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The Cassava Value Chain In Mozambique

Carlos Costa
(with contributions by Christopher Delgado)

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The Let's Work Partnership in Mozambique is made possible through a grant from the World Bank's Jobs Umbrella Trust Fund, which is supported by the Department for International Development/UK AID, and the Governments of Norway, Germany, Austria, the Austrian Development Agency, and the Swedish International Development Cooperation Agency.

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ABSTRACT

Cassava is the principal starch in Mozambique, at 30% of calories. It can be stored unharvested up to 30 months, but fresh cassava lasts only 3 days once harvested. Most processing in Mozambique is artisanal, to eliminate cyanogenic glycosides in the 90% of production from pest resistant bitter varieties. Only 6% of production in 2011 was used commercially for non-food, two-thirds for feed and one-third for starch. Low levels of productivity for cassava compared to elsewhere and poor transportation are the main barriers to the development of a processing industry. Unit costs of production range from US$0.09 to US$0.30 U.S. cents per kg. Producers would need to achieve 15 tons/hectare to be commercially viable, compared to average yields between 5 and 9 tons/hectare in Mozambique.

Actions recommended include: adoption of a "Master Plan "; time-limited subsidies for industrial High Quality Cassava Flour, ethanol, and starch; a network of service providers to operate in smallholder areas to deliver improved inputs and extension; promotion of farmers' associations for better access to service providers; research on pest control in sweet varieties; greater availability of global market intelligence; capacity-building for processing; and introduction of legal norms to prevent processors from polluting.

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ABBREVIATIONS

AEFC	African Enterprise Challenge Fund
AIDS	Acquired Immunity Deficiency Syndrome
AMPU	Autonomous Mobile Processing Unit
CAADP	Comprehensive African Agriculture Development Programme
CAGR	Compound Annual Growth Rate
CAP	National Agricultural and Livestock Census
CAVA	Cassava: Adding Value for Africa
CDM	Beers of Mozambique/*Cervejas de Moçambique*
CGIAR	Consortium of International Agricultural Research Centers
CSA	Climate Smart Agriculture
DATCO	Dutch Agricultural Development and Trading Company
DUAT	Direito do Uso e Aproveitamento da Terra (land use rights license)
EC	European Community
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
FAO	Food and Agriculture Organization of the United nations
FAOSTAT	Food and Agricultural Organization Online Statistical Database
GDP	Gross Domestic Product
GHP	Good hygiene practices
GMP	Good management practices
GoM	Government of Mozambique
HIV	Human Immunodeficiency Virus
HQCF	High Quality Cassava Flour
HQCF	High Quality Cassava Flour
IFAD	International Fund for Agriculture Development
IFDC	International Fertilizer Development Center
IIAM	Mozambican National Institute of Agricultural Research
IITA	International Institute of Tropical Agriculture
INNOQ	Instituto de Normação e Qualidade de Moçambique
MIC	Ministry of Industry and Commerce
MSU	Michigan State University
MT	Metric Tons
NEPAD	New Partnership for African Development
NGOs	Non-Governmental Organizations
NRI	Natural Resources Institute (University of Greenwich)
PEDSA	Agricultural Sector Strategic Development Plan
PPP	Public-Private Partnership
PROSUL	Pro-poor Value Chain Development Project
R&D	Research and Development
SADC	Southern Africa Development Community
SARRNET	Southern Africa Root Crops Research Network
SEBRAE	Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (Brazilian service assistance to micro and small enterprises)
SNV	Dutch NGO operating under the program PROSUL
SSA	Sub-Saharan Africa
SWOT	Strengths, Weaknesses, Opportunities and Threats
TIA	Mozambique national survey of smallholder agriculture/*Trabalho do Inquérito Agrícola*
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

This report seeks to identify key elements of cassava production, processing, marketing and consumption in Mozambique necessary to identify opportunities to increase income for smallholders and small-to-medium processors, and to draw greater all benefit for Mozambique from cassava. In particular, the report seeks to point to areas of policy attention capable of attracting a significant amount of private investment into industrial processing and marketing of industrially processed cassava products for both domestic use and export.

Cassava is a tropical food crop whose global production grew at 2.7 percent per annum between 2000 and 2016. Africa accounted for 57 percent of global production in 2016, and by weight cassava is Sub-Saharan Africa's main food starch, about one-third of total by weight. However, Asia and Latin America accounted for most of the industrial use of cassava, a rapidly expanding high value sector that includes: High Quality Cassava Flour (HQCF) with uses as diverse as processed foods and plywood: wet cake for beer-making: ethanol for distillery and pharmaceutical uses; and starch for sweeteners, toothpaste, and cosmetics.

In Mozambique, cassava is also the principal food starch (30 percent of all calories), well ahead of maize, but also plays a food security smoothing role, as in the rest of Africa, in that it can be stored for up to 30 months underground (unharvested). It is also more resilient to climate change than are cereals. However, fresh cassava has a shelf life of only three days once harvested. Over 100 varieties are grown in Mozambique. Most of Mozambique's sweet cassava is produced in the southern coastal region of Inhambane, but most national production is in the Northern provinces. Ninety percent of Mozambique's overall production consists of bitter varieties that are more resistant to pests and diseases, but contain cyanogenic glucosides that need to be eliminated though post-harvest processing for safe consumption as food or feed. Mozambique's average cassava yields are low relative to West Africa and one-half to one-third of Latin American or Asian yields, respectively.

Most cassava processing in Mozambique is non-mechanized and traditional, involving soaking, drying and chipping or grating. This is highly labor-intensive, low-profitability work. Some mobile mechanical processing units are found mostly in the South. Domestic markets are almost primarily for food, with a large majority consumed directly on-farm. Only six percent of production in 2011 was used commercially for non-food, two-thirds for feed and one-third for starch.

An optimistic set of estimates by an international consultancy in 2015 foresaw the possibility of using an upper bound of 212,000 tons of HQCF, cassava ethanol, and cassava industrial starch combined for domestic purposes by 2020, and selling a further 150,000 tons in regional markets (mostly South Africa) that year. Seemingly little progress has been made to date in achieving these levels of use. Further possibilities for trade arise from the fact that farmers in Mozambique consume and often produce both maize and cassava. If maize prices rise in the region, farmers can eat more cassava and sell more maize, and vice versa.

Low levels of productivity for cassava and poor transportation infrastructure in Mozambique are a major barrier to development of a viable larger-scale cassava processing industry, as from one point of view the cost of raw material is high. From the farm point of view, prices offered by industry are too low, perhaps 3 to 4 US cents per kg, which on a small farm does not make the effort worthwhile. Present cost levels, based on a survey by the author in Inhambane Province, is that unit costs of production on rain-fed smallholdings range from an equivalent of 9 to 30 US

cents per kg, under yields ranging from 10 to 3 tons/ha. Producers would need to achieve at least 15 tons/ha to be commercially viable at present market prices, compared to average Mozambique yields that have varied between 5 and 9 tons /ha over the last decade.

Policy over the years has tried to encourage development of the cassava sub-sector. The crop is a priority in the current Agricultural Sector Strategic Development Plan (PEDSA). Beer is normally taxed at 40 percent, but only 10 percent if made with cassava. Biofuels policy favours use of cassava feedstock. Food safety polices however have been lax, which discourages exports of high value-added cassava food products to regional markets.

The Government of Mozambique (GoM) should seek to implement a "Master Plan to Develop Cassava Value Chains" to promote industrial processing and bring together all stakeholders in a Cassava Platform. It will be critical to improve farm yields, and experiences elsewhere, including in West Africa, show that this is possible for smallholders. Since women are prominent in cassava production and processing, gender dimensions should be taken into account in implementation strategies. Germ plasm and pest control measures will be especially important.

1. INTRODUCTION

The purpose of this paper is to highlight key constraints and major activities in cassava value chains in Mozambique. It will assess achievements and limitations and draw lessons and implications for cassava development strategies and interventions to create new and better paid jobs at each level of the cassava value chain. Evidence and insights are taken from review of past studies, surveys, and reports on the worldwide cassava industry and, in particular, of the cassava value chain in Mozambique.

Some insights came from previous author-conducted interviews of field operators, and from visits for the present work to processing units and farms in the Southern region of the country (Maputo, Inhambane, and Gaza). Additional information came from secondary sources, such as firm reports, publicly available research studies, the Government of Mozambique, and the Food and Agricultural Organization (FAO). Collected information and findings are presented in more detail in the attached Annexes. The lack of reliable information on cassava in Mozambique and elsewhere in Africa can make it difficult to draw definitive conclusions, but the existing data begin to narrow issues to concrete questions that can begin to be addressed.

The report points out the need to support farmers to develop their own organizations, to improve access to best agriculture practices, management skills, capacity to become commercial rural service providers.

The Dutch Agricultural Development and Trading Company (DADTCO) is discussed in some detail; it is an example of an innovative business model in the cassava industry that, if improved and replicated, could greatly contribute to value chain growth and tangible benefits to smallholders. DADTCO is a private company established in 2002 in the Netherlands; its approach combines private entrepreneurship with social vision. DADTCO operates in Nigeria and Ghana, in addition to Mozambique. Its approach covers the whole cassava value chain, from input supplies to smallholder farmers, cassava processing, and marketing of the final product in local and international markets.

CleanStar/Ndzilo was another promising innovative initiative focused on processing ethanol from cassava for biofuel powdered cookstoves. The initial conception of the CleanStar/Ndzilo business model was an integrated approach which included stove sales, ethanol production, supply and distribution, there was no reliance on imported or donated ethanol. Unfortunately, the ethanol production was closed and a year later the whole project came to an end (for more information see Annex C).

2. CASSAVA VALUE CHAIN OVERVIEW

2.1 CASSAVA IN THE WORLD

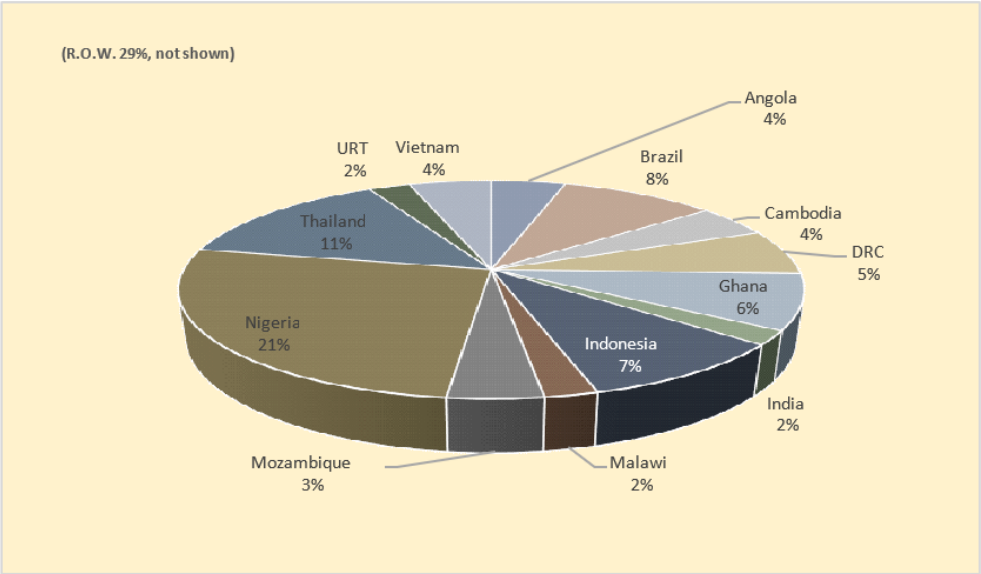
Cassava (*Manihot esculenta Crantz*) is a starchy root crop that can be stored across multiple years underground. It is typically harvested on an annual or biannual basis in tropical and subtropical areas. It is widely consumed across Sub Saharan Africa (SSA), mainly in West and East Africa. It is the most important source of calories in the humid tropics. Cassava is a primary food security crop in Africa due to its storability that allows considerable flexibility across weeks and seasons as to when it is harvested and thus the ability to provide calories on small farms in key deficit periods. It is also resistance to drought and disease, and tolerant to poor soils

Cassava is a fast-expanding tropical food crop on a global scale, apart from Latin America. In 2016 world production of cassava was 277 million tons (FAOSTAT), and the global compound annual growth rate (CAGR) from 2000 to 2016 was 2.7 percent.[1] Africa was the largest producer, accounting for 57 percent of the total. In 2016, cassava was by far the most significant starchy staple produced in Africa by weight, accounting for one-third of the total tonnage produced that year of the total of (in declining contribution by weight): cassava (34 percent), maize (15 percent), yams (14 percent) , rice (7 percent), sorghum (7 percent), Irish potatoes (5 percent), wheat (5 percent), sweet potatoes (5 percent), plantains (4 percent), and millets (3 percent) (FAOSTAT).

More than half (53 percent) of global cassava production is concentrated in five countries: Nigeria, Thailand Brazil, Indonesia, and Ghana (Figure 1 below). This growth has relied primarily on expansion of plantings rather than on rising productivity, except in parts of Asia (Table 1).

[1] Calculated using FAOStat data accessed October 18, 2018, and estimating the CAGR between the mid-points of 2002-2002 and 2014-2016.

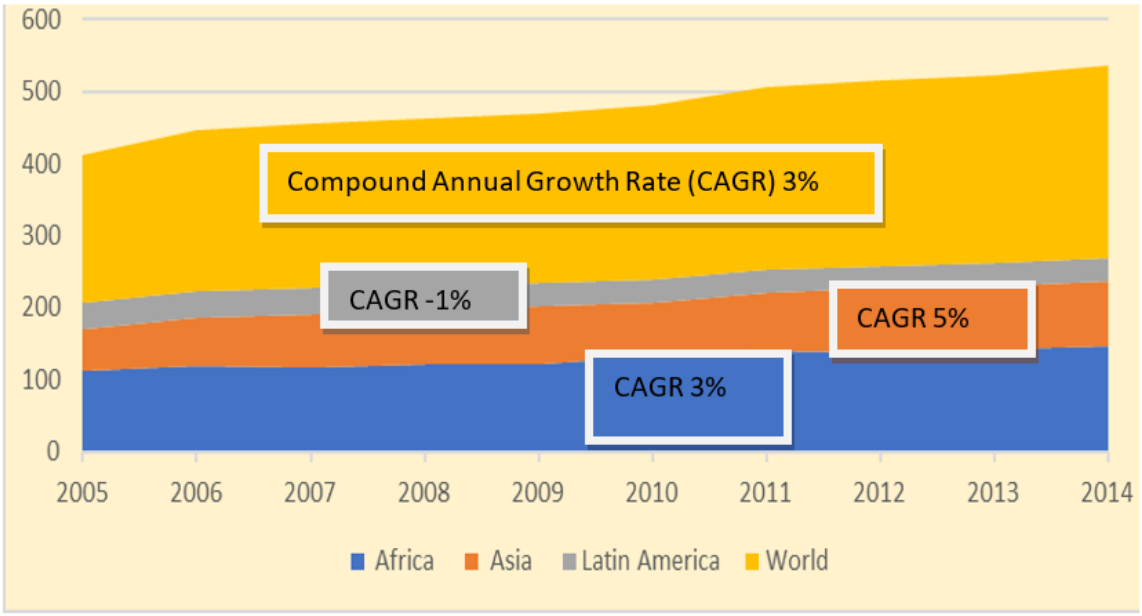
Figure 1: Main Cassava Producers Accounting for 71% of Production in 2016
(% of total shown)



Source: FAOStat

In the last 10 years Africa has claimed in average 55 percent of the total world production, Asia 31 percent, and Latin America 14 percent (Figure 2). Africa has had the average growth of the world while Asian countries registered the fastest growing rates. Nigeria produces alone around 26 percent of the world production (FAOSTAT).

Figure 2: Global cassava production growth 2005-2014
(million tons/year)



Source: FAOStat

Africa is the main world producer, however the levels of productivity per hectare are inferior to the other regions, but Mozambique yields are lower than Africa average (Table 1).

Table 1: Comparative average cassava yields 2000/02 to 2014/16 (metric tons/ha)

	2000-2002	2014-2016
Mozambique	6.0	8.9
Africa	8.8	9.2
South America	13.2	14.2
Asia	14.9	21.6

Source: From annual data in FAOStat, accessed October 18, 2018. The figures are the annual averages for the three-year periods shown.

Thailand—a leader in industrial diversified processing—Vietnam, and Brazil have greatly developed not only the main products but also sub-products of cassava; cassava is today an important cash crop in those countries. These countries based their strategy on ensuring a constant rate of productivity growth and the production of improved germplasm with greater starch content. Policies that favoured the use of cassava to produce ethanol also had a role in fostering the development of the cassava value chain.

In Africa, cassava is mainly a food crop grown by smallholder farmers, often women. Nonetheless, men are responsible for selling most of the surplus under the traditional division of labour. Cassava grows well in poor soils with limited labour requirements. Most of cassava farmers intercrop it with other food crops depending on the region (for instance beans, groundnuts, or maize). Cassava is propagated vegetatively[2], reducing the need for purchased inputs, and is flexible in terms of the timing of labour input. It provides a reliable and inexpensive source of carbohydrates during the lean season before cereal harvests for people in Sub Saharan Africa, where the consumption per capita is the highest in the World (Westby, 2008).

Cassava requires considerable postharvest effort due to its bulkiness; cassava fresh roots are 70 percent water. Because the roots are highly perishable, it's very short life difficult its use as an industrial raw ingredient. Some varieties of cassava, especially in West Africa, have high cyanide content that requires special processing before use as food or feed.

2.2 INTERNATIONAL MARKET TRENDS

The global trade in cassava products grew rapidly from the 1970s to the late 1980s, largely driven by European policy to discourage cereal feed grain imports, which did not apply to pelletized cassava and financed the expansion of that trade, especially from Thailand. Thai cassava exports from the Northeast of the country were also aided by construction of an extensive road network for unrelated security reasons in the 1970s that opened a hitherto remote region. While this

[2] A cutting is typically partially buried in wet soil with buds showing that sprout stems and roots that grow from the lower part.

trade fell after 1988, rapid growth of Chinese imports took over after the mid-1990s. China imported 9.3 million tons of dried cassava chips and pellets in 2015 for US$2.1 billion, with the chips mostly for ethanol, and mostly from Thailand and Vietnam. There was a decline in Chinese imports to 7.7 million tons in 2016 (FAOSTAT) mainly due to Chinese domestic policy switching to emphasizing increased use of corn for ethanol and feed, rather than preventing it (Chuasuwan 2017).

