Potential for commercial production and marketing of cassava: Experiences from the small-scale cassava processing project in East and Southern Africa

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Acronyms and abbreviations

AMREF	African Medical and Research Foundation
ASARECA	Association to Strengthen Agricultural Research in East and Central Africa
BMGF	Bill and Melinda Gates Foundation
CBSD	Cassava Brown Streak Disease
CCARDESA	Centre for Coordination of Agricultural Research & Development for Southern Africa
CFC	Common Fund for Commodities
CIAT	International Centre for Tropical Agriculture
CIP	International Potato Center
CIRAD	French Agricultural Research Centre for International Development
COVE	Cooperative Village Enterprise (Ghana)
CNP	Cyanogenic potential
EAC	East Africa Community
EARRNET	East African Root Crop Research Network
EAS	East African Standards
EC	European Community
ESA	Eastern and Southern Africa
FAO	Food and Agriculture Organization
GCDS	Global Cassava Development Strategy
HQCF	High Quality Cassava Flour
IDRC	International Development Research Centre
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IITA	International institute of Tropical Agriculture
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
KICAPA	Kibuku Cassava Processors' Association (Tanzania)
KICAFA	Kibale Cassava Processors' Forum (Tanzania)
LDCs	Least Developed Countries
LIFDCs	Low-Income Food-Deficit Countries
MAFSC	Ministry of Agriculture, Food Security and Cooperatives (Tanzania)

MTBE	Methyl Tertiary-Butyl Ether
NPV	Net Present Value
NRI	Natural Resources Institute
PAAP	Policy Analysis and Advocacy Programme of ASARECA
PAM	Program against Malnutrition (Zambia)
SARRNET	South African Root Crop Research Network
SIDO	Small Industries Development Organization (Tanzania)
SUA	Sokoine University of Agriculture (Tanzania)
TADENA	Tanzania Development Navigation
TARUCODEF	Tambani Rural Community Development Fund (Tanzania)
TAWLAE	Tanzania Women Leaders in Agriculture and Extension
TFNC	Tanzania Food and Nutrition Centre
TIRDO	Tanzania Industrial Research and Development Organization
UDS-CoET	College of Engineering Technology of the University of Dar es Salaam
USAID	United State Agency for International Development
VECO	*Vredeseilanden* Country Office
WOYEGE	Women and Youth, Environment and Gender (Tanzania)

Units

cm	centimetre
Ha or ha	hectare
HCN mg/kg	Hydrogen cyanide equivalent in milligram per kilogram
kg	kilogram
km	kilometre
t	tonne
ppm	parts per million
US$	United States dollars

About IITA

The *International Institute of Tropical Agriculture* (IITA) is one of 15 non-profit research-for-development organizations of the *Consultative Group on International Agricultural Research* (CGIAR). IITA (www.iita.org) works with partners in Africa and beyond to tackle hunger and poverty by reducing producer and consumer risks, enhancing crop quality and productivity, and generating wealth from agriculture. The CGIAR (www.cgiar.org), established in 1971, is a strategic partnership of countries, international and regional organizations and private foundations supporting the work of an alliance of 15 international Centres. In collaboration with national agricultural research systems, civil society and the private sector, the CGIAR fosters sustainable agricultural growth through high-quality science aimed at benefiting the poor through stronger food security, better human nutrition and health, higher incomes and improved management of natural resources.

About the CFC-IITA project on Small-scale Cassava Processing in East and Southern Africa

With financing from the Common Fund for Commodities (CFC), the Small-scale Cassava Processing project Phase I was implemented by IITA in collaboration with national food and agricultural research institutions in Madagascar, Mozambique, Tanzania, Uganda and Zambia. Cassava-processing technologies and market innovations were introduced to smallholders to enable the development of cassava products as a widely traded commodity that contributes to the economic growth of cassava-growing countries in Southern and Eastern Africa (ESA). In addition, the cassava sector was strengthened with sustained links between suppliers and users of cassava products through the organization of the various sub-sector agents to supply cassava to the markets of interest on a national, regional or international scale.

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We would like to acknowledge the inputs of Mr Han van de Meerendonk (2007) and Mr Shakib Mbabaali (2008) who were appointed by the Common Fund for Commodities ito visit the project countries and validate the results obtained by the project. We also thank Dr Adam Prakash, who represented the FAO as the supervisory body for the project, for his inputs.

