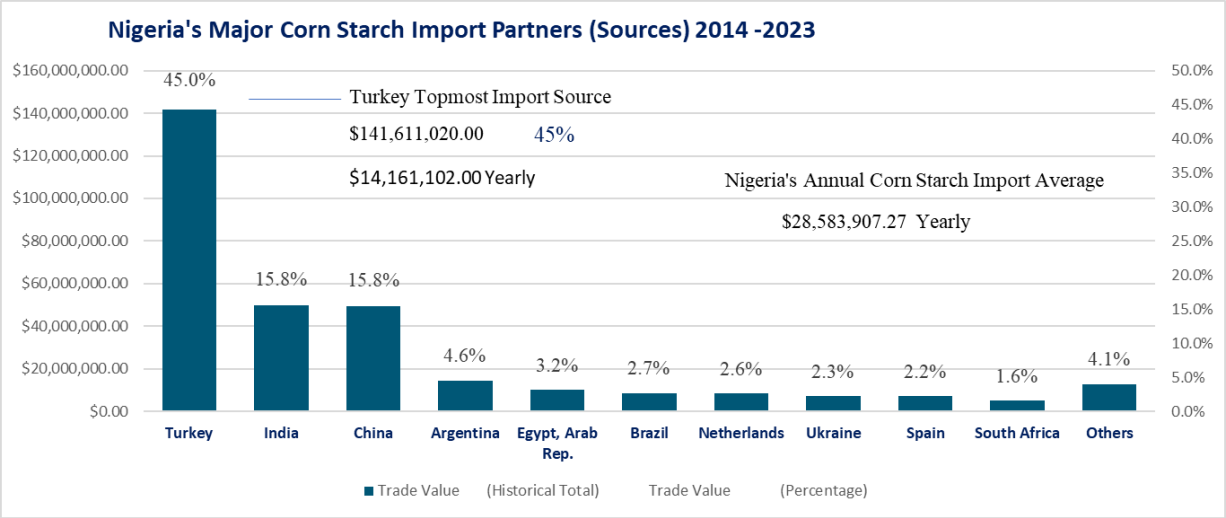


Figure 18: Nigeria's Corn Starch Import Partners (2014-2023)

Source; World Bank Data (2024) and Researcher's Analysis (2024)

Turkey the major source which is the most significant source as seen in Figure 18 will have to look for alternative international or domestic markets for corn starch worth $14,161,102.00 every year. The countries listed above will have to look for market for corn starch worth total volume of about 813,897.63 tonnes of corn starch with a projected trade value of about $660,373,279.09 between 2026 and 2035 at an annual average 67,824.80Mt valued at of $55,031,106.59 yearly.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

The broad objective of this study was to evaluate the domestic and international implications of a comprehensive cassava starch supply chain model with vertical and horizontal linkages in Nigeria for expanding Nigeria's annual Cassava Starch production by 400,000Mt. The specific objectives were to develop a hypothetical expansion model for the Nigerian Food grade Cassava Starch supply chain that captures the vertical and horizontal linkages for 400,000Mt of cassava starch annually, carry out Investment analysis to determine the economic viability and sustainability of introducing the cassava starch production model into Nigeria's starch production chain, carry out a stakeholder analysis to assess the distributive impacts of the externalities obtained in order to determine the benefits or loss to the various stakeholders involved and the magnitude of the benefit or loss, conduct a risk analysis to identify the risk associated with the project implementation in order to institute appropriate contractual arrangements to reduce or mitigate the overall risk exposure.

To achieve these objectives, a multi-stage sampling procedure was used. Stage one involved collection of the global data for cassava production and consumption, starch production, consumption, import and export identifying the key stakeholders especially those that the proposed model may impact. Stage two was the collection of the Nigerian data on cassava production, processing, consumption, starch processing, consumption, import and export. The third and final stage was the selection of four (4) States : Edo, Oyo, Benue and Enugu States based on their agroecological comparative advantage from the most suitable Agro-ecological zone for the cultivation of cassava based on combined data for soils, mean rainfall, mean temperature, temperature range and the length of growing season in Nigeria.

The analytical tools used were descriptive statistics in analysing the local demand and supply of cassava starch, global production of cassava and cassava starch, global market of corn starch. The relationships, the degree of relationships and possibilities of factors like Exchange rate, Population, Prices, Demand, Supply, Interest rates, Inflation rates, and other dynamics were evaluated with multiple regression analyses.

The investment analysis was done using the Net Present Value(NPV), Internal Rate of Returns(IRR) and Benefits – Costs Ratio(BCR) calculations for each segment of the model and for the whole model. For the Farm Inputs segment the Benefit – Cost Ratio (BCR) was 1.22, the internal Rate of Returns (IRR) was 33.0% with interest rate of 15% and the Net Present Value(NPV) was ₦170,027,760,841.18. For the Tractor Services segment, a BCR of 1.48, an internal Rate of Returns (IRR) of 37.6% with cost of capital of 27.5%, and Net Present Value of ₦317,899,434,725.76 were obtained. An investment analysis of the Integrator Farming segment showed a BCR of 1.37, an NPV of ₦448,443,063,423.36 and an IRR of 35.6% at the discount rate (cost of capital) of 15%. The BCR of the Cooperative Farming segment is 1.49, with an NPV of ₦1.05 trillion and an IRR)\ of 26.7% at an interest (discount) rate of 15%. Investment analysis of the cassava chips segment indicated a BCR of 1.36, a Net Present Value NPV of ₦554.3 billion and an IRR of 36.5% at a discount rate (cost of capital) of 15%. The BCR of the Haulage segment is 1.54, with an NPV of ₦170.9 billion and an IRR of 36.5% at the discount rate (cost of capital) of 27.5%. The Cassava Starch Processing segment indicated a BCR of 1.53, an NPV of ₦3.5 trillion and an IRR of 39.6% at the discount rate (cost of capital) of 27.5%.