2.2.1 African cassava producer countries in the market

Nigeria is the main African exporter in the global trade in dried cassava products. In 2016, it exported well over 600,000 tons of dried cassava products, more than doubling exports from 2014, the first year of significant trading in that commodity, following signature of an agreement with China in 2013 (FAOSTAT; *Premium Times* 2013).

In the region, Mozambique, Malawi, Zambia and Tanzania are the main cassava producer countries, but despite their production potential, cassava commercialization in Southeastern Africa remains in its formative stages, with only 10 to 30 percent of production currently marketed. Unlike West Africa, where cassava commercialization has centered on marketing prepared cassava-based convenience foods, the emerging cassava markets in Southeastern Africa have centered on fresh cassava, low value-added cassava flour, and experiments in industrial processing of cassava-based starches, biofuels, and feeds (Haggblade et al 2012).

Latin America has an advanced cassava food industry led by Brazil and processes several industrial cassava derivatives. The Asian countries are the most advanced in processing non-food cassava derivatives. The bulk of cassava products outside Africa is not consumed directly as food. Most of it is for industrial purposes and feeds.

Asia, and especially Thailand and Vietnam, are the dominant competitors for Mozambique with respect to global markets. Thailand is the world's largest exporter of cassava products; overall, it accounted for 75 percent of global exports of dried cassava products by value in 2016 (FAOSTAT). Thailand exports cassava chips (about 60 percent of Thai cassava exports by volume), cassava native starch, and modified starch. The latter two categories are for food and drink, paper, textiles, cosmetics and medical products (Chuasuwan 2017). Thailand's earnings from the export of cassava products reached nearly US$2.9 billion in 2016, having grown at about 15 percent annually since 2010. Thailand processes 40 percent of production into starch for both domestic and export markets (Ibid.). Vietnam exported US$1.5 billion in cassava products in 2015.

The success of Thailand in developing the cassava value chain is due to three factors (Dalberg et al. 2015):

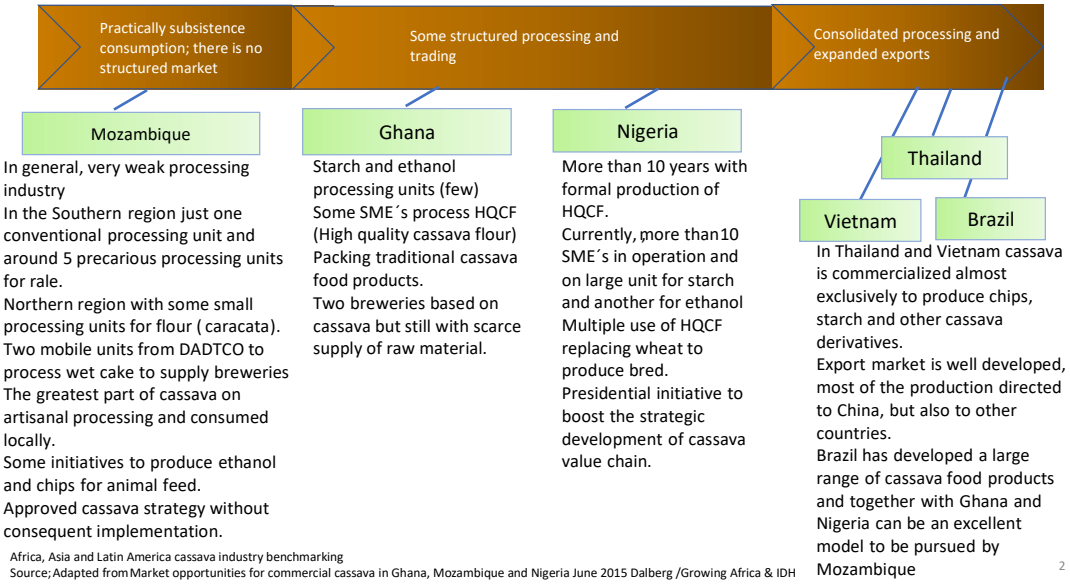
- The government strongly supported research and development (R&D), both to create high-yielding varieties and to promote use of cassava products in the manufacturing sector.

- Both governmental and non-governmental institutions have supported smallholder farmers—who grow most of Thailand's cassava—in accessing improved varieties, other inputs, and financing for production.

- The Thai government created a favourable business environment for cassava processing and end-use of products through interventions including: technology support for down-stream SMEs, support to contract farming systems, root and ethanol price guarantees, development of processing technologies, building of transportation and logistics systems, and identifying and developing alternative markets through international conferences, exhibitions, and study tours organized by the Ministries of Commerce and Foreign Affairs.

In Vietnam, the government has played a similarly strong role in developing the industry and promoting access to export markets. Vietnam is now the second largest exporter of cassava products, with a growth rate of 39 percent per annum in the value of exports between 2008 and 2012 (Dalberg et al. 2015).

Figure 3: Mozambique compared to most relevant cassava producer countries



Source: Dalberg Global Advisors *et al.* (2015)

In Africa, Nigeria has been particularly keen in developing its cassava value chain, as part of a strategy to diversify their economy to lower the dependence on oil products. In 2002, the Government launched the first national policy to promote increased output and processing of cassava. Later in 2011, the Government launched the Cassava Transformation Agenda, which sought to create a new generation of commercially-oriented cassava farmers linked to businesses in the value chain that could drive reliable demand for cassava.

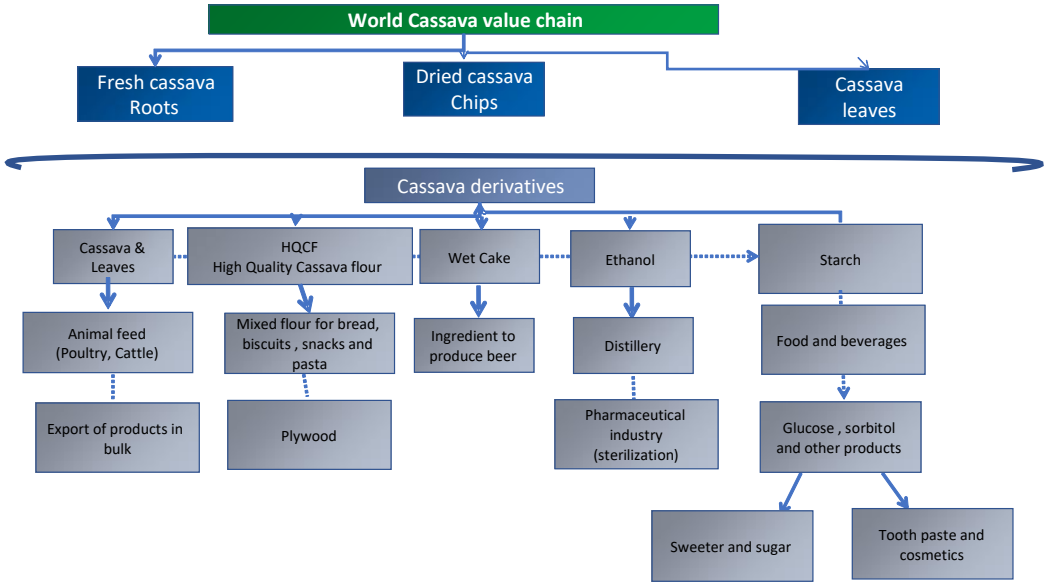
2.3 CHARACTERISTICS OF GLOBAL VALUE CHAINS

Some countries have developed cassava value chains, transforming the crop--once exclusively for food consumption--into a valuable commercial crop. Nigeria, Thailand, Indonesia, and Brazil are the major producers; however, Thailand has become the main cassava exporter and Brazil has developed the largest range of cassava food products. Vietnam, where cassava is the third export crop, carried out in the last 20 years a true revolution in the sector, improving drastically

the genetic material to increase productivity in about 400 percent (8.6MT to 26MT/Ha) and today its objective is to achieve 60/80 MT in a stable way.

Figure 4 below shows the level of development of the cassava value chain in the world, moving from production through processing and trade. In most countries the main concentration of jobs remains in production.

Figure 4: World cassava value chain



Source: Prepared by consultant based on collected information

In African, cassava production is still a task for rural families, with virtually no organized plantations. This is probably one of the main obstacles to building a sound cassava industry, since high perishability of the root limits any initiative towards processing if a stable and permanent supply of raw material is not ensured. Raw cassava supply from smallholders implies the need for a huge and solid logistics system. The latter requires adequate and well-equipped storage, an efficient transport network to collect the product through the production zones for aggregation, and to maintain the product in good condition until it is processed to a more stable form.

2.4 REASONS BEHIND SUPPLY-SIDE SUCCESS IN CASSAVA DEVELOPMENT

Thailand and Vietnam carried out supply-side revolutions to develop their cassava value chain when faced with demand surges, first from Europe and then from China. In these countries, cassava is essentially a cash crop.

Thailand	Vietnam
Governmental support to Research and Development (R&D). Introduced high yield varieties, with high starch content, appropriate to processing and promotion of high value cassava products.	Governmental support in partnership with CIAT to adopt cassava conservation and development strategies with emphasis on: Research on integrated cultivation technics appropriate for farmers.
Strong public/private partnerships to support smallholder producers. Provision of inputs, access to improved genetic material and financial support for production.	Public /private partnerships. Introduction of ten key technics to improve productivity, using adequate high yield varieties, high starch contents and tolerance to pests and diseases and introduction of improved production methods (intensive mechanization).
Business environment improvements. Technological support to SME´s, Support on adopting agriculture commercial agreements, technological processes development, building of warehousing systems and transports. Strong promotion of markets; identification of alternatives through international conferences, exposition, studies and events promotion involving key government departments. Export market well developed, made Thailand the main exporter.	Business environment improvements. Introduction of incentives for production. Governmental initiative to consider cassava as the only crop to produce bio-fuel due to its characteristics of being non-food crop in Vietnam. Introduction of a 5% supplement in 2015 to increase to 10% by 2025. Improved R&D technologies. Development of domestic and international markets allowed the country to increase exports by 39% between 2008 and 2014.

Other countries such as, Brazil (Latin America) and Nigeria (Africa) have also developed their cassava value chain but kept privileging human cassava consumption. Brazil has developed a huge range of cassava food products and benefits from a strong domestic market. Other countries, mainly in Africa, still consider cassava as a food crop. Mozambique despite the adoption of a strategy to develop the value chain, virtually has no cassava processing industry.

Brazil	Nigeria
Governmental support - For more than 30 years the cassava value chain in Brazil benefited from unequivocal support from State and Parastatal Research Institutes for increasing productivity by selecting and extending genetic material of better quality.	Introduction of fiscal measures to incentivize the replacement of wheat by cassava flour in producing bread and other bakery products. 10% charge on wheat imports. Cassava flour imports forbidden.
Involvement of Public -Private Partnerships in Government ag. research agency EMBRAPA's West Amazonia efforts to select cassava cultivars to achieve yields of 33 tons/ha, 3 times more than the regional average of 8-10 tons/ha.	Public/Private partnerships to create processing units (small/medium and large scales) under the program (CEDP). Introduction of the first large scale unit to produce HQCF.
Improvement of business environment. Long-term intervention of EMBRAPA and SEBRAE (government SME agency) in supporting the development of cassava and SME´s. Promotion of new products at domestic and international markets. Domestic market well developed.	Improvement of the business environment: Presidential initiative based on to vectors: 1) Support to R&D to produce improved varieties. 2) Cassava enterprises development project (CEDP) to promote the cassava business.

3. GENERAL CHARACTERISTICS OF CASSAVA IN MOZAMBIQUE

3.1 CASSAVA AS A STAPLE FOOD CROP IN MOZAMBIQUE

Cassava and maize are the main staple food crops in Mozambique; the production of cassava is concentrated in the northern Mozambique and along the southern coast. Due to the heaviest concentration of rural population, northern Mozambique accounts for around 85 percent of the total cassava production, with prevalence in the provinces of Nampula and Zambezia.

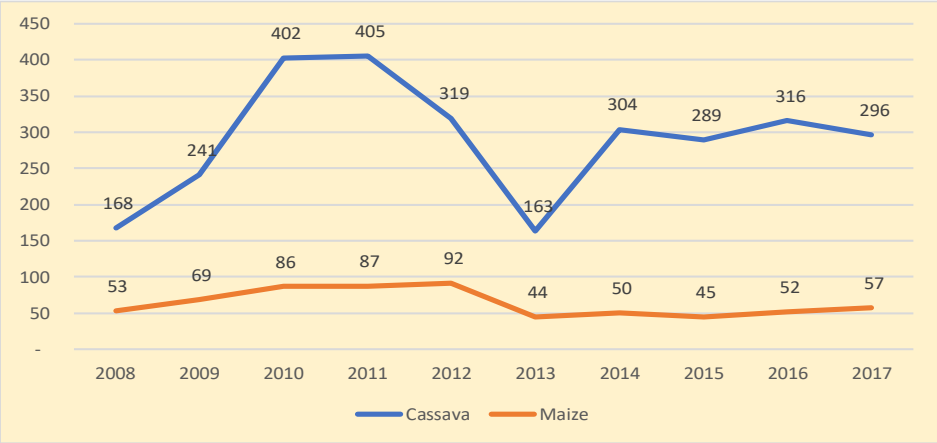
These provinces have high agricultural potential. Together, they have 39 percent of the population, 42 percent of smallholder farmers, and 38 percent of female-headed households. They are adjacent to the three of the country´s main trade corridors, Nacala (linking Mozambique to Malawi and Zambia), Beira (linking Mozambique to Zimbabwe), and the EN 1 (a key North-South road, connecting the Nacala and Beira corridors).

Cassava is an important food security crop, mainly in critical periods of law rainfall, due to its tolerance to drought. Given its unusually flexible planting and harvest schedule, it can be often harvested over multiple years[3]. The crop has broad agro-ecological adaptability and its ability to produce reasonable yields under fierce conditions (acidic and infertile soils), makes it the basis for food security at the household level as an important source of dietary energy.

Cassava is gaining increasingly importance has a staple food. Despite the volatility of cassava production, it is well above the other food crops as shown vis-a-vis maize in Figure 5.

Figure 5: Cassava and maize production in Mozambique

kg/capita



Source: FAOStat accessed December 2018

It is preferable to use these figures on production of cassava/per capita rather than consumption /per capita, due to the unreliability of the collected data on consumption; systems to collect

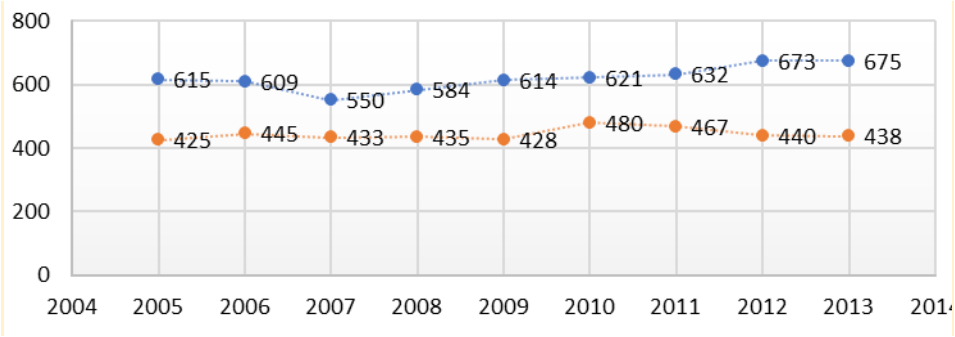
[3] As will be discussed, the prevalent bitter varieties are more pest resistant than the less common sweet ones and can be stored in the ground (not harvested) up to 30 months from planting.

data on cassava consumption are not well developed because of the informality of cassava commercialization. Cassava and maize together are essential to the diet of most rural families; roughly 85 percent of all farms grow and consume maize and cassava. These crops also provide a key part of the livelihoods of millions of farmers and many traders and processors across the country.

Cassava is an important contributor crop for Mozambique's overall GDP. Agriculture accounted for roughly 18 percent of GDP in Mozambique in 2016, and cassava production's direct share of agricultural production by value was more than one-quarter, leading to a share of overall GDP close to 5 percent (FAOSTAT October 2018). To this should be added any other contributions to GDP from cassava processing and marketing not counted as part of agricultural GDP.

Cassava is also the main provider of calories in Mozambique, see Figure 6. However, cassava as a food crop has some serious limitations: Rapid post-harvest deterioration following removal from the soil limits its marketability; and the roots are low in protein and some

Figure 6: K-calories per capita per day from cassava and maize

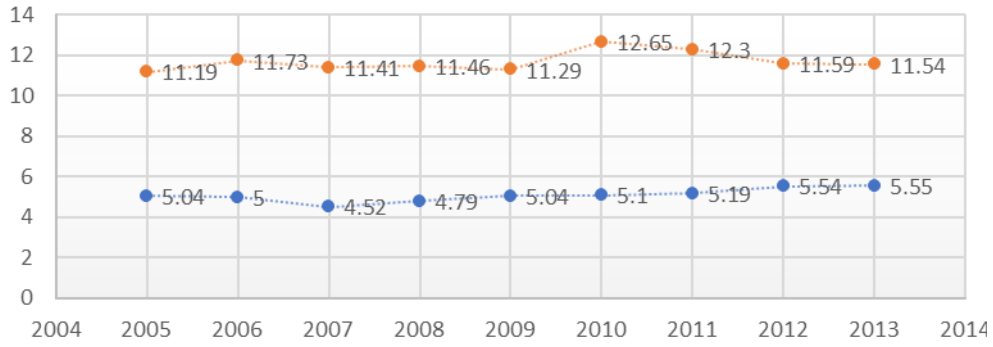


Source: FAO Food Balance Sheets; cassava in blue and maize in brow

essential micro-nutrients. Most seriously, cassava may contain bioactive products that are potentially harmful to human health unless adequately processed prior to consumption, especially the bitter varieties that contain cyanogenic glucosides. Other major staple foods such as maize and rice have a higher protein content than cassava and less drawbacks.