1

Introduction

Cassava is an essential part of the diet of 500 million people and provides a livelihood for millions of farmers, processors and traders. In some parts of Africa, cassava is referred to as a "complete" crop, i.e., complete in the sense of its versatility of use. Its leaves are high in protein and some essential minerals, and are therefore consumed by humans as a vegetable or can be fed to animals as silage. Its stems are used as a means of propagation. Its roots being carbohydrate or energy-dense can be used in a variety of ways for human food, animal feed or as an industrial raw material (starch, paper, pharmaceuticals, etc.). Cassava leaves are widely consumed in most ESA countries as a vegetable. The nutritive value of cassava leaves has been found to be comparable to those of soybean, maize and amaranth but with higher amounts of vitamins and minerals (Lancaster and Brooks 1993).

The production of cassava in Africa is faced with serious biotic constraints, such as diseases and pests, poor logistics for the supply of planting materials, poor agronomic practices, small and unorganized production systems, poor postharvest handling and processing. These lead to inefficiency and high costs of production, poor quality and low-priced products and an unorganized marketing system. All these contribute to the unprofitable nature of traditional cassava farming.

Despite the high energy content of cassava roots and the superior quantity and quality of proteins in the leaves, the crop has wrongly been tagged an inferior food only on account of the low protein content of the roots. Policymakers in some countries are undecided about commercializing the use of cassava in industries, for example, for ethanol or starch production, because of the possible negative impact on food security. As a result, production systems remain small and unprofitable. This further perpetuates rural poverty.

Many years of research that were focused on improving cassava productivity have not effected the much-needed impact on poverty. The research community has recently accepted that productivity-enhancing technologies alone, without access to profitable markets, cannot get poor farmers out of poverty. Cassava-dependent farmers in remote locations have no access to markets for their fresh roots; traditionally processed cassava products – although less perishable than fresh roots – are rebuffed in more rewarding markets because of their characteristic poor quality and safety. In ESA; potential industrial users including food manufacturers are unwilling to use such products due to concerns about safety of the manufactured foods and a possible negative consumer reaction.

Farmers therefore have a limited opportunity for large-scale sales of cassava roots as the market for traditionally processed products is restricted to village-level household consumption. Consequently, smallholder farmers hesitate to adopt new varieties that offer yields in excess of household needs and the demand from village markets. Commercializing the sector can increase the ability of smallholders to adopt improved crop varieties and to process and produce better quality foods for sale. Farmers would then be able to derive benefits from meeting the growing global food demand while at the same time achieving food security and improved livelihoods. Increasing local production and utilization of cassava can save countries from using scarce foreign exchange to import food and industrial raw materials.

The Global Cassava Development Strategy (GCDS) envisioned that: "*(c)assava will spur rural industrial development and raise incomes for producers, processors and traders. Cassava will contribute to the food security status of its producing and consuming households*". Private and public investments are required to reach this vision (Plucknett et al. 2000). Investments in technologies that can alleviate the challenges of the sub-sector are critical to the upgrading of traditional subsistence operations to commercial operations; this will benefit a whole range of stakeholders and reduce the overwhelming poverty among smallholder producers. Critical biotic and abiotic constraints have to be solved; production systems need to become more efficient to increase their competitiveness; postharvest processing technologies for transforming cassava into high-grade foods, as well as industrial raw materials, need to be introduced. Effective marketing strategies and institutional innovations, such as standards, grades and branding, are needed for the profitable marketing of cassava products. Public education is also required, to improve the image of cassava as a nutritious food on account of the high protein content in the leaves, the high energy content of the roots, and its suitability for many industrial applications.

To initiate the commercial operation of a cassava value chain nationally and regionally, well-targeted research initiatives are required. The right technologies and appropriate approaches for developing the sector need to be identified, to deliver the desired benefits to smallholder farmers. Relevant technologies and market innovations need to be tested at the pilot scale to learn the lessons of technology adaptation, the challenges, and other preconditions for success. Commercializing a value chain, as a rule, requires an understanding of the series of activities that link farmers to markets; these include the channels through which inputs and information reach farmers, and how commodities travel from farmers to consumers. There are many research and development initiatives with the primary objective of finding solutions to the constraints militating against the efficient operation of a cassava value chain.