From the Investment analysis for the entire model, the benefit cost ratio BCR is 1.43 which is greater than 1, the Net Present Value of ₦6.3 trillion that is positive, and an internal Rate of Returns (IRR) of 35.1% that is greater than the discount rate (cost of capital of 25.5%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. The NPV >0, BCR >1, and IRR >

Discount rate(interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested should be funded.

The model will provide 11,420 direct job opportunities with average annual income of ₦86. Million add an annual production of 2 million tonnes of cassava to the country's annual production and as such help sustain Nigeria ass the top cassava producing nation.

The model was found to have a positive significant impact on the local economy as it will help cover the demand -supply gap in the cassava starch sub-sector, guaranteeing the locally dependent industries involved in further value-addition, the core raw material to thrive without impact of the variations in the exchange rates. This gap is annually found to be 320 tonnes of cassava starch. The model also projects to produces additional 80,000Mt of cassava starch yearly for export annually worth $38,497,285.49 (₦55,821,063,956.42) while saving Nigeria a further $28,583,907.00 in the substitution of corns starch import with the local production of cassava starch. This will majorly affect Turkey from where Nigeria usually imports 45% ($14,161,102.00) of and India and China each will also bear about 15.8% of the impact leaving Argentina, Egypt, Brazil, Netherlands, Ukraine, Spain, Saudi Arabia and others with the task of seeking markets alternative to Nigeria that can offtake the outstanding 23.4% of the corn starch that Nigeria usually imported annually. With the investment analysis of the entire model,

the benefit cost ratio BCR obtained is 1.43 which is greater than 1, the Net Present Value is ₦6.3 trillion that is positive, and the internal Rate of Returns (IRR) is 35.1% that is greater than the discount rate (cost of capital of 25.5%) which is the forecast average from the historical average of the commercial interest rates in the last 10 years. The NPV >0, BCR >1, and IRR > Discount rate(interest rate) matches all the terms of a project that Pannell, Nguyen, Loncg Chu and Kompas, 2024, suggested the model should be funded. The model will also provide 11,420 direct job opportunities with average annual income of ₦86.

Million, add an annual production of 2 million tonnes of cassava to the country's annual production of cassava helping keep Nigeria as the topmost cassava producing nation in the world.

The possible risks are changes in government affecting the model, poor execution by the involved stakeholders and possibility of the model not being able to raise the required capital to invest towards actualizing the additional 400,000Mt cassava starch production yearly.

5.2 Conclusion

The study observed that it is economically viable and sustainable to invest in the cassava starch model towards annually producing 400,000Mt of cassava starch. This shows that the investment can return invested funds at the interest rate prevalent, and still bring in significant returns on investment with a good positive net present value of the income streams. The model is also significant in job creation, improvement of the gross domestic product (GDP), significant import substitution of corn starch, earning of foreign exchange by the export of the production excess for domestic consumption and sustenance of the value-adding industries dependent on starch for their productions in the health, food, and other dependent industrial sectors.

5.3 Contribution of the study to Knowledge

The results of the historical data analysis and forecast showed the Exchange rates, Interest rates, Inflation rates, population growth rates, land availability for similar agricultural investments, and the possible domestic and international implications of a model like the comprehensive cassava supply chain model as proposed.

The findings also offer relevant information for policy making in Farm Inputs, Tractor services, cooperative contract farming, commercial cassava farming, cassava chips production, haulage of cassava and cassava chips, and cassava starch production.

The study also shows the cross-elasticities between the cassava starch and the corn starch prices in the international market relevant for policy making. The impact analysis also prepares the policy makers for the possible global market disturbances in corn starch and cassava starch markets.

5.4 Recommendations

Based on the findings of this study, to balance the domestic demand and supply of cassava starch, the importation of corn starch should be substituted with local production of cassava starch. And also, to earn significant foreign exchange from the export of cassava starch, the following are recommended:

1) Considering the economic viability of the proposed model, the federal and state governments should consider policies that will encourage local and international investors to invest in the model. Provision of assistance in land acquisition, aggregation of farmers for the cooperative involvement and restrictions in the importation of corn starch and favourable tax conditions for local production of cassava starch are suggested.
2) That the federal government should consider all the segments of the cassava starch supply chain model in policy making. This should include favourable commercial lending interest rates by the commercial banks to ensure that capitalists are encouraged to get involved in them.
3) That researches in other supply chain similar to the cassava starch supply chain be carried out to see the possibilities of stirring domestic industrial productions to match local demands, improving Nigeria's gross domestic product (GDP), balance of trade and per capita income of the citizenry.

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