Figure 7: Maize and cassava's contribution to protein in Mozambique

(grams protein/capita/day)



Source: FAO Food Balance Sheets; cassava in blue and maize in brown

3.2 CASSAVA PRODUCTION, PROCESSING, AND MARKETING IN MOZAMBIQUE

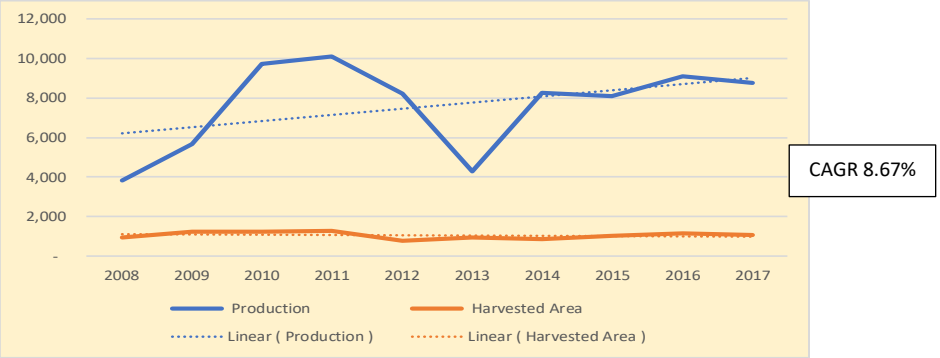
3.2.1 Production levels

Mozambique ranks 11th in the world and 5th amongst African countries with regards to cassava production in 2016 (FAOSTAT). In the last 10 years (2007 to 2018), Mozambique cassava production grew on trend at CAGR of 8.67 percent, as shown in Figure 8, but showed great volatility along the way. For example, production suddenly dropped to levels below 6 million tons in 2013, after being 10 million tons in 2011. Although cassava does not need to be harvested in an annual cycle, unlike cereals, no obvious major explanation for this rapid decline comes to mind, suggesting that sudden changes in national level cassava figures need to be assessed with caution.

Furthermore, it should be noted that in Figure 8, 2010 and 2011 are recorded as years with the highest production ever, although harvested area did not change much, implying that yields in both years must have been substantially higher than on average.

Figure 8: Growth of aggregate annual cassava production and area harvested in Mozambique

In tons and hectares



Source: FAOStat, accessed December 2018

To provide food under a wide variety of circumstances and time periods, most cassava farmers grow a diversity of cassava varieties and maturities at the same time in different plots. These will typically have a mix of yields and resilience to pests, diseases, drought, and wet conditions, as well as differing underground storage needs (Donovan et al. 2011).

3.2.2 Cultivation practices

Cassava is typically grown in Mozambique on small areas of land, usually one-quarter to one-half ha, on an average rural household holding of 1.5 ha, according to the 2009/2010 agricultural census (CAP 2009/2010). At that time, 12 million people were reported to be involved in cassava production, processing, and marketing on approximately 2.5 million out of approximately 3.9 million farms (Ibid.).

Major Mozambique cassava growing provinces in cultivated hectares are: Nampula 337,300; Zambezia 299,400; Inhambane 119,900, and Cabo Delgado 112,700. These provinces produce both bitter and sweet cassava types, while the other growing areas in the country produce

mainly sweet cassava types (Salvador et al. 2014). The importance of cassava in the southern provinces in particular is clear given the share of land farmers dedicated to this crop, particularly in Inhambane; cassava accounts for more than half of total farm area cultivated there on average, and well above the national average of roughly 0.5ha/farm.[4]

Mozambican farmers grow a large range of cassava varieties; over 100 varieties country-wide, (Donovan et al. 2011), including a wide array of both bitter and sweet varieties.

The type of varieties cultivated in each province depends on the level of acceptance for consumption (especially taste), the yield performance of the variety, the crop duration to maturity and the availability of planting material. In general, in areas of major production, every household produces both sweet and bitter types, but the population cultivating bitter varieties is large. There is a tendency (encouraged by some development agencies) to grow increasingly amounts of sweet cassava because of concerns about the cyanogenic contents of bitter cassava.

Bitter cassava contains poisonous cyanogenic glucosides that can be fatal and must be removed before eating. The poison can be removed by peeling the roots, grating, dewatering, and fermenting, roasting and drying. In Mozambique, cassava-growers typically process bitter cassava roots into "*rale*", a fermented porridge flour similar to West African *gari*, with cyanogen content reduced to acceptable levels for human consumption. Sweet cassava can be consumed directly, often boiled, grilled, or deep-fried. Cassava leaves are also used for nutritious garnishes in sauces.

Bitter cassava in Mozambique comprises more than 90 percent of production in Mozambique, as they have higher yield than sweet varieties, are more tolerant to pests and diseases, and can be stored in the soil more than 12 months (up to 30 months or more); that is, they can be harvested at leisure (Salvador et. al. 2014). Sweet varieties contain less than 100 mg/Kg fresh weight hydrogen cyanide, so are consumed fresh, sometimes even raw, (Salvador et al. 2014; Donovan et al. 2011).

Despite the higher content of cyanide glycoside in bitter cassava, which influences the taste (McKey and Beckerman, 1993; Chiwona-Karltun et al., 2004), the pattern of consumption in Mozambique indicates that the bitter cassava varieties are much more consumed than the sweet ones (Donovan 2011).

Besides the characteristics pointed above, which ease its production, apparently the population is more acquainted with bitter varieties because the taste has passed through families for years.

On this subject, an essay written in 1988 by Professor Sander Essers of Wageningen University[5] points out that the two nutritional drawbacks of cassava, namely cyanogenic potential and lack of proteins, add to resistance to extreme drought, so cassava cultivars containing high levels of cyanide may have important benefits for the farmer. Cultivation of bitter varieties is frequent in several regions of Mozambique where the population is extremely poor. The essay concludes that prevention of cyanide intoxication should not primarily be pursued by the development of low cyanogenic cultivars, but by:

[4] Note that the average amount of cassava area cultivated by farms at a national level falls in the 0.4 ha to 0.6 ha range, as estimates between the decadal Census of Agriculture (CAP) and the annual National Household Sample Survey (TIA) differ in this range.

[5] "Bitter Cassava as a drought resistant crop, a case in Mozambique"

- Enhancing agricultural practices leading to a sustainable form of production (improving soil fertility, water management etc.);
- Adherence to processing methods that allow for sufficient cyanide removal from the tubers and leaves. (For emergency situations suitable rapid processing methods may have to be developed and disseminated; and
- Enhancing the availability of supplementary foods to balance the diet.

3.2.3 Post-harvesting handling and storage

Good practices in post harvesting handling and storage of fresh roots and leaves is vital to ensure a final product quality. The quality, sustainability and the safety of the plant lies not just on the preharvest factors but most importantly on postharvest management, especially for a crop like cassava with rapid deterioration rate (Iyer et al. 2010). Reduction of postharvest losses can help to improve the quality of fresh cassava root. Some proven measures to prevent loss include the use of improved cultivars with longer shelf life, application of proper agriculture practices during cultivation, proper handling during and after harvest, and use of the appropriate processing techniques (Kader and Rolle 2004).

After harvest, the root is transported to the local storage places, processed and later the final product packed and put in storage until sold. Packaging and storage are the major factors in postharvest handling to ensure food security and safety of the final product (Daramola et al. 2010). Packaging guarantees the quality of the root by protecting it from bruises and injuries and prevents excessive moisture loss and also the stored root influences the quality of the product formed as well as its yield (Akingbala et al. 2005).

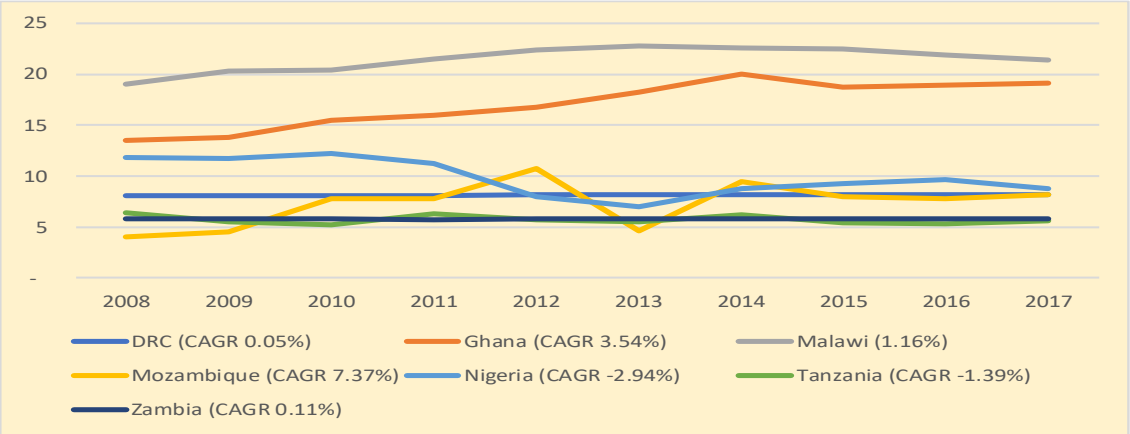
Mozambique has no policies with regard to packaging and storage of fresh roots. This is an area that deserves attention, and measures should be adopted to encourage operators at all levels to use more advanced methods of storage and packaging, like those being used in other cassava producing countries.

3.2.4 Cassava productivity

It is widely believed that agricultural growth in most of Africa has been largely driven by the expansion of the area under cultivation, with yields remaining stagnant at between 30 per cent

Figure 9: Comparative cassava yields in select African countries 2008-2017

tons/ha



Source: FAOStat (accessed December 2018)

and 60 per cent of their potential (IFAD, 2011). Some analysts also believe that the growth on cassava production is due to expanding areas of production. However, there is some evidence that cassava yields have grown significantly in the last decade.

In general, Africa has the lowest average regional cassava yield (8 tons/ha), compared with Asia (22 tons/ha) or South America (13 tons/ha). These low yields are mainly due to lack of use of adequate inputs, such as fertilizers and pesticides, slow dissemination of high-yield varieties, and spread of pests. Ghana achieved the highest yield growth; in ten years it grew from 13 to 19 tons per hectare. Nigeria has decreased from 13 to 9 tons/ha (FAOSTAT), but reportedly with better quality since the cultivars have higher starch content (*Premium Times* 2013).

Malawi, which has a high level of productivity when compared with the other African countries, and Ghana have the highest yields in Africa.

In Mozambique, cassava yields per hectare are low when compared with African stars such as Malawi and Ghana, and certainly with Asia and Latin America, as discussed above. Average Mozambique yields in the last 10 years are reported to vary between 5 and 9 tons/ha, with the highest compound annual growth rate of yields among the main Africa producers (Figure 9). Nevertheless, yields in Mozambique are only slightly higher than the Africa average, suggesting there has been significant catch-up in recent years in Mozambique.

Traditionally the Northern Provinces have higher yields than in the South, probably due to more fertile soils. In Inhambane and Gaza, on the South Coast of Mozambique, the yields are reported to be less than 5 tons/ha. However, in the last few years a massive program to develop the cassava sector, increasing the introduction of new varieties and better control of pest diseases, was carried out in this region by the Mozambique Institute of Agricultural Research (IIAM) and other agencies, and has improved yields substantially. Recently, with the help of some projects—such as those of the Dutch Agricultural Development and Trading Company (DADTCO)—that supply cultivars, inputs, and extension advice, farmers have achieved 9 to 22

tons per hectare (interview with Nelson Joaquim, DADTCO extensionist). But this success is not widespread.

The United States Agency for International Development (USAID)-funded International Fertilizer Development Center (IFDC) is running a program in partnership with DADTCO that claims cumulative achievements from 2014 to 2017 (IFDC 2018):

- More than 12,000 farmers are using improved technologies on 8,000 ha.
- Many increased yields to above 15 tons/ha.
- Six million cuttings of improved high-yielding cassava varieties distributed to farmers.
- 3,106 demonstration plots established.
- Field days attracted 4,800 farmers (2,900 women); 2,427 collection centers were built to improve aggregation efficiency. The centers are also being used for farmer training and input sales.
- Five two-fertilizer blends were introduced: a high-nitrogen blend to stimulate stem production and a high-potassium blend to stimulate root production.

3.3 CASSAVA PROCESSING IN MOZAMBIQUE

Cassava processing in Mozambique is still at an embryonic stage. Mechanized processing is not a developed channel. Processing in Mozambique has two vectors: non-mechanized and mechanized.

3.3.1 Non-mechanized production

This includes the traditional methods of cassava processing at household level to produce "*rale*" in the South, and in the North to produce a kind of porridge known as "*karakata*". Rale production involves peeling the roots, grating, dewatering, and fermenting, roasting and drying. *Rale* is similar to the West African *garri*. In some cases, traditional processing involves peeling, chipping, and sun drying. The chips are then soaked, fermented, and dried to produce the fermented flour. For flour production, the dried product is pounded in a mortar. These methods of processing are widespread across the country. They are also very labor-intensive. Most small farmers producing cassava process a significant part of fresh and dried roots at home this way.

3.3.2 Mechanized processing

This typically includes micro and small mechanized processing units in Mozambique, which produce "*rale*" and flour, and represent significant labor saving over doing these tasks manually. Industrial capacity in Mozambique is very limited and it is not presently a significant employment generator. There are few mechanized processing units, most of them located in the Southern region. Inhambane is the Province with the most micro and small processing units with mechanized equipment.

Domestic end markets for products like industrial starch and ethanol are small. The few existing industrial processors face high costs to source cassava due to low yields and long distances required to buy enough volumes. Inefficiencies in the supply chain drive up the cost of end products and make it more difficult for processors to compete with imports.

3.4 PRESENT MARKETS FOR CASSAVA PRODUCTS AND DERIVATIVES

3.4.1 The present market is mainly for traditional foods

Most of fresh and dried cassava and leaves are consumed directly by rural families. A small but growing percentage of it is transported to main towns to be consumed by urban families, but this is still a tiny market for fresh cassava, mainly due to the quick perishability of the root and lack of adequate packing.

The major challenges for cassava producers and processors in Mozambique are access to markets and creating interest in new market opportunities. This can only be achieved by diversifying offerings by introducing a larger range of products with emphasis on non-food industrialized products.

Available cassava products for consumption in Mozambique are presently very basic. Fresh and dried roots and leaves are directed to home consumption in the form of traditional foods; in the North, most commonly as a porridge made from cassava flour, and in the South, as *rale*.

It is estimated that only six percent of Mozambique's cassava is used for commercial purposes, of which four percent is for animal feed (an estimated 400,000 tons) and two percent is used in industrial processes (an estimated 200,000 tons) (Donovan et al. 2011).

There are only a few mid-scale processors, most of them based in the Southern region on the coast, due to several reasons. These include: lack of reliable access to raw material, poor availability of financial management and technical skills, and recently the damages caused by a cyclone. This has reduced substantially the availability of quality cassava flour and *rale*.

The only notable large-scale industrial processing of cassava in the last few years was to produce wet cake for beer brewing (see Annex B). This initiative has been carried out by DADTCO operating in the field with two mobile units to produce wet cake successfully to supply CDM breweries. DADTCO's activities have accounted for most of the industrial-scale supply of around 20,000 to 25,000 tons annually of processed cassava products in Mozambique, mostly wet cake for beer production. Due to a recent decision of the brewer concerned, CDM, to use maize to replace cassava wet cake, DADTCO is now planning to invest in starch production to explore larger markets other than the domestic breweries.[6]

Cassava chips have been used informally for animal feeding, however despite its great potential in the domestic market, few animal feed processors are interested in adding cassava to their products. The few initiatives taken so far have been not stood out. Mozambique's small manufacturing sector suggests that there may be limited prospects for domestic demand for industrial cassava products like starch.

These apparent failures are a clear example that any initiative to process cassava will need a clear strategy considering not only the market demand but the whole set of conditions needed to build an efficient and feasible industry, from production to marketing.

[6] Philafrica DADTCO new owner has invested in new equipment to process wet cake with low percentage of fibers to supply the beer company and to produce other cassava products such as HQCF.

3.4.2 Regional demand in SADC for industrial cassava products looks strong

Although present industrial uses of cassava are few in Mozambique, the potential is large, especially for regional exports. Key potential product lines include: High Quality Cassava Flour (HQCF), primarily used directly in preparation of processed food products; cassava Wet Cake, primarily used for beer brewing; cassava-based ethanol; industrial grade cassava starch for a wide variety of applications; and fresh roots used for industrial purposes.

Mozambique has a privileged economic relationship with South Africa, the main market within the Southern Africa Development Community (SADC) countries. Some competitor suppliers are also cassava producers, such as Tanzania and Malawi, but Mozambique can benefit from greater proximity to South Africa via the South. As will be seen in the next section, regional demand for higher grade cassava starch and other products is high and likely to grow rapidly.

4. MOZAMBIQUE CASSAVA VALUE CHAINS

4.1 THE PRESENT MAIN CASSAVA PRODUCTS ARE TRADITIONAL FOODS

4.1.1 For direct human consumption as food

Although cassava value chains are more developed in Southern Mozambique than in the Northern and Central regions of Mozambique, overall the cassava value chain is much less developed in Mozambique than in Asian countries such as Thailand and Vietnam, and Latin America countries such as Brazil, at least with regards to adding value through industrial processing.

The main primary products from cassava are:

- *Fresh roots***.** Fresh cassava roots are consumed mostly in the southern and central part of the country. Sweet varieties, with low levels of cyanogenic glycosides, are required for fresh consumption. Typically, households peel and boil the fresh roots before eating. Consumers can also eat them raw.
- *Dried roots***.** Traditionally, dried cassava roots are the intermediate products in one of the pathways of (typically fermented) flour production. Harvesting cassava is a laborious and time-consuming effort; farmers typically do not harvest cassava every day. Drying needs dictate the harvest calendar (with a preference for harvesting at the start of the dry season for this reason), and also can involve heavy work within the farm household to press water out of roots with weights or a mechanical press.
- *Leaves***.** Cassava leaves are part of the diet of most Mozambicans. They are high in protein and vitamins, and they offer a prized source of greens to be used in sauces and relishes (Nassar and Marques 2006).

Patterns of production and consumption as food vary from region to region but most of the production is still for subsistence (Table 2).

Table 2: Regional differences in mix of cassava products sold by farm households in 2008

(Rows sum to 100%)

Region	Composition of Cassava Products Sold by Farm Households				
	Fresh roots	Dried roots	*Rale*	Flour	Animal feeding
North	1%	99%	0%	0%	0%
Center	58%	39%	3%	0%	0%
South	33%	0%	67%	<1%	<0,5%
National Average	3%	94%	3%	0%	0%

Source: Donovan et al. (2011) using HH survey data from National Agricultural Information System of Mozambique (TIA) survey, 2008.