1.1 Cassava research initiatives

One of the most important and potentially most influential development initiatives that provided strategies for solving these constraints is the "Global Cassava Development Strategy and Implementation Plan". This was spearheaded in 2000 by the Food and Agriculture Organization (FAO) and International Fund for Agricultural Development (IFAD) in collaboration with the International Centre for Tropical Agriculture (CIAT), French Agricultural Research Centre for International Development (CIRAD), IITA, and Natural Resources Institute (NRI). There was support from the World Bank, Swiss Development Corporation, and the Canadian International Development Research Centre (IDRC). The strategy proposed improving the livelihoods of the rural poor through the introduction of market-led root crop technologies, including improved planting material, value-adding and agro-enterprise development.

Many research institutions, including IITA, have for many years tried various approaches to raise the cassava sector to a higher level, to contribute to food security, employment, import substitution and the GDP of countries in ESA. In partnership with many national research institutions, ministries, the private sector and advanced research centres worldwide, IITA has initiated various African-based initiatives and interventions within its remit to conduct cassava-related research. Different models have been tested to understand and document how cassava is used as an input for food, feed and industrial raw materials; the factors associated with its passage through several marketing or supply channels, including its transformation; how much and at which stage of the channels value is added to it, and how the value can be maximized at the least possible total cost to the competitive advantage of every actor in the chain.

IITA has been involved in brokering the involvement of small- to medium-scale farmers, processors and industries in cassava production, processing and utilization through various research-for-development efforts in Africa. New processing methods have been developed to transform cassava into food, feed and industrial inputs. Since 1997, farmers' associations in West Africa have been supported, at a pilot stage, to test production and processing technologies and through linkages to industrial users. Flour, chips and starch from the pilot activities were tested by industries for the commercial manufacture of foods and other consumer items (Abass et al. 2001; 2011). Some field and feed trials were initiated with commercial feed millers in West and East Africa to develop and validate cassava-based feed formulations for poultry, pigs and cattle. As an example, feeding tests done in East Africa showed that silage made from leaves and chips improved milk production from crossbred dairy cows (Kavana et al. 2005). These took advantage of the crude protein levels of the leaves, which are about two to three times higher than in other fodder crops, such as alfalfa, Napier hay and *Brachiara* (Tewe and Bokanga 2001).

Results obtained during testing of cassava as an industrial input show that both the processing and industrial uses are profitable. In the early years (the 1990s), the two IITA networks, the Southern Africa Root Crop Research Network (SARRNET) and the Eastern Africa Root Crop Research Network (EARRNET) which are supported by the United States Agency for International Development (USAID) and the Association to Strengthen Agricultural Research in East and Central Africa (ASARECA) were involved in these activities in East, Central and Southern Africa. More recently, many NGOs became involved in cassava development activities by adapting the results of research and successful models to diversify farmers' conditions for addressing various constraints in the sector in the three regions.

1.2 Learning from West African experiences

The promotion through government and policy initiatives in West Africa of cassava commercialization in the past decade has enjoyed major achievements – which can be replicated elsewhere. Industrial starch production was promoted by the Government of Ghana in 2001 through its Cooperative Village Enterprise (COVE) programme. The COVE programme led to the establishment of a starch processing plant which bought roots from villages in the vicinity of the plant. Despite the challenges encountered by the project, the effect was an increase in cassava production in Ghana. The experience suggests organizing farmers into blocks of farming systems, in which farmers can mechanize production; have access to processing machinery, credit and training opportunities; and enhance their postharvest and micro-enterprise skills. This set-up can effectively improve the commercialization of the commodity. The Ghanaian effort also led to substantial job creation in rural areas, and to the development of the textile industry through import substitution.

In Nigeria, the cassava commercialization and market promotion programme was implemented from 2002 to 2008. The programme aimed to commercialize or expand production and to improve domestic utilization. Improved agro-processing technologies were applied for the production of intermediate products such as high-quality flour (HQCF), starch, glucose syrup and ethanol. This was combined with a policy to replace imported raw materials with the intermediate cassava products. An *ex-ante* evaluation of the returns on investments in some 26 Nigerian States carried out in 2005 identified cassava as the best commodity for investment, with an estimated gross return of US$570 million/year over a period of 17 years. The follow-up industrialization efforts showed that more labour-saving technologies in production and processing could greatly increase the competitiveness of the crop in Nigeria. The programme significantly increased production by nearly 10 million tonnes (t) in the 6 years of implementation.