4.1.2 Industrially processed products

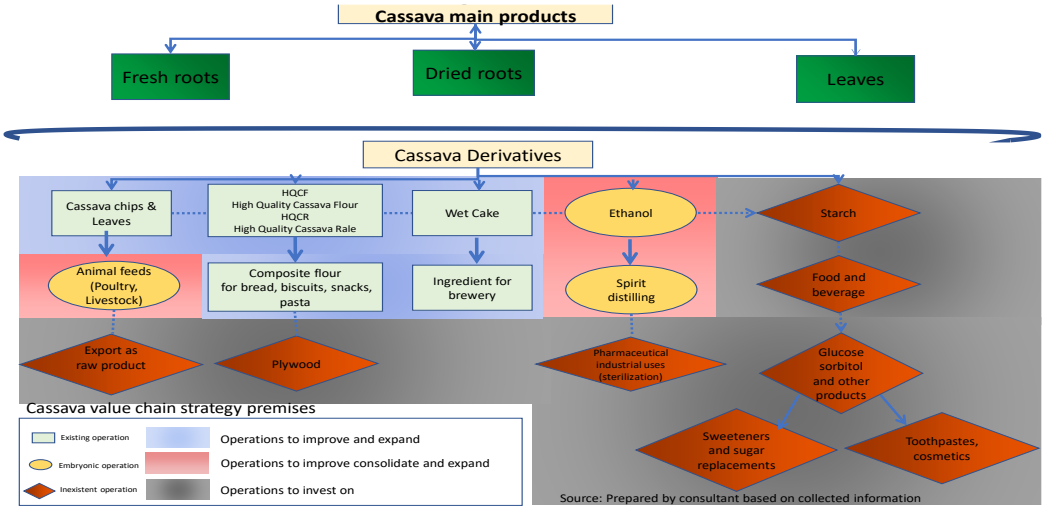
The industrial use of cassava in Mozambique is less than 0.5 percent of national cassava production. In the present development stage of Mozambique cassava value chains, the existing domestic markets for cassava industrial products are:

- **Cassava chips and leaves for animal feed:** An important use for cassava is animal feed. The leaves are high in protein, and thus a potential substitute for soy bean cake or alfalfa (lucerne). The root contains mainly carbohydrates and is thus a maize replacement.
- **High quality cassava flour (HQCF):** The present low quality of cassava products is preventing producers from achieving more demanding markets for this kind of product. High quality cassava flour (HQCF) can be partly used as a wheat flower substitute in bread, pastries, cookies, and biscuits. How much wheat flower can be replaced, depends in part on the type of product and quality requirements of the consumer.
- **Wet cake:** In 2011, in Nampula Province, an initiative led by Mozambique SABMiller subsidiary Cervejas de Mozambique's (CdM) began to produce Impala beer using cassava wet cake as an ingredient. Since then, the promotors have expanded their initiative to the southern Province of Inhambane.
- **Ethanol** is used largely in the spirit distilling industry. Its potable form, extra neutral alcohol (ENA), is blended with water and other flavours to make many alcoholic beverages. In Mozambique in 2010, there was an initiative to produce ethanol for cook-stoves, but is no longer active. Attempts to date to produce ethanol have not progressed as planned. An example of this is *CleanStar*, an initiative to produce and supply ethanol to integrated cook-stoves business, but the factory ceased operations in 2013, apparently one of the reasons was incapability to compete with ethanol from molasses.

4.2 OUTLINE OF CASSAVA VALUE CHAINS

Cassava value chains in Mozambique are multiple, but of vastly different size depending on end consumer. Some of high-value derivative products, such as ethanol, are not developed enough to be considered a supply chain. Others are very large, but diffuse, of variable quality, and not well-organized by market principles. Most production is consumed on the farm or sold directly to other local consumers or small-scale market agents.

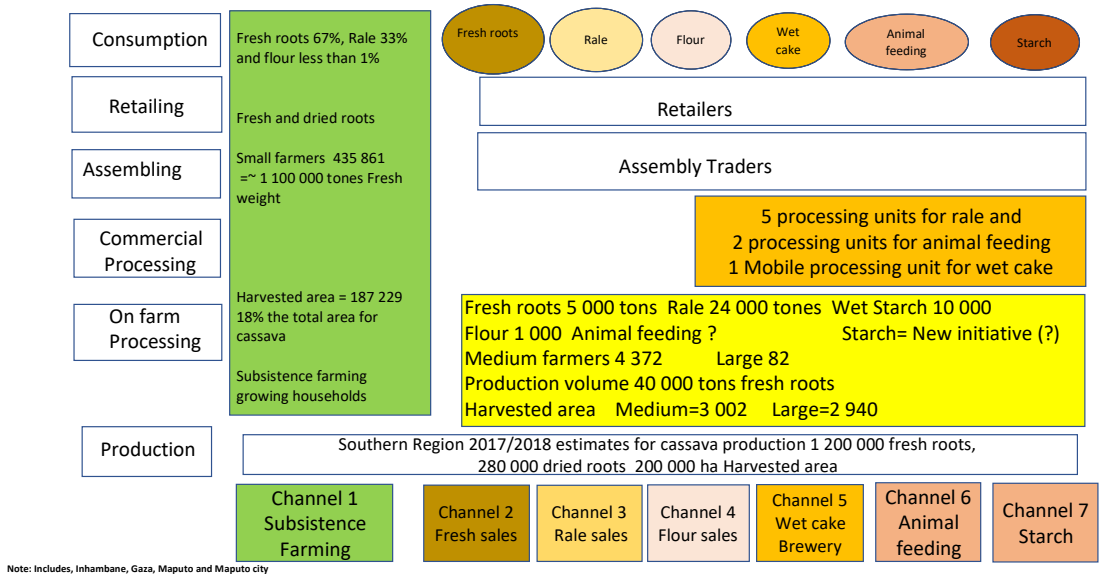
Figure 10: Main cassava value chains in Mozambique including value-added derivatives



4.3 SOUTHERN MOZAMBIQUE CASSAVA VALUE CHAINS

In southern regions near the Mozambique coast, the population process cassava roots into *rale*, which is an important component of their diet. They also consume cassava flour

Figure 11: Southern Mozambique Cassava Value Chains



Note: Includes, Inhambane, Gaza, Maputo and Maputo city
Source: CAP 2009/2010 Faostat

processed in small factories or homemade, but in much lower quantities than *rale*. Animal feeding is being explored but it is still in its infancy. The Government agricultural research agency (IIAM) in the last few years has supported development of the cassava value chain by providing technical assistance to produce better planting material and use better agricultural practices.

4.4 Central and Northern Mozambique cassava value chains

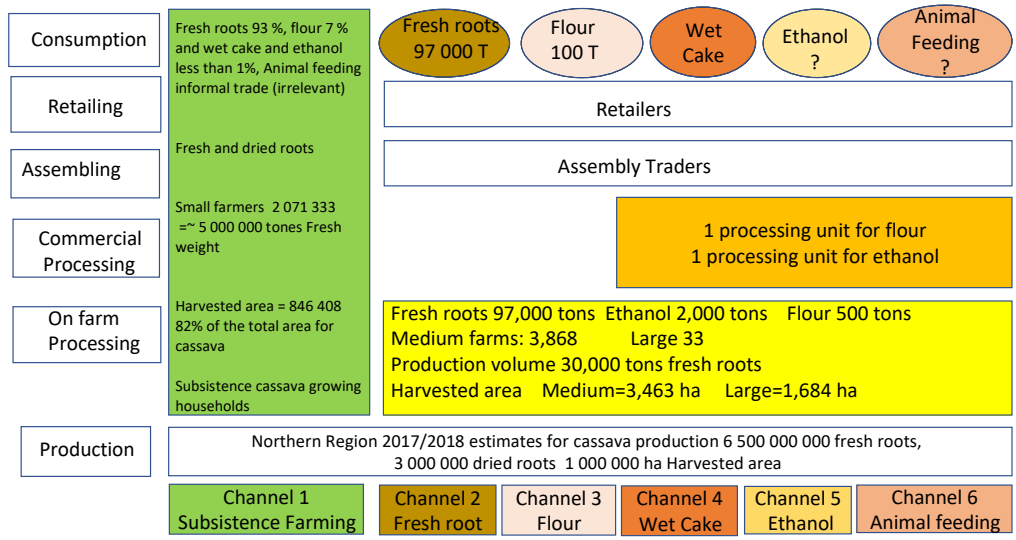
The cassava value chain is larger in the Northern region, but it is less developed. The channels are not much developed, and the rural population is still consuming considerable fresh roots and dried cassava processed into flour at home by them. The use for animal feeding is done informally and often poultry or small ruminants are fed through the residual (waste) from the stored cassava, because normally cassava is put to dry in open spaces under precarious ceilings to avoid rainfall. The central region is less developed than the northern region and cassava is consumed more in the fresh form, while in the northern region dried cassava is preferred.

4.5 COMMERCIAL POTENTIAL AND OPPORTUNITIES FOR MOZAMBIQUE

4.5.1 The potential for High Quality Cassava Flour (HQCF)

HQCF production can be initiated for the local market, for the bread, biscuit, and snack industries, but may need public sector incentives to jumpstart the private sector. Local HQCF production in Mozambique was estimated at about 100 MT in 2014. These small quantities of HQCF are processed by 10-15 small associations and micro-processors. HQCF is sold to small bakeries or used for local production of cassava-based cakes and cookies (Dalberg et al. 2015).

Figure 12: Central and Northern Mozambique Cassava Value Chains



Note: Includes, Niassa, Cabo Delgado, Nampula, Zambezia ,Tete, Manica e Sofala
Source: CAP 2009/2010 and Faostat

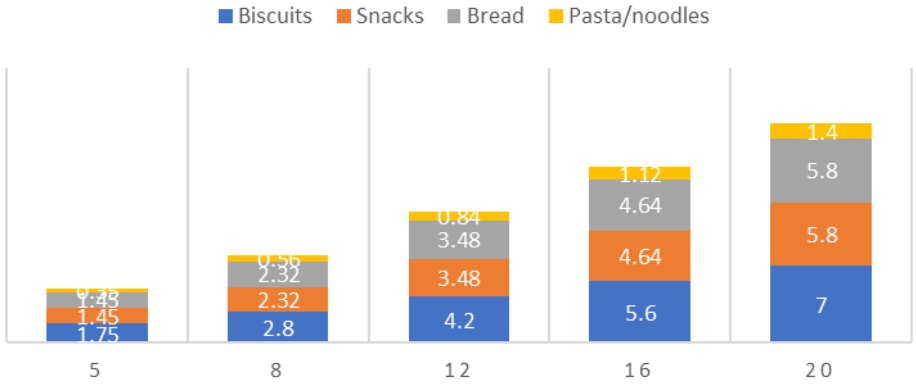
Domestic potential for HQCF use in bread is about 10 percent of wheat use, 20 percent for biscuits, and 50 percent for snack foods. Mozambique's annual wheat imports, accounting for almost all local availability, were estimated at 750,000 tons in 2014, converted into 580,000 tons of flour. Approximately 65 percent of the wheat flour is used in production of bread, with 25 percent used for biscuits and snacks, and 10 percent used in the production of pasta and noodles.[7] This yields an estimate of a potential maximum use of HQCF of 90,000 tons annually in Mozambique. Mozambique's current use of HQCF is just 0.1 percent of this, indicating substantial opportunities for growth (Dalberg et al. 2015)

The addressable demand for HQCF (Figure 13) is expected to grow to 20,000 MT by 2021, assuming appropriate policies and incentives are put in place, far short of the potential 90 000 MT. The leading driver of this demand is expected to be biscuits at about 35 percent of the total (~7,000 MT), followed by bread and snacks at 29 percent each (~5,800 MT each) and pasta/noodles at about 7 percent (1400 MT).

[7] Source: UN COMTRADE data assessed in Dalberg et al. (2015). Originally the years shown were assumed to start in 2017 after a two-year start-up, but that has not been the case thus far.

Figure 13: Addressable Demand for HQCF in Mozambique over five years

(000 tons, Year 1 to Year 5)



4.5.1.1 Main issues to address to ensure HQCF processing is viable

Despite the importance of improved traditional flour and *rale* within Mozambique's domestic market, the commercial viability of HQCF is still to be proven. The main industrial processors of cassava in Mozambique are struggling to expand the commercialization of improved cassava products and derivatives.

The high perishability of fresh roots requires careful post-harvesting handling and very rapid processing. Low productivity emerges as the main constraint preventing farmers from producing at profit and the processors from getting the fresh or dried roots at affordable prices.

Building a viable cassava processing industry will require a well-defined program to overcome the main constraints preventing the industry from producing HQCF and HQR (*rale*) and to expand its domestic sales. Research programs carried out by international institutions have concluded that these improved cassava products can only be growth drivers for cassava value chains if affordability constraints are better addressed.

If Mozambique is going to expand the HQCF and HQR market, it will have to promote research on technology along different stages of the value chain to develop processing systems that allow production of lower cost, safe products. Research should be similar to what has been attempted by the Natural Resources Institute (NRI), University of Greenwich[8] through the Cassava: Adding Value for Africa (CAVA) program (financial support for phase one from Melinda and Bill Gates Foundation), and the Federal University of Agriculture, Abeokuta, Nigeria, with research inputs from the European Union Cassava Growth Markets project. The latter has enabled implementation of a major multi-country program of work in Nigeria, Ghana, Tanzania, Malawi, and Uganda.

The above efforts focus on research to develop improved processing technologies to produce HQCF. They were undertaken to understand and optimise the use of HQCF in paperboard, plywood adhesives, sugar syrups, and other food uses; this can substantially enlarge use of HQCF to take advantage of economies of scale. NRI's collaborative program activities focus on the four key areas below:

- Overcoming emergent diseases threatening cassava production.
- Adding value through processing and business development.

[8] https;//cassava.nri.org/key-areas - NRI Cassava program University of Greenwich

- Managing waste within the value chain for economic returns.
- Strengthening the capacity of developing country scientists and practitioners.

This program can be a good reference for a Mozambique cassava value chain strategy to create a financially-viable environment from the outsetto support development of these activities. Mozambique policymakers should introduce a 10 percent required quota of HQCF in bread production using wheat, similar to the policy now in effect in Nigeria.

4.5.2 The potential for wet cake production

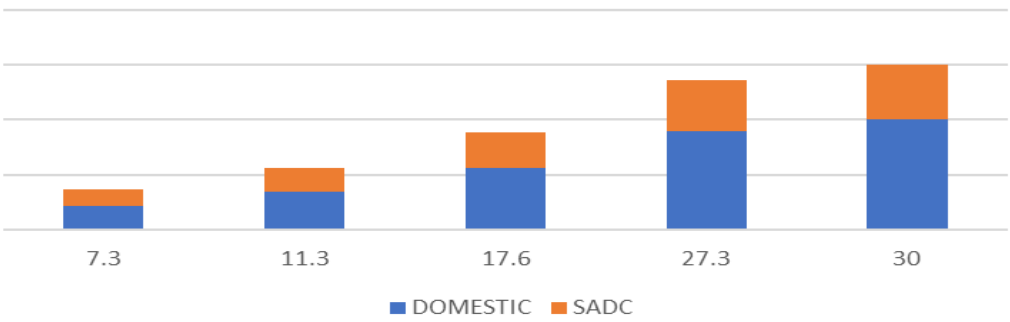
DADTCO is buying fresh cassava at the farm gate to process to wet cake with two mobile processing units. This product is used as an ingredient to produce beer by CDM. This beer is sold in the market for about two-thirds of the price of other domestic beers, making it more affordable to the average rural consumer. DADTCO is the single large-scale off-taker for the cassava on the farms concerned, purchasing fresh roots for conversion into wet-cake. This operation has been profitable for the small farmers concerned since they can rely on selling their fresh roots production for a known and typically higher price, compared to what they would get by transforming it into chips and selling on the spot market.

With an assured commercial outlet, farmers can easily improve their incomes through increased production. This initiative has been successful to date, albeit at modest scale. Because starch—potentially from cassava, but also maize—is a better ingredient for beer, and the cassava wet cake causes some technical problems during processing, the promotors of this program are thinking to invest in producing starch to replace wet cake soon. Presently, the purchases of fresh roots for wet cake are between 20,000/25,000 tons, but this could double if DADTCO moves ahead with their intention to invest on starch production as an alternative to wet cake.

4.5.3 The potential for use in ethanol production

Mozambique consumes a relatively large quantity of ethanol, but currently cassava is not being used for ethanol processing in Mozambique. One company, CleanStar, invested in an

Figure 14: Addressable demand for cassava for ethanol in Mozambique over five years
(000 tons)



Source: Adapted from Dalberg et al. 2015. Originally the years shown were assumed to start in 2017 after a two-year start-up, but that has not been the case thus far.

industrial factory and began producing cassava ethanol in 2010 for clean cookstoves. The cookstoves were powered by locally-produced ethanol made from locally-grown cassava in an attempt to tackle deforestation, land degradation, malnutrition, poverty, indoor air pollution and carbon emissions with one innovative initiative (see Annex D for the evolution of this initiative). A significant volume of ethanol is used for production of alcoholic spirits. One local pharmaceutical company uses ethanol in production of medications and for sterilization of equipment, with current demand estimated at 1,200 liters and growth expected to reach 12,000 liters in future (Dalberg et al. 2015).

The local and regional addressable demand for cassava ethanol is expected to reach 30 million liters by 2021 (Figure 14). The domestic market is expected to drive this growth accounting for about two-thirds of total demand or about 20 million liters, most of it going to production of spirits.

4.5.3.1 Main issues to address to ensure that cassava-based ethanol production is viable

Ethanol production is a relatively new industry in Mozambique; it will likely require infant-industry subsidies to be financially viable during the phase of consolidation. The ethanol industry as shown above has a very promising market in Mozambique. Similar to HQFC and any other cassava-processed products, the profitability of processing depends on dealing with issues related to post-harvest handling to ensure the roots (fresh or dried) meet adequate quality demand and are delivered at affordable prices.

Any initiative to use cassava roots as the main raw material for ethanol must be based on the following factors, due to the characteristics of a cassava production system dominated by smallholder producers:

- Location of factory premises in a region where cassava is traditional and well- known by the surrounding producing and consuming communities, and where competing outlets for new cassava production are not likely to inordinately hinder supply to the factory.

- An adequate network of organized farmers acquainted with cassava production and willing to take part in a promotion program that will bring basic inputs and technical assistance to improve their productivity and purchase their surpluses at a fair price.

- Use of harvest loss-reducing technologies to lower costs of production.

In addition, the Government should consider temporary adoption of adequate fiscal policies to motivate investors, mainly as regards import duties for ethanol or substitutes to protect the industry from import competition during the consolidation phase (Telma Venichand, CleanStar Sales and Marketing Manager: see Annex C for more information). However, any fiscal incentives to industry need to be time-limited to avoid discouraging innovation, efficiency and a lasting fiscal drag.

4.5.4 The potential for industrial starch

Mozambique has never produced industrial starch. Demand has been generally low, but with introduction of Impala beer by CDM the demand increased slightly since starch is a better ingredient than raw wet cake. Imports of industrial starch and derivative products, mainly from South Africa, were 2,900 tons in 2013. These include native starch, glucose, syrups, dextrin, and modified starches, indicating a small domestic market.

Mozambique's domestic market for starch and derivative products is not large enough to sustain industrial processing today. Potential end-uses include food and beverage companies and pharmaceuticals. Many of the large multinationals that are major consumers of starch elsewhere, like Nestle and Unilever, do not currently manufacture in Mozambique. Only one company makes pharmaceutical products locally and it reports annual demand for starch at approximately only one ton.

In contrast, the regional SADC starch and derivatives market is large and quickly growing. Imports of all starch products in all forms in SADC stood at 364,000 tons in 2013, driven by glucose and sugar syrups at 64 percent, native starch at 24 percent, and dextrin and other modified starches at 12 percent (Dalberg et al. 2015).

Cassava starch is in high demand in South Africa due to its favorable industrial properties and cost effectiveness. South Africa imported on the order of 30,000 tons of industrial starch annually over the 2014-2016 period, about two-thirds from cassava (Urban-Econ Development Consultants 2017). The demand for cassava flour, starch, syrups, and glucose, is expected to rise rapidly in South Africa due to urbanization, currency devaluation and continuing fluctuation in grain prices.

These factors are contributing to cassava already being used in South Africa as a substitute for higher priced raw materials (maize, wheat, potato) (Urban-Econ Development Consultants 2017). The impediment to importing needs in this regard is the absence of processing capacity in producing countries, as newly harvested roots must be processed immediately.

If a reliable market outlet at cost-effective price levels can be developed, Mozambique has considerable potential for industrialization of cassava starch making. The spot price for "native" cassava starch ready for industrial processes in South Africa in mid-2017 was approximately Rand 8 (US$0.62 at the time) per kg (Urban-Econ Development Consultants 2017). This gives a benchmark for assessing present Mozambican competitiveness. In any event, there has been limited activity or investment to date in industrial processing in Mozambique. Mozambique requires a cassava strategy focused on creating an industry able to compete at the regional and international level.

The addressable demand for cassava starch and derivatives is expected to be of the order of 17,000 tons by 2020, with only 2,000 tons coming from the domestic market (Dalberg et al. 2015). These are cautious figures may still be on the high side, since the domestic market for starch is very small and any starch industry based in Mozambique will have difficulty competing with derivatives from cereals such as corn.

However, soon the market for starch products can be increased using starch for biodegradable packaging material. In fact, biodegradable polymers gained significant attention from researchers decades ago. Biodegradable polymers reduce pollution. In recent decades, one of the most important targets in the development of biodegradable polymer area is to produce cheap starch-based biodegradable polymer. Native starch is suitable to produce biodegradable polymer material because it is available abundantly at low cost. Starch is harvested from varieties of crops such as corn, potato, sago, cassava, wheat, etc. Among the crops, cassava is most widely grown to produce sustainable and cheap source of starch globally (Sin et al, 2011).

Considering the increasing world concern on environmental issues, replacing non-biodegradable products can be a huge market all over the world, and cassava producer countries can take advantage of this opportunity.

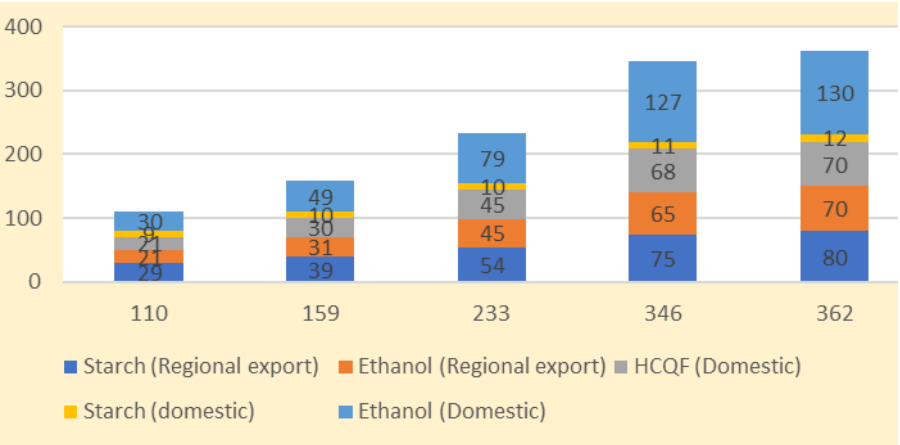
4.6 UPPER-BOUND ESTIMATE OF ANNUAL FRESH ROOTS POTENTIALLY NEEDED BY INDUSTRY

Cassava is still considered by many to be a poor man's crop, and does not attract the attention it deserves as an industrial crop. The market for cassava derivatives is increasing rapidly in southern Africa. Despite having considerable production, the Mozambique supply chain for cassava is very fragile. One hundred varieties are planted. Typically, plantings come from previous crops. Input use is low and it is low-quality, and land tenure is not secure. This unsatisfactory crop framework does not help in attracting investments to exploit the enormous potential for industrializing the cassava value chain.

To be successful, any agri-industry must be supplied with enough good quality raw material of on a regular basis. The present situation of the cassava value chain does not engender confidence in raw material availability, nor that the right raw-material environment for business growth is present.

Figure 15 summarizes industrial needs for raw materials for cassava processing if the potential markets for HQCF, ethanol, and starch were to take off in Mozambique. It is important to notice that these figures represent only one-third of the latent potential and they need to be understood in the context of Mozambique's position as the 11th largest producer of fresh cassava in the world.

Figure 15: Potential industrial needs for cassava raw material in Mozambique if a processing industry takes off over the next 5 years
(000 tons of raw cassava roots)



Source: Adapted from Dalberg et al. (2015), based on the previous Figures. The columns assume a two-year start up prior to column one, the first year of the program.

5. ADDRESSING SUPPLY CONSTRAINTS IN MOZAMBIQUE CASSAVA VALUE CHAINS

Farm-level production constraints differ in nature as well as magnitude across different size classes of farm and by major region. These differences are helpful to understand when assessing the potential for job and income creation.

5.1 Size classes of Mozambique's cassava farms and collective action

In Mozambique cassava value chains present different characteristics within size categories.

Three different producer groups can be distinguished, according to the Census of Agriculture and Livestock (CAP) 2009/2010.

- Many small farms with holdings of average 1.5 ha on average but using around 0.4-0.6 ha on average nationally for cassava. There were around 2.5 million small farms.
- Medium farms with a plot larger than 10 ha but smaller than 20 ha but using in average 1.2 ha for cassava. Approximately 8,000 farms.
- Large commercial farmers with more than 10 ha but usually less than 40 ha using on average 12 for cassava. Inhambane has more than a half of the existing large farms (65 out of 115).

The first two groups are often organized in associations, normally with 20 to 30 members on average. Each association member has his/her own field. Often the association itself can have a collective small plot of land, used for producing seed or for demonstrations of agricultural practices. Sometimes the associations are organized in a "Forum" that integrates several associations, on average between 7 and 14 associations per Forum.

Association land ownership is in general collective. Although some associations managed to get the DUAT (Direito do Uso e Aproveitamento da Terra [land use rights license]-Rights to use and benefit from the land), it is common to find associations without it. It is even more difficult for small farms to legalize their plots through obtaining a DUAT because they are unaware of their land rights, and if they know their rights they lack the financial and technical support necessary to assert those rights effectively.

Cassava value chains also differ across the main regions, due to the diversity of climate, ethnicity, cultural traditions, historical trade flows, dietary practices etc., resulting in different consumption and marketing patterns. Figures 14 and 15 give an idea of the different channels that can be found in the three different regions of Mozambique (northern, central, and southern). The northern and central regions account for more than 80 percent of total cassava production, but the markets and the industry are somewhat more developed in the southern provinces, mainly in Inhambane, where the cassava industry is concentrated and the market for cassava is a bit more sophisticated.

5.2 FARM-LEVEL PRODUCTION CONSTRAINTS

A review of the literature and field experience suggest that the following issues apply to smallholder farming systems in Mozambique.

- Smallholder producers have poor access to quality inputs, pesticides, fertilizers, mechanized plough, among other things.
- Limited availability of improved disease-resistant stems (cuttings) has been a major impediment to increasing farmer yields and protecting from loss to disease.
- Despite the existing programs to produce better planting material, availability is limited, and dissemination efforts have been ineffective, with only small groups of farmers engaged through NGO/donor value chain development programs having access to improved stems.
- No private seed companies exist to multiply cassava stems; thus, distribution channels continue to rely solely on government and NGO initiatives.
- Several diseases and insect pest plagues have deeply affected cassava production, such as the African mosaic disease , cassava bacterial blight , cassava brown streak disease, the mealy bug, cassava green mite, and termites and large grain borers that attack dry chips of cassava in storage.
- Smallholders, who account for almost all cassava production, are poorly organized and spread widely across difficult to reach rural areas, making aggregation of enough volumes on a consistent basis very difficult.
- Yields are quite low, with some estimates as low as 1.5 tons/ha, though an average is estimated at 3-5 tons/ha; for many farmers, even basic agronomic practices like appropriate plant density and spacing are not properly applied.
- Temporary gluts occur that are associated with prices so low that farmers choose not to harvest their roots.
- Per-farm output of cassava is low. Thus, processors are forced to source from a greater number of farmers, increasing time and cost of securing adequate supply.
- Harvesting cassava is labor-intensive and non-mechanized, discouraging rapid response to sudden opportunities.
- Since cassava is a high perishable crop after being pulled from the ground, farmers normally delay or stagger the harvest until they have buyers for their cassava. In the southern region, "*Maguevas*" women coming from the main cities are the main cassava traders and often have agree on buying cassava still in the ground from the smallholder producers to sell in urban markets.
- Harvesting is also affected by the limited access to markets for cassava products due to weak presence of cassava industry able to produce new value-added cassava products (high quality cassava flour and *rale*, animal feed, starch, ethanol etc.) with quality to meet demanding domestic, regional, and off-shore markets.
- Lack of a strong institutional system to support cassava business development by creating conditions to provide key services to producers, processors and traders is hindering creation of a strong cassava business network and appearance of efficient commercial farmers.

5.3 THE DYNAMICS OF AGGREGATION AND TRADE ISSUES

- The perishable nature of roots presents a serious impediment to commercialization of production. As raw roots contain 60 to 70 percent moisture, they have a shelf-life of only two to three days. Once harvested, they should be either consumed immediately after cooking (if safe) or processed into more stable product forms (IITA 2006).
- Raw cassava storage is one of the main constraints for producers and traders. The traditional practice of delaying the harvesting of cassava is inefficient and prevents land for being used for other purposes. Furthermore, the roots can be infected with pathogens and its flavour can be altered. Modern and more adequate processes to avoid spoilage, such as waxing the product or even freezing it, are not used.
- Due to low knowledge about, or capacity for, processing, traditional farmers are often unable to process large outputs themselves and must sell their crop at very low prices to market traders to avoid spoilage. Traders often buy cassava on farms before it is harvested. Farmers often resort to this method of sale when they need money, and it is likely to be an expensive form of credit as the bargaining power of farmers is low.
- Traders select roots suitable for sale in the fresh roots market and reject roots not considered sufficiently tender or juicy. Large quantities of roots may be rejected when the cassava is fully mature and too big for fresh root marketing. Traders will not tolerate over-aged and disease infected roots.
- The trade-offs between cassava and maize commercialization, which chiefly on the border with Malawi, due to the close maize marketing links offer interesting and profitable trading opportunities for both countries, particularly during drought years. In the northern region of Mozambique, 50 percent of the population consumes both cassava and maize in shifting proportions throughout the year. During the lean season, late in the rainy season when maize prices peak before the main maize harvest, they consume large quantities of fresh cassava, the only staple food they can harvest during this period. After the maize harvest, when stocks and plentiful and maize prices low, maize flour accounts for a large proportion of the porridge they consume. As the dry season proceeds, cassava flour becomes increasingly prevalent in regional diets. For this reason, Mozambiques's cassava producers and traders perform an important buffering role ensuring regional food security during drought years (Donovan et al, 2011; Haggblade et. al., 2012).

5.4 UNIT PRODUCTION COSTS DECREASE WITH SCALE

The low level of productivity on farms is no doubt the "Achilles heel" of the whole industrial cassava processing business in Mozambique. Small farmers producing on rainfed farming have high costs per unit, often not remunerated by the prices they can get in spot markets.

The price of raw material is crucial for any agri-industry initiative; in the case of cassava it is more critical due the fact that average prices per kg paid to farmers do not cover costs.

In the case of DADTCO cassava processing, farmers are paid between 2,000/2,500 meticais (presently US$32 to US$40) per ton (or 3 to 4 US cents per kg) depending on whether root transport is included or not, no matter the distance they come from. But some farmers are pushing for a price twice that amount to cover their production costs and make some profit. DADTCO claims that the problem is not the price but the volume of production the farmers must achieve

to produce economies of scale; with larger volumes, they will start making money (Van Melick, DADTCO manager, Nov 2015).

In fact, with the new partnership with SNV, a Dutch NGO operating under the program PROSUL, DADTCO claims that some farmers with improved genetic material (cassava stems) are achieving 20-22 t/ha and with local varieties can produce around 15t/ha, however this has not spread among all 4,000 farmers in the DADTCO program in the southern part of the country.

As stated above, few farmers selling to DADTCO can produce larger quantities to offset losses in production, due to low productivity and the small size of plots allocated to cassava production. This issue puts some pressure on DADTCO in negotiating with the farmers since the company cannot afford to buy at higher prices than those which will allow breakeven processing operations. Despite evidence that famers can increase productivity, it is a long process that will require strong technical support to farmers through a solid and steady extension services network.

All other cassava initiatives must cope with the same problem. For instance, allegedly one of the reasons for closing of the CLEAN STAR/NDIZLO ethanol processing facility to fuel new clean-burning ethanol stoves, was the inability to supply the factory with affordable raw material. There were also two other reasons in addition to price paid to farmers causing this: 1) the processing unit was located in Dondo in Sofala Province, a region with poor cassava production and 2) the cassava buying agents for the ethanol venture faced fierce competition from the CDM beer company , which was operating in both regions of the country that have high cassava production (interview Telma Venichand, former Sales and Marketing Director; and Emmet Costel, operations manager at CleanStar/NDZiLO company. For more information on this subject see Annex 3).

In fact, hypothetical comparison of traditional rainfed farming system production costs with more efficient irrigated farming suggests significant differences. Current smallholder rainfed farming obtains yields above 10 tons/ha at best, and much less on a regular basis, even with introduction of new and richer varieties. Variations go beyond weather outcomes, such as whether the farmer adopts best practices and the natural resource endowment of the farm.

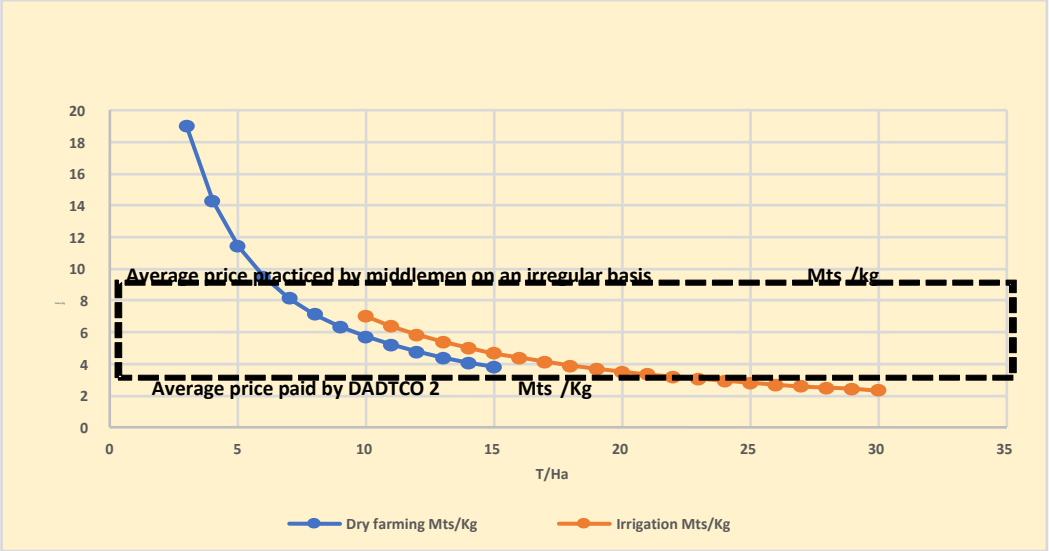
Based on present market dynamics, rainfed smallholders can expect to incur costs between Mt 19.0/kg and Mt 5.7/kg (30 US cents to 9 US cents) respectively for 3 to 10 tons/ha. Even under the unconvincing case of the producer achieving 15 tons/ha, the costs will be always near the average price paid in the market. With irrigated systems, yields can achieve 30 tons/ha or more; but if the yields vary from 10 to 30 tons, the costs will be around Mt7.0/kg and Mt2.3/kg respectively, providing some margin to the producer (Figure 16).

5.5 CROSS-CUTTING ISSUES FOR SMALLHOLDERS AFFECTING CASSAVA PRODUCTION

5.5.1 Gender

Women are typically more involved in the labor-intensive tasks of cassava production and artisanal processing, such as peeling, manual grating, and other low-returns to labor segments of the cassava value chain; men often benefit from easier access to working capital, secure storage, and transport services. As such, men are typically more involved in the more lucrative segments of the value chain (Donovan et al. 2011).

Figure 16: Unit production costs per kg decrease with scale in terms of tons/ha of yield



Source: Prepared by the author based on figures collected from interviews of cassava stakeholders in Inhambane Province

Women also tend to have less access than men to land, inputs, financial support, and even market opportunities. Even where there is apparent balance in the number of male and female members within the associations dealing with cassava, men almost always oversee the main positions and control the key areas of operations (Ibid.).