These initiatives in Ghana and Nigeria raised expectations for quick improvements in the livelihoods of the general populace, particularly in rural areas. The outcomes in West Africa seem to suggest that cassava has a high potential to contribute to the development of ESA if its production, processing and utilization are well coordinated.

1.3 Testing products derived from cassava in ESA

In the light of these positive outcomes in West Africa, a research-for-development project on small-scale processing and the vertical integration of the cassava subsector in ESA sponsored by the CFC was implemented in five countries – Madagascar, Mozambique, Tanzania, Uganda and Zambia – from 2003 to 2008. Simple and appropriate technologies for converting raw cassava into different derivatives were tested. Small-scale processing technologies for high-quality products developed by IITA were introduced into selected pilot communities in the five countries. The pilot tests resulted in the delivery of premium-quality intermediate products (i.e., high quality flour, chips, starch and improved *rale,* also known as *gari*) to consumers and industrial end-users in the pilot areas. These shelf-stable processed products were cheaper to transport from remote pilot villages to distant urban markets and they attracted premium prices.

Some selected industries participated in testing the use of the products as alternative raw materials in the manufacture of industrial items such as textiles, paper, animal feed, biscuits, wafers and bread. Consequently, the industries demanded quantities that exceeded the production capacity of the pilot groups.

To increase institutional support, the project collaborated with national regulatory agencies to develop quality standards for the cassava products. To date, the national standards have been harmonized for ESA and are being used as regulatory instruments in the region. Machine fabricators were trained and backstopped to develop and manufacture processing machines. Some of the fabricators commenced sales of machines to individuals, institutions, NGOs and governments in the region. The knowledge gained by stakeholders from the pilot activities has become useful in the design of new development programmes by national institutions, NGOs and policymakers, to reduce rural poverty, hunger and expenditure on food imports. Development agencies, such as USAID, FAO, and the Bill & Melinda Gates Foundation (BMGF), along with international NGOs and others have designed new research and development programmes using the same model. Private investments in small-, medium- and large-scale cassava production and processing plants have subsequently increased in the ESA region.

To increase the potential adoption of mechanized processing systems as a poverty and hunger reduction option, this publication seeks to explain the approach used to implement the pilot project, to draw the lessons learned from the project, as well as additional lessons from similar projects in Africa. Specifically, the objectives are five-fold: (i) to show the need for commercializing cassava production, processing and marketing, including industrial uses; (ii) to provide some investment guides to potential investors; (iii) to show the potential for mechanized processing and market expansion for cassava products; (iv) to show the factors that influence commercial efficiency and how they can be improved to achieve sustainability; and (v) to determine the potential benefits of public investments in the sector in terms of food security, employment and rural income.

2

Need for commercialization of the cassava sector

In ESA, wheat, rice and maize have been the most visibly recognized staple foods in rural and urban areas over the last four decades. As such, food security policies and strategies have concentrated on ensuring self-sufficiency in those food commodities which are largely imported. Food crops such as cassava, sorghum and millet are better adapted to the agro-ecological conditions of the region and more resilient to the effects of climate variability. These crops were widely consumed and accepted in pre-colonial years; they have become neglected and relegated in recent times (CATISA 2007). As a region, ESA is quite prone to frequent and severe droughts. It is well-known that cassava plays an important role in food security, especially in areas where the risk of drought is high (FAO and IFAD 2004). The rural poor resort to cassava as their main source of food during drought seasons.

Indeed, the occurrence of frequent and severe drought conditions is inducing many governments to diversify their food crop base by promoting an expansion of cassava output. This is in recognition of the fact that rice- and maize-based national food security has been persistently threatened by recurring droughts and adverse weather conditions, as well as economic factors, such as the high cost of chemical inputs and importation of crops from the West. In general, the policy and strategies under structural adjustment programmes have reduced the direct intervention of public marketing agencies, and removed or reduced the price subsidies granted to cereal producers in most ESA countries. This situation has assisted cassava development (FAO 2001; Barratt et al. 2006).

There are strong indications that many least developed countries (LDCs) in the ESA region are willing to tackle the burden of huge expenditure on imports by developing the production of cassava products that can effectively replace imported items such as starch, wheat and rice.

In 2007, President Armando Guebuza of Mozambique, requested scientists in Mozambique to develop technologies for mixing high quality cassava flour (HQCF) with wheat flour to reduce the cost of bread. In 2011, the Mozambican parliament passed 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. In Tanzania, the government, under the National Agriculture Master Plan, focused on the promotion of cassava and sweetpotato to cover food deficits. As part of the Tanzania Agricultural Research Project Phase II (TARP II), the government initiated the development and promotion of improved processing, packaging and storage of sweetpotato and cassava for the diversification of use and commercialization of value-added products under smallholder conditions. The Ministry of Agriculture, Food Security and Cooperatives of Tanzania (MAFSC) initiated efforts in 2006 to develop a broad-based cassava development programme under the Department of Crop Promotion. The Commission for Science and Technology of Tanzania and major stakeholders in the country further refined the national cassava document in 2009. In 2008, a composite flour programme for cassava, sorghum, millet and maize was planned under the postharvest unit of the MAFSC. The FAO in Tanzania supported these efforts by leading the formation of a cassava committee to help with decision-making on production issues, particularly on the production and distribution of clean planting material. Indeed, the Revolutionary government of Zanzibar is currently in discussion with the government of Nigeria on how to promote the improvement of cassava production and processing technologies further in Zanzibar. In Zambia, the Programme Against Malnutrition (PAM) and a number of other agencies have been promoting cassava production in the country's erratic rainfall zones as a form of low-cost drought insurance (Barratt et al. 2006). In 2003, Zambia encouraged the supply of processed cassava to the national food reserve to stimulate increased production.

In addition to maize and rice, cassava was identified by Centre for Coordination of Agricultural Research and Development for Southern Africa (CARDESA) as a principal driver for future agricultural growth in Southern Africa (IFPRI and ReSAKSS-SA 2011). ASARECA's Staple Crops Programme suggests that the livelihoods and food security of poor households in East and Central Africa can be enhanced through building stakeholders' platforms for cassava (ASARECA 2011).

2.1 Benefits of commercializing the cassava sector

Addressing constraints through research and development initiatives that include value addition to the crop is expected to increase production, food availability, food security and income for small producers through a greater "demand pull" for fresh cassava. Furthermore, the use of derivative products such as HQCF, chips, starch, etc., as human foods or raw materials by local industries to partly replace imports would lead to a substantial reduction in food imports, and increased foreign exchange savings in the producing countries. The four major potential benefits (i.e., increased production, food security, income generation and foreign exchange savings) are developed below.

Increased production

Commercialization of the cassava sector necessarily brings with it a "demand pull" that leads to an increase in domestic production. This was demonstrated in Nigeria from 2002 to 2008 when commercialization was promoted under a special initiative. Production increased by 25% without any significant export of cassava products within the 6 years (Abass et al. 2011). With a greater demand for the crop, farmers can be encouraged to grow higher-yielding varieties and use improved agronomic and other postharvest practices. For policy considerations, a properly planned and coordinated commercialization of the sector is a sure way of achieving the objective of increased production through the demand-pull effect.

Food security

Traditionally, people in the ESA region have tended to cultivate cassava purely for subsistence purposes. Cassava has the ability to grow in many areas with acidic and infertile soils, and performs much better than cereal alternatives under such circumstances. Such a characteristic makes it a more flexible and food-secure crop than many cereals. During drought seasons, a reduced supply of cereals – the dominant food staples – always occurs. Demand for food aid, mostly in the form of cereals, sugar and oil, increases then as well. During such periods, locally produced cassava is used at the household level to mitigate hunger. In many such cases, little attention, in terms of appropriate agronomic practices and improved processing technologies, is given to the crop. As a result, production generates low yields, is inefficient, achieves poor economies of scale, and the volumes available, for home consumption or sale, tend to demonstrate substantial seasonal variation (FAO and IFAD 2004).