Women in smallholder areas are typically less literate than men, and men are typically favored where traditional culture prevails. In three small-scale processing units visited by the author, it was found that women normally take care of simple but laborious tasks such as manual peeling of cassava, but no women were observed handling processing equipment or in management positions dealing with stocks or sales.

5.5.2 Human morbidity

Major diseases such as HIV/AIDS and malaria are important vulnerability factors in Mozambique. Mozambique is among the 10 most HIV/AIDS-affected countries in the world in terms of infection rate. The main areas of incidence coincide with transport corridors linking Mozambique to South Africa, Zimbabwe, and Malawi.

HIV is more acute in the southern region, but it is present in all regions. The immigration and emigration phenomena seen in the southern region, with a number of people leaving and returning, seems to aggravate the situation. Most economic corridors are affected by this pandemic. It is no doubt an issue to consider in implementing programs because of the effect on rural families´ emotional temperament and on the availability of labor.

Malaria is also present in most of the country and its impact on rural families' welfare also calls for specific programs to prevent the disease from decimating the population in wet zones.

5.5.3 Climate change issues in production

Climate change effects on agriculture in Mozambique are severe, and one of the most significant emerging challenges to household livelihoods. Crop yields are threatened by a shortening growing season, greater water stress, and increasing incidence of diseases, pests, and weed outbreaks (Niang et al. 2014). Among the various environmental changes brought about by climate change that limits crop yields, heat and water stress are considered the most important (Bita and Gerats 2013).

Studies on cassava climate change resistance have found that cassava's tolerance to high temperature and intra-seasonal drought leads to less reduction of productivity over time compared with maize, millet, and sorghum (Jarvis et al. 2012). Nevertheless, extreme weather conditions such as prolonged drought and excessive rainfall leading to floods are detrimental to cassava output.

5.6 OUTLINE OF SOLUTION STRATEGIES FOR CONSTRAINTS ON FARMERS

Supply-side issue for farmers	Possible solutions
Uncontrolled pests and diseases reduce the motivation for farmers to increase cassava production.	Support specific programs to introduce new varieties with higher yields, starch content, and disease/pest resistance.
Producer organizations are weak, with little management capacity; ineffective or missing production and processing cooperatives.	Encourage farmers to organize themselves in cooperatives and unions, since this type of collective action offers better prospects for developing business skills, opportunities, and market power to defend their interests. Also reinforce associations of cooperatives.
Very weak commercial links between producers and markets means fewer sales opportunities, which reduces incentives for increasing production for sale.	Promote outsourcing schemes and supply contracts between producers and processors. Adjust legislation to better cover farm contracts and sales situations to protect all parties better.
Absence of trust among stakeholders at different stages of the cassava value chain inhibits expansion; poor information access places producers in a weak position for bargaining on prices.	Include cassava within the existent market information systems; disseminate the use of SMS in the rural areas for market information; advertise heavily the benefits of establishing commercial contracts between sellers and buyers; and divulge the mechanisms for ensuring compliance with the norms to increase transparency.
High incidence of HIV/AIDS and other pandemic diseases in parts of the Central and Southern region limits the availability and quality of labor.	Promote campaigns to prevent and control the dissemination of the diseases through specific programs to support affected rural families.
Uneven playing field in competition for labor from other value chain stakeholders such as, those dealing with maize, rice that normally receive more support from the Government for development.	Lobby the Government to provide the same type of support to cassava value chain establishing a clear strategy to develop the value chain.
High rates of illiteracy and lack of commercial knowledge, compounded by social issues around gender, are a problem at each step of the value chain, but problems here are greatest in production, where most of jobs (and poverty) are concentrated.	Provide technical training to producers through functional literacy programs; establish specific programs with a gender lens to address issues in access to inputs and land, processing, financing and management techniques.
Poor quality of fresh cassava sold and low yields are due to the way the land is prepared, the use of inappropriate genetic material and, also to the low density of planting. Because of this, farmers incur higher than necessary costs of production and consequently are often not provided effective incentives by the market prices on offer. Many produce most of the time at average costs well below break-even point (Fig. 16 above)	Reinforce the activity of the agricultural research establishments (nationally IIAM, internationally, the International Institute of Tropical Agriculture, Ibadan, Nigeria) to fulfil the tasks the private sector is unwilling to assume such as, improvement of logistics of quality cassava stems distribution, breeding of improved, disease and pest-resistant new varieties, training in food sciences and food safety, fostering international knowledge exchanges among others. Seek means to better induce private sector participation. Attract mechanized services and input suppliers to the rural areas through the creation of service hubs. Promote partnerships between Research and Development entities and cassava stakeholders (Examples of the programs of the Brazilian agricultural research agency EMBRAPA, and the Brazilian small and medium enterprise agency SEBRAE).

6. PROCESSING AND MARKETING ISSUES IN EXPANDING CASSAVA VALUE CHAINS

6.1 SUPPLY-SIDE ISSUES FOR PROCESSORS

The main constraint for industrial processing is inability to secure an adequate supply of fresh cassava to run factories, given low yields, high unit costs of raw material, and scattered farmers. Without strong supply chains, processors will not be able to operate at a minimum capacity level to lower average costs enough to be able to make a profit.

Some other constraints have been pointed out by cassava stakeholders across the country, small and medium farmers, the entrepreneurial sector, the Government, and NGO's. The main ones are:

- Lack of organized associations to invest and manage processing units:
- No incentive to use mechanized equipment because of the small volume of cassava production from individual producers;
- Shortage of processing machinery manufacturers especially for the medium size units;
- Lack of qualified, experienced, and efficient managers;
- Processors are short of money, and bank financing for machinery investment and working capital is not adequate due to high interest rates;
- Poor electricity network and water systems in rural areas;
- Cassava process demands clean water not always available where potential investors are located;
- Difficulties in technology generation, transfer, management, and absorption (in the value chain);
- Inadequate marketing information;
- Lack of skilled labor, aggravated by absence of training facilities, to improve food safety, productivity, production quality, and technical skills;
- Absence of updated national food laws, standards, and specifications for food products and quality control;
- Absence of hygienic standards including lack of sensitivity to adoption of GMP (Good management practices), GHP (Good hygiene practices) and HACCP (Hazard Analysis Critical Control Point);
- Limited research and development support; and
- Lack of adequate incentives such as fiscal support.

6.2 SOLUTION STRATEGIES FOR SUPPLY-SIDE CONSTRAINTS ON PROCESSORS

This section summarizes the main supply-side issues for industrial cassava processors, and outlines possible pathways to explore for finding solutions.

Supply-side issues for processors	Possible solutions
Irregular and under-supply of raw material to processing units. Cassava supply for processing competes with self-consumption, local wet markets, and artisanal processing.	Establish out-grower schemes for cassava production and fresh cassava supply, promoting legal contracts between processors and farmers.
Lack of management knowledge and technical capacity to manage processing units.	Provide intensive training to workers at all levels of the processing cycle, mainly to women, including programs specifically designed to improve the management and equipment handling capacity.
Lack of business infrastructure, water systems, electricity, and maintenance service providers within rural areas.	Establish service provider networks to assist processors in maintenance. Support the acquisition of equipment by service providers able to provide technical assistance to rural clients.
Inefficient transport systems from fields to processing units. No concentration points to take advantage of economies of scale to lower costs.	Create and support specialized service provider centers (hubs) to assist both sellers and buyers; create centers equipped with adequate drying systems, storage capacity, and conservation systems to aggregate raw and dried cassava to facilitate regular and adequate delivery to processing units.
Labor scarcity in the region due to the exodus to cities, with more incidence in the southern regions near the largest cities and also more likely to emigrate to South Africa.	Prioritize the training of women in improving their management skills and processing to handle the absence of trained men that have emigrated.
Lack of financial capacity of potential domestic investors.	Establish a fund to support the financing of fixed assets (mainly equipment) and working capital for raw cassava.

6.3 OUTLINE OF SOLUTION STRATEGIES FOR COMMERCIALIZATION CONSTRAINTS ON PROCESSORS

This section summarizes the main market-related constraints for cassava producers and processors, and outlines possible pathways to explore for finding solutions.

Commercialization issues	Possible solutions
Lack of established markets for industrial quality cassava products. Home artisanal production and traditional marketing arrangements prevail.	Support in adopting new processing technologies tailored to each circumstance with emphasis on the processing by farmers´ associations. Introduction of quality standards for cassava products (National Institute for Standards and Quality of Mozambique (INNOQ) and partners)
Insufficient diversification of products and lack of adequate market infrastructure. (Example: lack of storage facilities or practices capable of addressing problems with high perishability of raw roots).	Support the diversification of cassava products to satisfy different market segments. Create market infrastructure in strategic zones along main roads with conservation appliances (drying and cooling units to preserve fresh cassava).
Prevailing cassava production and artisanal processing costs are high relative to low prices in wet markets, which do not encourage expanded sales by producers. Family labor is typically not costed or under-costed relative to commercial opportunity costs in current sales, allowing present markets but blocking commercial expansion. Weak commercial networks with lack of adequate infrastructure, high transport costs, poor dissemination of relevant technical and market information.	Promote the adoption of better planting material, better dissemination of information, and better agriculture practices (such as, land preparation, inputs use, better plant density), to boost yields, achieve economies of scale, and boost fundamental profitability along the value chain.
High competition for direct and processed food use from substitute products seen as having better nutritional attributes, such as maize, rice, sweet potato, and wheat.	Diversification of cassava products through vitamin enrichment to fortify nutritional attributes, allowing better consumer appeal vis-a-vis competitors. Production and dissemination of technical information among value chain stakeholders.
Lack of incentives and fiscal benefits to boost production, processing, sales, and consumption of cassava and its industrial products and derivatives.	Introduction of fiscal measures to incentivize the growth of the value chain in all its dimensions.

6.4 ENVIRONMENTAL ISSUES ASSOCIATED WITH LARGE-SCALE CASSAVA PROCESSING

As already mentioned in this report, cassava in Mozambique is primarily produced by small-scale farmers and processed at the family or village level. Industrial processing at medium to large scale is still rare.

In countries such as Thailand, China, Vietnam—where larger-scale cassava value chains are more developed—processing is regarded as polluting, a burden on natural resources. Larger-scale technologies used to process cassava into starch are now even more water-intensive than traditional methods, yet often are located in areas of water scarcity. Industrial cassava processing for starch extraction produces large amounts of effluent high in organic content. If untreated, this may be observed in the form of stagnant effluent pools emitting strong odors.

Other forms of processing, despite requiring much less water, generate visible dust waste. Because of the visual display of pollution, cassava processing beyond the artisanal level runs the risk of being perceived by local populations as contributing significantly to environmental damage and water deficit. So far, few systematic impact studies focus on the environmental impact specifically, although some deal with the quantity and composition of waste produced by this industry.

Furthermore, cassava processing generates solid and liquid residues from separation of toxic cyanogenic glucosides from the edible material. Two important biological wastes that may damage the environment are derived during cassava processing: cassava peels and the liquid effluent squeezed out of the fermented parenchyma mash (Obueh HO and Odesiri-Eruteyan, 2016).

To develop the cassava processing industry, given the steady increase in supply and demand for cassava, strategies must highlight the need for measures to reduce environmental waste effects of cassava processing. Public outreach on the possible negative environmental effects and how to mitigate them are also needed.

7. GOVERNMENT POLICIES WITH RESPECT TO CASSAVA VALUE CHAINS

In 2009, cassava was Mozambique's largest single source of food crop calorie intake, accounting for 30.2 percent of total calories (Donovan et al. 2011). Cassava remains today a critical part of Mozambicans' diets, with the average citizen consuming some form of cassava every day. However, nearly all consumption remains informal, with local and household processing of traditional foods.

Policy has traditionally had limited impact on the promotion of formal value-addition opportunities. However, since the Government is facing acute problems in ensuring food and nutrition security, it has demonstrated growing interest in exploiting the potential of cassava products and its derivatives for human consumption and industrial use over the last decade.

7.1 GENERAL POLICIES

Concerned with inadequacies in smallholder access to appropriate planting materials, service providers (inputs, extension), remunerative prices, and consistency of demand by the private sector, the Ministry of Industry and Commerce (MIC) prepared a *Cassava Development Strategy* with support from the European Community (EC) and the Food and Agriculture Organization (FAO) (MIC 2007).

The strategy adopted has the overall objective to develop the value chain to improve food security and increase incomes of farmers, processors, and traders. The means of doing this would be through new investments to take advantage of the potential domestic and off-shore market for cassava derivatives. According to the MIC Strategy, the Government should lead an initiative to assist cassava stakeholders, including (Ibid):

- Create an enabling environment to support the role of cassava in both food security and income generation.
- Identify and develop of market opportunities for cassava products.
- Support development of cassava value chains, including production, processing and marketing to meet identified market opportunities for improved traditional products (flour and *rale*), high-quality industrial cassava flour (HQCF), and cassava for livestock feed.
- Undertake research on cassava-based production of industrial products with longer-term potential, surveys of potential for significant market demand for such products, and financial feasibility studies for business elements requiring significant private sector investment.

The policy envisions cassava continuing to contribute to household food security, while also contributing to poverty reduction through increased value-added end products being brought to market, both nationally and, in the longer term, internationally.

Following these policies, the Mozambique Government initiated promotion of the cassava value chain by giving cassava projects priority in agriculture development programs, as well as accelerated support to cassava producer farmers by adopting government-funded research,

germplasm replication, and extension programs to improve genetic material for planting and making it available to farmers.

In 2007, President Armando Guebuza of Mozambique requested scientists in Mozambique to develop technologies for mixing HQCF with wheat flour to reduce the cost of bread. Following this initiative, the MIC promoted the use of HQCF as a substitute for imported wheat flour. Driven by a spike in the price of wheat in 2010, the Government asked research institutes and end-users to explore adoption of HQCF in bread and other products. No formal policy was put in place, and the pilot composite flour promotion projects have not been scaled as of this writing. While some local bakers still produce cassava breads and other products, efforts are scattered, and political investment remains low (Dalberg et al. 2015).

Over the last decade, MIC launched a series of studies and task forces aimed at exploring prospects for cassava commercialization. The Government also moved forward biofuels production legislation to encourage domestic production from commodities such as cassava (Marcelina Mataveia, May 2009). Finally, the Government, through MASA, included cassava as a priority food crop in PEDSA (2011/2020), the Agricultural Sector Strategic Development Plan, recognizing the socio-economic importance of cassava for Mozambique economy.

7.2 FISCAL POLICIES

In 2011, the Mozambican parliament had the First Reading of a Government bill introducing a new, lower rate of tax for beer made from roots or tubers, particularly cassava. The low tax rate was intended to make the new beer competitive and encourage farmers to produce more cassava. The cassava beer excise tax relief was subsequently developed and adopted to incentivize the use of cassava in beer, offering a reduction in the excise duty on beer from 40 percent down to 10 percent for cassava-based beers. The excise break on the Impala beer has been critical in enabling CdM to sell the beer at about 70 percent of the price of a mainstream beer (Ibid.). This low pricing has been a major driver of demand and popularity of the Impala brand.

To date, cassava policies in Mozambique have successfully incentivized the cassava beer industry, although that may be changing, and it seems that further fiscal incentives may be needed to encourage broader industrialization and access to export opportunities such as for starch and ethanol.

7.3 FOOD-SAFETY POLICIES

Food safety has been somewhat neglected in Mozambique. Since most cassava production is consumed directly by rural families, controlling food safety is solely the responsibility of homemakers preparing cassava-based foods, normally women. Contrary to Malawi and Zambia, Mozambique has no food safety policy or standards for commercially-sold processed cassava foods.

Thus, commercialization presently transfers responsibility for food safety to commercial farmers and processing industries for the cassava-based products they sell. Commercial cassava processors recognize the need for food safety standards that ensure consumer safety and at the same time protect processing firms from litigation (Haggblade et al, 2012). Given the danger to human health from improperly processed cassava, large-scale commercial food and feed industries

require quick, effective tools for testing of cyanogenic glucoside content in their raw materials and final products (Brimer 1994, Abban, Thorsen and Brimer 2011).

Mozambique has already registered cases of people dying or contracting severe diseases by ingesting cassava products with a high degree of toxicity due to cyanogenic glucosides (such as linamarin and lotaustralin). The presence of cyanide in cassava is also of concern for animal as well as human consumption. Mozambique urgently needs to introduce legislation to regulate and control the safety of cassava products available in the market (cassava roots, processed products, and cassava leaves).

8. THOUGHTS ON A RENEWED STRATEGY FOR CASSAVA SUB-SECTOR DEVELOPMENT

8.1 PREMISES

Regarding Cassava value chain development, the last decade brought growing interest from industry and government in prioritization of cassava for food and industrial products. Many interventions exist—involving the Government, donors, international and national companies, and NGO´s, either individually or through Public-Private Partnerships (PPPs) —that are helping change the status of cassava from a food security crop to a profitable commercial crop.

The policy environment is thus very favorable to new initiatives, Government, civil society, and private companies, and funders are all collaborating and investing in improved planting material, extension services, and other productivity initiatives.

Smallholder farmers are mostly in remote locations and typically have limited understanding of commercial relationships in a modern business environment. Farmers are largely unorganized, and the few farmers´ associations are weak. Farmers are not thought to be well linked to markets outside their own local areas. Farmers also fear that large-scale cassava production could lead to displacement of farmers from their land and raise issues around resettlement.

Based on the analysis above, it is possible to design an intervention strategy based on specific activities to solve the problems, or at least to address the concerns by overcoming the challenges and mitigating the constraints that hinder the development of businesses along the value chain.

In general, the strategy to develop cassava value chain in Mozambique should be focused mainly on bringing science to the crop. The Mozambique Government should adopt a strong policy to develop the cassava value chain, similarly to the strategy adopted by countries in Asia and Latin America, and Ghana and Nigeria in West Africa.. In this regard, activities to increase productivity should be the entry point for interventions.