The recent global food crisis started to manifest itself in 2006/2007 and the cost of food has soared around the world. This is especially true for cereals and cereal-based foods. Because of the resultant high food price inflation, some sections of the population in a number of countries were unable to get access to the food they required. This has caused social unrest, particularly in many low-income countries. According to the FAO (2008), one way to help to mitigate the strain of food price inflation, especially in future crises, is to diversify the crop base. This strategy calls for a focus on locally produced, nutritious and versatile staple foods that are less susceptible to the food price volatility of international markets. Cassava is a good candidate for such a strategy.

Income generation

Cassava has great potential for income generation. Being more than a simple food crop for the rural poor, it can further serve as a source of cash for low-income farm households and as a raw material for further processing into value-added products for both rural and urban consumption. In Nigeria, Brazil and Thailand, adding value to cassava has been shown to have a high potential for farmers and other stakeholders along the value chain to earn premium prices from buyers in industry instead of selling only the perishable roots to traders. Going for multiple purposes would therefore potentially lead to higher income earnings for all stakeholders along the value chain of a commercialized cassava sector. Being able to process raw roots into more shelf-stable products would enhance farmers' bargaining power to negotiate and obtain better prices than when they offer only very perishable fresh cassava. As more farmers benefit from the demand pull for cassava due to its commercialization, incomes would increase and become more regular. Additional benefits would come from using higher-yielding varieties and improved agronomic and other postharvest practices.

The primary beneficiaries of commercialization are the resource-poor smallholder farmers and the youth who will be engaged either in productive on-farm employment or in cassava-processing plants. An increase in demand for the industrial use of cassava as a raw material or for export can lead further to the emergence of a new breed of private sector participants who may take advantage of the opportunities of the market and establish production, processing, transportation and marketing enterprises. This will expand the range of stakeholders (producers, small- and medium-scale processors, fabricators, traders, consumers, national institutions and the government, and private sector agribusiness entrepreneurs) gainfully employed in different cassava-related activities. Additional activities will generate income for many who would otherwise be underemployed or unemployed. An increase in industrial activities and trade in the rural areas thus translates into the creation of local employment opportunities, a reduced exodus of young people to urban areas, and improved rural and urban income, food security and livelihoods.

Hence, commercializing the cassava sector through the introduction of simple market-oriented technologies to small-scale farmers and/or farmers' cooperatives can greatly enhance their earning potential and improve their livelihoods. The easy-to-use technologies would allow them to transform highly perishable fresh roots into stable market-grade intermediate products such as chips or flour. In turn, this would:

- expand their marketing opportunities;
- reduce their dependence on traders;
- extend the storage life and market value of the harvested cassava;
- improve the quality and safety of intermediate products; and
- encourage end-users to take up cassava as an input.

As already explained above, adding value would improve selling prices. In addition to cassava destined for human consumption, improvements in the quality, volumes and regularity of supply could further make it a regular input for several industries. Cassava has been proven to increase the quality and marketable yield of consumer goods, such as biscuits, pasta and wafers (Abass et al. 1998). This enhances the demand for the consumer goods and encourages consumers to pay more for them. Smallholder producers can derive higher financial benefits from the increased sales volume.

Foreign exchange savings

Recent reductions in global stocks of cereals, including wheat, rice and maize, have posed financial hardships for countries that import these commodities and depend heavily on them as food. The imported items have become too expensive for national treasuries. However, the majority of the population have by now developed a strong taste for the imported food items and their products, such as bread, cakes, biscuits, noodles, etc. The demand and import prices for these items continue to increase despite the reduced ability of the countries to finance their importation. Figure 1 provides examples of these trends from Tanzania, Madagascar and Zambia. While Tanzania imported nearly 900,000 t of wheat grains and flour in 2009, Madagascar imported 100,000 t and Zambia 20,000 t. In 2008, the price of wheat rose drastically in all three countries, as did the price of many other global cereal commodities.