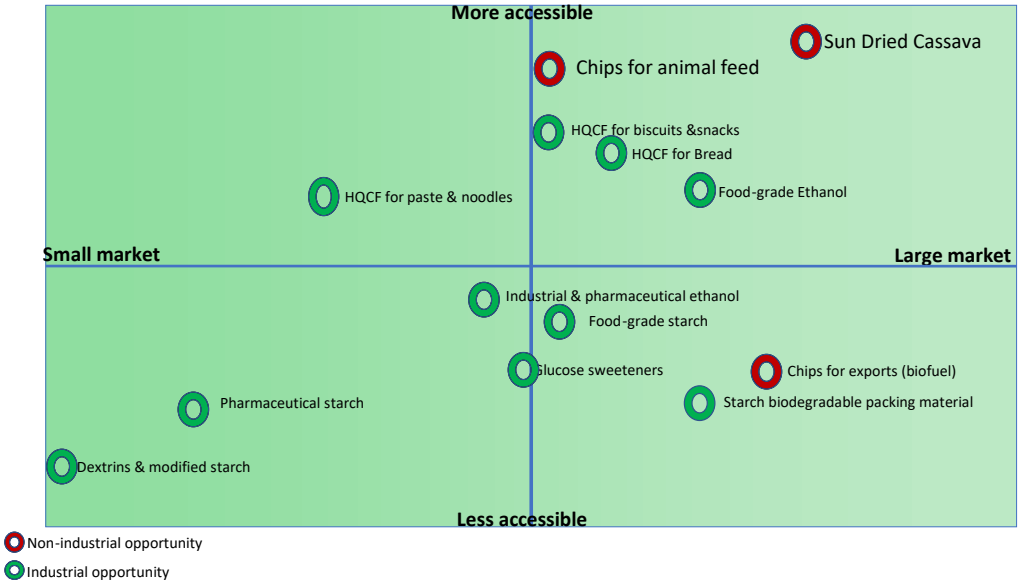
8.2 PRIORITIES FOR DEVELOPMENT OF THE CASSAVA VALUE CHAIN

Figure 17 below suggests priorities to follow in industrializing the cassava value chain in Mozambique. However, it is important to stress that any further investment will need to be supported by a healthy value chain, able to supply the market with enough and good quality of raw cassava fresh roots. The main priority is to boost existing production of raw material by better supporting small and medium-scale farmers.

It is imperative to introduce best practices: farmers must have access to better planting material, adequate inputs and must be able to control their own land. In this regard, the Government of Mozambique must adopt and implement adequate policies, adapted to each phase of cassava value chain development.

Potential PPPs should target linking the private sector with the relevant Ministries, departments, and other state agencies such as IIAM (Instituto de Investigação Agronómica de Moçambique), INNOQ (Instituto de Normação e Qualidade de Moçambique) and civil society.

Figure 17: Industrial and non-industrial cassava opportunities in Mozambique ranked by potential market size and degree of accessibility of the opportunity



Source: Slightly modified from Dalberg et al. 2015

9. RECOMMENDATIONS

The main recommendations for interventions to address the issues outlined in this paper are summarized below.

9.1 ENABLE AN ADEQUATE ENVIRONMENT TO DEVELOP THE CASSAVA VALUE CHAIN

Cassava will continue to contribute to food security, but its potential as a raw material for agro-processing can also make the crop an important contributor for poverty reduction among smallholders and eventually provide a significant input to development of agro-processing in Mozambique. The potential market for cassava derivatives, as pointed out above, suggests that Mozambique should target heavy investment in industrializing the value chain, although this must be achieved cautiously, following very well-defined steps based on the principle of "easier things first" and using the private sector to implement. Figure 17 above suggests that Mozambique should:

- First, process HQCF to explore the large domestic market of bakeries to replace wheat, wet cake for beer production, and pellets for animal feeding.
- Second, encourage efforts to install ethanol processing units to reduce imports of this product and to supply the tiny pharmaceutical and small spirits beverage industry.
- Third, encourage production of starch, given high and growing regional demand in SADC, and for which required start-up investments are significantly higher than for other product lines.

To support industrializing the cassava value chain, the main priority should be to increase farm productivity and reduce post-harvest losses. Beyond that, the Government should:

- Adopt a specific "Master Plan to Develop Cassava Value Chains" similar to Nigeria, Ghana, and some Asian countries with higher-level development of cassava. The Master Plan would guide implementation of the principles established in the 2007 Cassava Strategy for Mozambique, steering public sector activities to develop the value chain. Nigeria adopted measures such as support to contract farming systems, but their flag-ship initiative also promoted blending of HQCF in wheat flour for bread baking industry, beginning at 10 percent substitution and growing higher (Dalberg et al. 2015).
- Set up a Platform and means to coordinate, monitor, and evaluate implementation of the Master Plan over time. The Platform should include the main stakeholders for cas-sava and derivatives and create a shared vision of goals to achieve and means to get there.
- Allocate resources and develop and adopt policies to enable new businesses in the cas-sava value chain—such as those related to food safety still to be introduced in Mozam-bique—and regulate and further legislate biofuel production to support development of the cassava value chain.

- Attract funds and partners to implement the activities envisaged in the Master Plan by creating a network of field service providers near the smallholder farmers, particularly to deliver technical assistance and capacity-building; also promote technical hub services.

- Attract financing, either from specialized financial institutions or from specific development programs, to support small farmers through tailored financial schemes.

- Prioritize investment to improve road, water, and electricity systems in production areas to support agriculture, development of mechanized processing facilities, and production of adequate raw materials to supply processors.

- Support local processing companies in accessing export markets by hosting or attending trade shows and conferences.

- Intensify technical support schemes for processors, which could include providing subsidies to cover start-up costs, new types of financing loans, and capacity building for people throughout the processing supply chain.

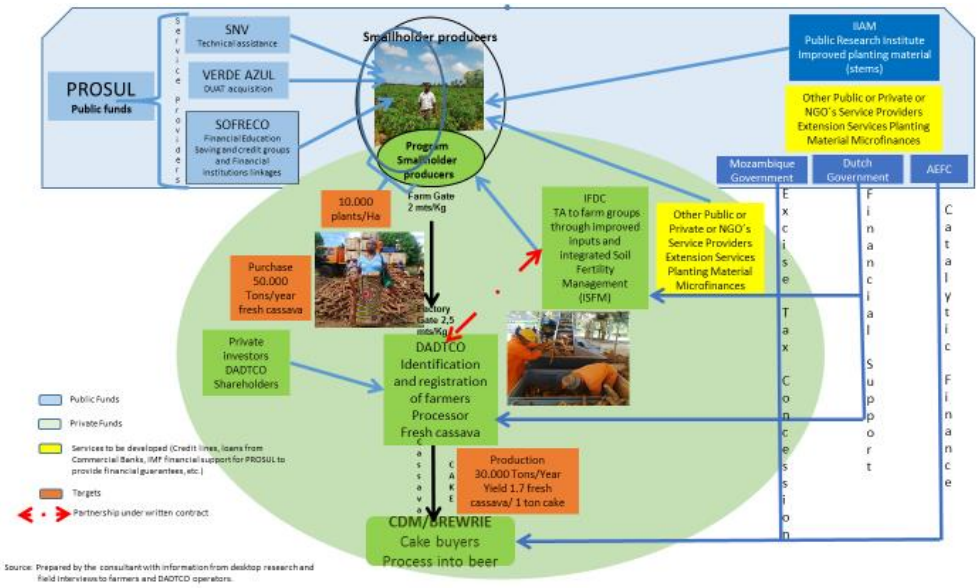
To increase efficiency, any intervention program should be gender-balanced and should consider the need to:

- Introduce literacy programs for women.
- Train women at the same level as men on technical, technological, and management issues, not just to be able to manage business but also to have better access to financing and more complex markets.
- Due to the large number of rural families involved in cassava production and heavy labor requirements, add cassava-specific goals interests to programs address pandemics such as HIV/SIDA, malaria and tuberculosis.
- Promote adoption of Climate Smart Agriculture measures to facilitate farm adaptation to damaging climate change effects.
- Carry out a massive campaign to mentor small-scale processors on the negative influence on the environment caused by uncontrolled cassava processing effluents, while introducing laws to prevent medium and large cassava processors from polluting.

9.2 ESTABLISH A CONDUCIVE STRUCTURE TO IMPLEMENT THE MASTER PLAN

Implementing programs to support smallholder farmers requires a mix of many different skills and resources to address a wide variety of issues. The best way to approach this is through PPPs. The experience of the CDM/DADTCO partnership, detailed in Annex B and portrayed in Figure 18, provides a good example. As shown in Figure 18, third-party operators successfully established bilateral agreements to intervene in the process of enhancing smallholders' capacity to supply cassava fresh roots to DADTCO reliably.

Figure 18: The CDM/DADTCO PPP cassava program in Inhambane province



The Government and the other stakeholders should encourage the creation of PPPs under the Mozambique legal framework to intervene in the cassava value chain. These agreements should be subject to a contract to achieve agreed targets by specific dates and lay out verification procedures.

PPPs are most useful where no single actor has all the competencies required to address the interconnected issues in each situation or policy area. PPPs are effective when all parties feel that they hold important and complementary roles within the partnership arrangement, and that the benefits from involvement in the PPP align with their own goals and objectives.

As discussed in Section 4 above, fiscal measures can also help provide a facilitating environment for establishment of specific sub-sectors of cassava processing. Examples were lowering the tax on beer made with cassava or an import tariff on HQCF. However, such measures should always be temporary; the incentive to improve efficiency must always remain.

9.3 SUMMARY ON IMPROVING PRODUCTION

Although discussed in more detail in the report, the topics below summarize implementation priorities.

9.3.1 Improving collective action involving smallholders

Farmers should be encouraged to organize in associations to facilitate access to service provider support. Support to access to land rights by DUAT acquisition will reinforce their capacity to practice commercial farming. Focus should be primarily on improving smallholder farmers' capacity to produce high-quality fresh roots to sell in a more demanding market, and to supply processing units.

Farmers must be prepared to jump to the second phase of processing their own production mechanically. Farmers should be organized in such a way that they can guarantee the critical mass of good quality raw cassava, not only for their own consumption but also to supply a reasonable processing unit.

Vertical integration offers opportunities for smaller farmers and processors to better access growth markets. Cooperatives could be a superior form of organization to improve competitiveness and help farmers achieve their goals.

9.3.2 Production increase and stabilization through technological improvement

Today in Mozambique, direct consumption of cassava represents about 70 percent of total production. Industrialization of the cassava value chain seems to be the only way to ensure a growing and higher value market for producers. Cassava farmers need to produce cassava at a quantity beyond household consumption use to provide consistent, reliable supply to the processing industry.

This will require introduction of best agricultural practices to increase the use of inputs, develop, and disseminate high-yield varieties (improve germplasm distribution, breeding) to increase production volume and to improve productivity.

9.3.3 Intensification of pest control measures

The seed system in Mozambique is very weak, cassava is genetically complex, and it is subject to several diseases and pests that hamper production growth. The spread of pests is a major factor in the insufficient supply of raw cassava, especially sweet varieties, calling for intensification of pest control measures.

It is crucial to develop the seed/stem system. In this regard, the priority should be to bring science to cassava to develop and disseminate pest-resistant cassava varieties.

IIAM should collaborate with international specialized institutes such as IITA and peers in Africa, Asia, and Latin America to acquire and multiply adequate resistant varieties with higher starch content and productivity. Together with other stakeholders, the Government should work to encourage development of a private or PPP germplasm distribution system that will facilitate

distribution of new varieties among farmers efficiently. Some work on improving planting material is under way, but much more is needed. IIAM and its partners need strengthening to undertake more intensive breeding research and extension work, to cooperate better with peers in other countries, and to educate producers on the use of new cassava cultivation techniques.

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ANNEX A

DONOR ASSISTANCE TO THE CASSAVA VALUE CHAIN

External development partners interested in promoting cassava value chains began to increase in Mozambique over the 15 years. Major international public research initiatives like the Southern Africa Root Crop Research Network (SARRNET), coordinated by the International Institute for Tropical Agriculture of the CGIAR, began to implement projects to help expand the productivity of cassava farmers in Southern Africa countries. Before that there were only sporadic interventions and most of them were part of broader agricultural programs that privileged other crops considered more important than cassava for both food and nutrition security and for commercial purposes.

One of the first activities implemented was in the region known as Chinyanja Triangle (CT) over the period from 2004 to 2009. The Chinyanja Triangle covers central and southern Malawi, the Eastern Province of Zambia, and the Tete Province of Mozambique. The region was named after Chinyanja—a common language along the shared borders of these countries (IITA/SARRNET 2012).

The IITA/SARRNET main strategy in CT was the mass production and dissemination of appropriate, disease-free cassava planting materials through (1) the establishment of seed multiplication nurseries, (2) the development, evaluation, introduction, and promotion of new cassava varieties and products for market acceptability, and (3) the development of appropriate cultural practices (Ibid.).

In fact, the first years of the new century determined the beginning of a new era for the cassava value chain. Most of the African cassava producer countries felt the effects of a cassava boom that took place over the last two decades. Aware of this, NEPAD (New Partnership for Africa´s Development) launched a program in 2005 known as NEPAD's Pan African Cassava Initiative, which adopted the theme "Cassava: A Poverty Fighter in Africa" (NEPAD, no date). The program's philosophy is that production of cassava can be viably and sustainably expanded when driven primarily by market forces.

The initiative's main objective is to mobilize the large potential of cassava to contribute to food security and income generation among African countries. Activities to be carried out include:

a) Technical and financial support to commodity chain institutions;
b) Support for technology development and dissemination; and
c) Facilitation of access to finance Action by African countries.

Under this initiative countries would design and implement a strategy to develop and modernize the cassava sector, including partnerships with the private sector (farmer organizations and agribusiness operators) to strengthen the commodity's supply chain. The action by partners would be to provide technical assistance and co-financing to support country efforts to develop the cassava sector.

Following this initiative some countries, among them Mozambique, began to pay much more attention to cassava development to explore its potential to contribute to reducing poverty and

hunger in the rural areas, and to contribute towards reducing the country´s import bill and consequently reducing the trade deficit, one of the major problems affecting Mozambique economy.

Mozambique as mentioned above, adopted its first cassava development strategy in 2007. From then on, many initiatives in support of cassava value chain have been implemented, integrating different donors and implementing agencies.

Table A1.1: Main cassava value chain projects under implementation

Implementer	Scope	Goal	Beneficiaries	Funder
Ministry of Agriculture; Pro-poor value chain development project in the Maputo and Limpopo corridors (PROSUL)	The project involves pro-poor and climate resilient improvements in three value chains: irrigated horticulture, cassava, and red meat. Takes place in southern Provinces of Gaza, Inhambane and Maputo.	The project goal is to establish improved and climate-resilient livelihoods of small farmers in selected districts of the Maputo and Limpopo corridors. Its development objective is to achieve sustainably increased returns to smallholder farmers from increased production volumes and quality in the targeted value chains, improved market linkages, efficient farmer organisation and higher farmers‟ share over the final added value.	Around 8000 farmers throughout-grower schemes, contract farming, and hub services.	IFAD/ Mozambican Government
IITA/Feed the Future "Mozambique improved Seeds for Better Agriculture” . Partners: Center for Tropical Agriculture (CIAT), the International Center for Research in the Semi-Arid Tropics (ICRISAT), and Instituto de Investigação Agrária de Moçambique *(*IIAM).	SEMEAR is a 5-year (2015-2019) program led by IITA to disseminate improved legume seeds and complementary crop management practices through the PARTI–Platform for Agriculture Research and Technology Innovation. Takes place in Feed-the-Future	The overall goal of SEMEAR is to increase the adoption of improved technologies, income, and food security. It will increase the production and supply of breeder, pre-basic, basic, and certified seeds in FTF-ZOI and strengthen the national seed systems; scale up and enhance the adoption of improved varieties and best management practices using	Adoption of improved technologies of at least 100,000 households of smallholder farmers. SEMEAR’s targets are 88.7 tons of breeder and pre-basic, 715 tons of basic/foundation seed and 10,004 tons of	USAID/Feed the Future

	Zones of Influence (FTF-ZOI) in Mozambique, namely Manica, Tete, Zambézia, and Nampula provinces.	participatory approaches; and enhance national policy dialog on seed and fertilizer supply.	certified seed supplied.	
Let´s Work Program (LWP), Implemented by the World Bank	The Let's Work Program will conduct analytical work on select value chains, including cassava, to try to identify comprehensive interventions in the value chains for job creation	To catalyze private sector investments that help create a significant number of jobs, and/or to significantly improve the quality of jobs (e.g. productivity, wages, labor and working conditions, inclusion – such as women and youth, etc.). It includes analytical work and pilot operations that support the following three areas of focus: 1) promoting the creation of private sector jobs through a value chain-based approach; 2) increasing the productivity of jobs that already exist; and 3) helping connect people to jobs.	Focus on the bottom 40% of the population.	Let's Work Initiative/ World Bank
Cassava Platforms including diverse stakeholders (Example: CDM, DADTCO, SNV, IFDC, PROSUL, Verde Azul, Dutch Government, Mozambique State Agencies)	To join efforts to intervene through PPPs on cassava initiatives by complementing each other interventions to achieve shared public good objectives.	To reconcile interventions to take advantage of the synergies generated by each implementer in favour of the final goal.	To benefit as much smallholder farmers as possible, to promote market linkages to enhance industrialization of cassava	Mozambique Government/Private Sector

ANNEX B

CASE STUDY OF CDM'S IMPALA BEER[9]

Background

As stated above, raw cassava roots are very bulky and very perishable, and thus expensive and difficult to transport, so processing must be done near primary production. To overcome these constraints, the Dutch Agricultural Development and Trading Company (DADTCO) entered into a partnership with a major potential user of cassava wet cake, *Cervejas de Moçambique* (CDM). DADTCO is a Netherlands social enterprise that pursues both poverty alleviation and profits; it came up with an innovative response by spearheading the development of a new technology that brings the cassava processing factory to the farmers. The main goals to achieve with this initiative are:

- Engage with farmers as business partners to commercialize cassava in a profitable way;
- Improve food security and incomes of farmers through increased cassava production and sales;
- Replace imported grains with domestic cassava for multiple uses in profitable domestic industries and for exports.

The Autonomous Mobile Processing Unit (AMPU) deployed by DADTCO is a small factory that transforms roots into high-quality cassava cake that can be stored for two years. The AMPU operates in a cargo container that can be moved from one rural area to another during harvesting. DADTCO buys cassava roots from individual farmers living near the AMPU and processes the roots into cassava cake. Cassava cake can be used in numerous agricultural and industrial products, including Impala beer, a new product from CDM that currently uses all the cassava cake produced by DADTCO in Mozambique. DADTCO is operating AMPUs in Nigeria, Mozambique, and Ghana, with the prospect of rolling out to 27 other African countries.

In view of these advantages, the SABMiller company saw an opportunity to set up the local beer consumption market in Mozambique and access a new market segment by developing a cassava-based beer locally sourced and produced. Thus, they joined a PPP public-private partnership (see diagram above) formed by them, DADTCO, the Dutch government, and the International Fertilizer Development Center (IFDC) for which the Dutch government provides funding. The African Enterprise Challenge Fund (AECF) provided initial catalytic finance to SABMiller to pilot the concept and, the Government of Mozambique has supported the project by providing excise tax relief.

DADTCO has been able to purchase farmers' cassava and reduce losses through speedy processing using two Autonomous Mobile Processing Units (AMPU), representing a decentralized sourcing and processing model for cassava. Through this model, DADTCO can process cassava at the farm in rural areas where smallholders grow their crops. Traditionally, farmers have cultivated cassava primarily for consumption but have sold some in local markets after shredding

[9] This case study was prepared based on available literature mentioned in references, visits to the DADTCO operations zones, interviews to DADTCO CEO for Mozambique Mr. Hubert Van Melick, DADTCO extensionist Nelson Joaquim and some farmers selling to DADTCO in Morrumbene district of Inhambane indicated by DADTCO managers.

and drying it. Selling fresh cassava to DADTCO, which arranges transport and buys in large quantities, offers farmers the opportunity to earn larger amounts of cash while using less labour. The AMPU is moved to different areas as a function of harvesting schedules.

DADTCO cassava wet cake producers for CDM/SABMiller's Impala Beer is the main buyer of fresh cassava roots for industry in Mozambique. Impala beer is the world's first commercially-made cassava-based beer, and has become an affordable, high quality alternative in rural areas to informal or illicit alcohol. Impala Beer demonstrates that commercialization of smallholder cassava production is feasible, but requires deep immersion into the supply chain through near-farm processing.

Results

This initiative has been successful up to now and has potential for expansion, although there are discussions on the end user side about the availability at scale, and on the farmer side about the level of prices (farmers´ perception is that DADTCO do not pay the right price to cover their costs, they claim for 4,500/5,000 Mts per Kg instead of what DADTCO is paying in average between 2000/2500) depending if it includes transport or not no matter the distance of cassava roots origin.

The established PPP´s involving DADTCO have different partners in the Northern and Southern regions (see Annex III), It began with IFDC in charge of delivering some technical assistance to farmers on the use of improved planting material (stems) and shift now to SNV a Dutch NGO working under the PROSUL project (See Annex 1 for more information). This model increases the flexibility of the PPPs due to the multi-functionality and location-specificity of the stakeholders. As it can be seen in Figure 18 in the main text above, the initiative adopted a model of PPP with established relations between the partners and allowed room for new entrants, either from the private sector, NGO´s or even new specialized State agencies to contribute to a common objective of creating jobs and incomes for farmers and processing workers through reinforcing the industrialization of processing of smallholder cassava in Mozambique.

Thus, the initiative is based on three vectors:

- **Scale**: DADTCO sees its prospects as strong both within Mozambique and on the African continent. CDM's demand for cassava cake is high and is growing owing to the popularity of Impala beer, but his may also lead CDM increasingly into using easier to source maize. With improved cultivation techniques, cassava farmers can increase their yields from 10 tons per hectare to 20–25 tons per hectare. DADTCO hopes to reach 12,000 to 15,000 farmers in each of the regions it is operating and to expand into cassava flour production in coming years.

- **Replicability:** SABMiller's interest in replication and ability to pre-finance it in several other countries, including Zambia, Tanzania, South Sudan, Kenya, and Uganda, over the next few years, makes replication more likely.

- **Sustainability**: DADTCO's business model is profitable and sustainable. Environmental sustainability is a priority, and DADTCO is working with IFDC to promote crop rotation and protect soil fertility attempting to increase productivity to allow the farmers to perform over the breakeven. But if DADTCO depends on CDM as the only buyer, it will be

always in a critical situation since this specific beer market has been so far protected by the Government with a current tax of 10% on cassava beer, compared with 40% for malt beers, and it would be frustrated if the taxes are altered.

Lessons learned

Market demand is the first and essential component underpinning the success and sustainability of the projects. SABMiller established supply chains to profitably fulfil consumer demand.

Similarly, the initiative would not have been so successful without the use of Post-Harvest Loss (PHL) reduction technologies; by bringing mobile processing units to the farm, DADTCO was able to substantially reduce post-harvest losses.

However, without access to finance, smallholders, traders and processors would not have been able to access the technologies and solutions required for the project's success.

Despite DADTCO, in partnership with IFDC and later with SNV a Dutch NGO, provide support to thousands of farmers, so far only few of them have achieved a reasonable productivity between 20-22 tons/ha using improved stems supplied by SNV, the farmers using local varieties but with good practices are achieving around 15 tons/ha (interview to Nelson Joaquim DADTCO extensionist), has pointed out above, most of the farmers still sell at a loss, unless they are able to intercrop cassava with more profitable crops to offset the losses occurring from cassava production however, this is difficult to achieve if plots allocated to cassava growth, are smaller than half hectare, what happens with most of the farmers.

Even with strong market demand and use of appropriate technologies, training and aggregation were essential to ensuring that traders, processors, and anchor buyers could cost-effectively source from smallholders.

Lastly, diversity, although high quality wet cake is a good ingredient for beer production the processor (CDM) is facing technical problems due to the fibre content of the product. Because starch can replace wet cake without this problem, DADTCO decided to invest in cassava starch production, a move that can be the enter point for the expansion of cassava industrialization in Mozambique.

In fact, Philafrica Foods, DADTCO new owner, has now built new units (one in the Northern region, Nampula Province and another in the Southern region, Inhambane Province) with equipment to improve the cassava processing producing starch cake a cleaner product with a lot less fibres, although still a wet product but much better for brewing and able to process cassava into HQCF (High quality cassava flour).

Whith the refining unit in place DADTCO expects to provide the beer company with a better ingredient for Impala beer and to explore more sophisticated urban markets with a new range of cassava by-products such as fibre for feed stuff and the bakery industry (Hubert Van Melick, January 2018).

With this new moving DADTCO sees the market very promising although it fears for lack of fresh cassava to supply the factory needs (Huber Van Melick, January 2018).

ANNEX C

CASE STUDY ON CLEANSTAR/NDZILO ETHANOL-BASED COOKING FUEL[10]

Background

CleanStar/Ndzilo was the first initiative in Mozambique to build a facility dedicated to producing ethanol-based cooking fuel for sale with the company's cookstoves in Mozambique's capital Maputo.

Besides the intention to produce ethanol from cassava, the initiative adopted an innovative approach by supplying cook stoves to its clients and providing training on how to use it to take the most from the new experience.

With this innovative initiative CleanStar intended to offer Mozambican households an affordable new form of cooking that was cleaner, faster, and safer than using charcoal to address 4 interconnecting problems (Stefen Maard, 2013)[11] :

i. A subsistence farming crisis with rural families practicing "slash-burn-degrade-move" agriculture.

ii. Accelerating forest destruction caused largely by charcoal production.

iii. Widespread nutrition deficiency and food price instability, with rural families over-reliant on a small mix of staple crops and urban families experiencing major food price fluctuations due to over-reliance on imports.

iv. Major cost and health impacts of charcoal use for urban households given high (and increasing) prices and that inhaling charcoal smoke it is equivalent to smoking 2 packs of cigarettes per person per day, mostly affecting women and small children (according to the WHO).

The initial conception of the CleanStar/Ndzilo business model was an integrated approach which included stove sales, ethanol production, supply and distribution. There was no reliance on imported or donated ethanol and all parties involved would make a profit from it. The model was vertically-integrated, which means that the system was directed by a restricted number of business leaders controlling each aspect of the value chain (Puzzolo, 2013).

Results

At the beginning based on a well elaborated plan featuring plenty of job development with a biofuel plant in the Sofala province, contracts with local farmers to grow cassava, a locally relevant marketing plan, and a pack of international investors to give the project a boost, the company was able to sell 10,000 of ethanol cook stoves in the first year of operations, number that grew up to 33,000 in 2012 and sold around 1 million of liters of ethanol.

[10] This case study was prepared based on available literature mentioned in references, interviews to Clean Star/Ndzilo Sales and Marketing Manager Mrs. Telma Venichand (December 2018) and Operations manager (May 2018) Mr. Emmet Costel

[11] Change makers Website:http://www.novozymes.com

However, despite this demand, the company was unable to achieve the scale and retail penetration required to make the venture financially viable, and through a press release in 2013 announced the closure of the biofuel manufacturing business to focus on the stoves sourcing ethanol and to review its strategy on the best possible options for continuing its activities adopting a new designation NewFire Africa.

Unfortunately, the restructuring proved unsuccessful, and on July 2014 NewFire Africa announced a voluntary liquidation, due to continued losses.

Lessons learned

CleanStar/Ndzilo managers claimed that that the closing of operations didn't mean the plan wasn't worth trying. For them the initiative left at least 33,000 customers out there with a high-quality, cleaner-burning stove and millions of people around the world who were inspired by this initiative.

NewFire Africa stated, without specifying, that the failure was because the fees and costs were too high and the market was not ready to pay the resulting high price for the product; in parallel a diversion of funds resulted in the early closure of the pilot project (Triple Pundit, July 2014). In fact the closure of the biofuel factory obliged the company to import ethanol from abroad at higher prices than it could afford to operate at a profit (Telma Venichand, CleanStar Sales and Marketing Manager) .

However, despite all reasons behind CleanStar/Ndzilo failure to achieve their objectives, some lessons should be taken from this failed initiative:

1) Any initiative to use cassava as a main raw material must be based on three factors due to the cassava production system (dominated by smallholder producers) and the high perishability of the fresh roots:

    - Right location of the factory premises in a region where cassava is traditional and well known by the surrounding communities (Dondo was not the best location for the CleanStar/Ndzilo initiative).

    - Adequate surrounding network of organized farmers acquainted with cassava production and willing to embark in a promotion program that will bring basic inputs and technical assistance to improve their productivity and purchases their surpluses at a fair price.

    - Use of harvesting losses reducing technologies like that used by DADTCO to lower down the costs of production.

2) Clear vision of the competition for cassava supply within the region where the factory is located (DADTCO activities in Northern and Southern regions has limited the cassava supply chain for CleanStar, Telma Venichand, CleanStar Sales and Marketing Manager).

ANNEX D

DIVERSE CASES OF PROCESSING IN SOUTHERN AND NORTHERN AREAS

South: Small processors located in villages in Inhambane – Zavala

- Processing units are located in small villages along the EN 1 (National Road). Buy raw cassava from associations and individual producers at Mts 2.50/Kg.
- Cassava is peeled manually in the reception zones, mainly by women paid at 100 Mts/day.
- Use rudimentary machines to process cassava. Produce around 2/3 tons of *rale* month, corresponding to 8/12 tons of processed raw cassava (ratio 4:1)
- Sell rough *rale* at the local market in 15 kgs buckets at 200 Mts. Sell to middle agents finer *rale* packages of 15Kgs at 250 Mts, which are transported to urban markets (Maputo) and also some along the along the National road (Madendere).
- Process other cassava products from dried chips which are later sun dried to be used to transform into flour and to make bakery products and traditional food of the *sadza* type.
- Often these processors receive orders for 10 tons of flour, what demands the processing of around 40 tons of raw cassava. Cassava flour can achieve Mts 350/15Kgs.
- These processors have severely limited knowledge about cyanide contents in cassava products and know little about derivative markets.

South: Small/medium growers/processors-Inhambane (Jangamo–Inharrime- Massinga-Morrumbene)

- Own on average around 5 ha and achieve yields of about 4/5 tons/ha.
- Use an average plant density of about 2500 plants/ha of traditional varieties. This is far from the advisable density of 12,500 plants/ha of improved varieties with fertilization.
- They have made some progress and are now achieving an average of 8,300 plants /ha. Began to sell to DADTCO at 1.5 Mts/Kg, but now the price has increased to 2.5 Mts/Kg.
- Produce without inputs. No use of fertilizer, nor of manure. Use of leaves to improve land conditions in an organic way. Rotate annually the land.
- Receive technical assistance from the Dutch SNV, under the PROSUL project of the Ministry of Agriculture. Some of the cassava growers are just beginning to experience new varieties.
- The prices of flour are very volatile and fluctuate according to the availability of the fresh cassava from farmers. Sometimes can achieve Mts 450/20kgs but if the supply of raw material increases, it can drop to Mts 150/20 Kg.
- Investments in adequate equipment for processing are very high; to minimize the overall costs, processors often rent their equipment to others.

South: Associação Josina Machel (Inharrime- Chongola)

- Created in 2000. It has 13 members; 9 are women. Cultivate around 25 ha all told.
- Members supply the unit with their own production and are paid according to the delivered quantities transformed in *rale*.
- Also buy fresh cassava from other grower non-members at Mts 2.00/Kg. The association is supported technically by SNV/Mathale under the PROSUL program. Produce around 250/300 Kg of *rale* a week.
- They have 2 types of granulated *rale* that are sold at 28/30 Mts/Kg for rough quality and 30/35 Mts/Kg for fine and medium quality.
- Presently the processing unit is in very bad conditions the situation was aggravated by the damage caused by a recent cyclone. These days there is no production at all.
- The location of the unit despite its proximity to the EN 1 (less than 5 Km) is not suitable for this kind of activity. There is no electricity available from the national company and the association faces severe problems to access water; it is to costly to use their own diesel generator.
- Labor is difficult to hire, to bring water daily to the unit is considered a very heavy work.
- Despite having been one of the most supported Associations for almost a decade, the results are not visible and they face today an apparent collapse and claim for urgent help to renovate the damaged unit and to solve the problems with water and electricity.

South: Associação WAPSHALA (Gaza - Manjacaze)

- The association integrates 33 members, of which 23 are women.
- Grow and process fresh cassava for their own consumption and processing.
- Process a significant range of cassava products: plain and mixed flour, biscuits and cassava cakes besides other mixed products.
- Produces “maheu” a traditional alcoholic beverage, very popular among the rural families.
- Produce also salted and spiced cassava chips, and also with sugar.
- Produce animal feed stuff by mixing moringa leaves, horticulture waste and cassava leaves.
- Face some market problems. Are not able to place significant quantities in the market to allow to reduce unit costs.
- Recently have received an order to supply 80 tons of dried cassava to be sent to China. This could be a window to progress towards the international market, but it is dubious that in the present conditions the association can keep supplying those quantities with the required quality and in a steady way.
- Want support on market research, to identify new markets and to participate in key exhibitions in the country and abroad.

South: Unidade de processamento Liana Lda. (Inhambane – Morrumbene)

- Installed in 2014, investment in Brazil equipment.
- Acquire fresh cassava from neighbour areas (radius of 20 Km from the processing unit) using a own tractor with a trailer.
- Have capacity to process around 120 tons/year.
- Produce only during 6 months a year because the roots are too humid and the rainy weather make the access to raw material difficult.
- The processing unit has equipment for the several phases of the processing. Produce flour and *rale* and sells under the commercial name of Liana.
- The unit has liaisons with the great commercial surfaces in Maputo. Its sale price is 40 Mts/Kg. Sells also buckets of 20 Kgs at Mts 140/150.
- Face labor scarcity for peeling because it is a manual task and it is done mainly by women.
- The distance from the main urban markets (600 km), make sales difficulty.
- Lack of market information.
- The processing unit is owned by a business family from Morrumbene where they run other businesses. They have a micro financial business and are willing to link it to the support of smallholder to help to create a network of raw cassava suppliers.
- The owners are also planning to create a cassava planting material nursery on their own to spread it among the growers to help them to improve their crop and to create good network of suppliers.

North-Central: DADTCO Nampula – Ribaué, Morrupula South: Inhambane – Morrumbene, Zavala

- Operates in two provinces of Mozambique.
- First mobile unit (AMPU) placed in Nampula: Fist platform installed in Ribaué and 2º in Morrupula .
- In February 2013 began operations in the Southern region of Mozambique. One platform in Morrumbene and another one in Zavala. With an investment of around Mts 6 million Inhambane production began in 2015.
- Moves from one to another according with the availability of raw cassava to process.
- Buy cassava from the smallholders and provide together with other service providers technical assistance. Some smallholders have shown a great progress in density planting and productivity.
- Prices paid by DADTCO are not considered enough remunerative but since some smallholders are increasing dramatically the productivity began to find the actual Mts 2.50m Kg paid by DADTCO attractive enough.
- Supplies CDM on order basis have no specific contract.
- DADTCO is negotiating a deal with the new initiative for a starch factory with CDM and Illovo. It will supply wet cake initially tom the new factory from Inhambane processing platforms.
  (See DADTCO/CDM case study in the ANNEX B for more information on this initiative).

North-central: Nampula Province

- Districts of Nampula register some interesting activity on the cassava value chain showing a trend for increasing processing of cassava and diversification of cassava products. Some information about this activity was collected but need to be confirmed and updated as well, the activities in the other two important northern provinces producers of cassava (Zambezia and Cabo Delgado).
- Taking into account the huge production of cassava here are few initiatives in Nampula, Cabo Delgado, and Zambezia provinces that can drive the industry to a new stage if properly supported and developed[12].
- Registered commercial production initiatives from Nampula private business are:
  - OLIMA - Ribaue (6ha)
  - WISSA - Mutivaze (2ha)
  - Gastão - Mogovolas (10ha)
  - Caiaia - Ribaue (10ha)
- Nampula has also registered processing activities on both sectors subsistence and commercial.
  - Families sector producing *Karakata* and *Makaka*, for own consumption and local sales.
  - OLIMA private business (starch, and flour)
  - WISSA private business (flour, traditional food fresh Mathapa, Mathapa powder)
  - Manuel Caetano - Carapira (flour).
  - Nacololo - Monapo (flour).
  - Monapo - sede (flour).

ANNEX E

LIST OF KEY INFORMANTS

Name	Position
Daniel Chapo	Inhambane Governor
Filomena Maiopue	Provincial Director of Agriculture and Food Security
Pentula	IAAM agronomist (Inhacoongo agro-station)
Daniel Ozias Mate	PROSUL Coordinator
Samuel	Josina Machel Association
Ana Mussanhane	Liana Investments
Gomes	Liana cassava processing unit
Miguel	Bread association (Amapão) President
Danilo Narcy	Bakery owner
Hubert Melick	DADTCO – Mozambique operations manager
Nelson Joaquim	DADTCO – Cassava extensionist
Telma Venichand	CleanStar/NDZiLO – Sales and Marketing Director
Emmet Costel	CleanStar/NDZILO – Operations Manager
Maida Khan	UEM (Mondlane University) Researcher

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