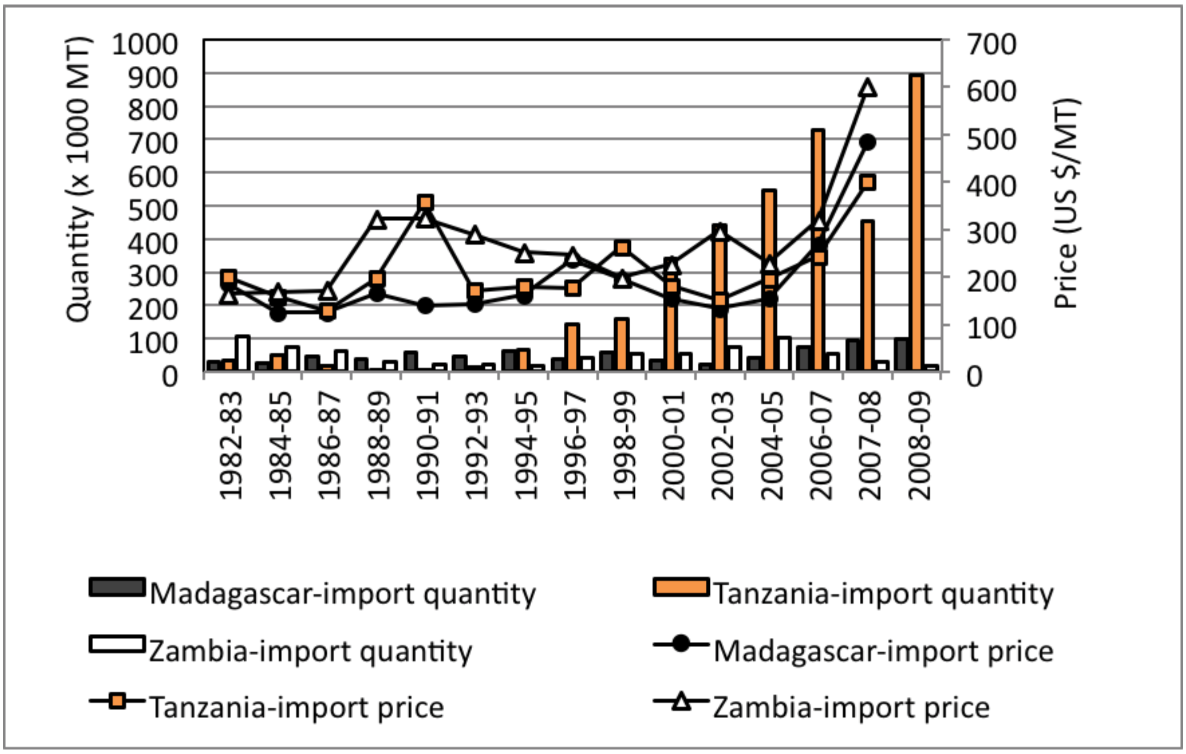

Figure 1: Trends in importation and cost in three East African countries, 1982–2009.

The price of wheat from the United States (i.e., no.2 Hard Red Winter, f.o.b. Gulf) ranged from US$382 to US$449/t between February and April 2008, approximately 80% higher than in the corresponding period in 2007 (FAO 2008). These high export prices and sustained high demand, combined with soaring freight rates, pushed up the domestic prices of bread and other basic foods in importing developing countries. This situation significantly increased the import bills of the world's poorest countries, particularly the Low-Income Food-Deficit Countries (LIFDCs), causing a reduction in food imports in 2008 (Fig. 1) and social unrest in many places.

Wheat constituted Tanzania's highest source of expenditure on food in 2008, followed by palm oil and malt. In Zambia, wheat was the second highest source of expenditure on imported food, after vegetable oils; it was third highest in Madagascar after rice and soybean oil. Imports of wheat in 2007/2008 were estimated to be 494,000 t in Tanzania, 115,000 t in Madagascar and 35,000 t in

Zambia in particular (FAO 2007). With an indicative import price of US$410/t in Tanzania, US$670/t in Madagascar and US$430/t in Zambia, these three countries spent an estimated total of US$296.4 million in foreign exchange on wheat imports in the 2007/2008 season alone. Developing countries are estimated to have spent a record total of US$255 billion on food imports in 2007 and this reached an estimated new high of US$343 billion in 2008; nearly half of this was spent on cereal imports (FAO 2008) and a far smaller amount of foods was received.

Products derived from cassava, such as HQCF, chips, starch, etc., have proven to be dependable staple foods in many countries of West and Central Africa (i.e. ,Nigeria, Ghana, Sierra Leone and the DRC); they have also proven to be suitable raw materials for local industries that can partly replace imported wheat flour and corn starch in baking, textiles, paper, etc. Cassava has a good chance to provide a useful input to different industries and to make substantial foreign exchange savings in the respective ESA countries.

There is, therefore, a pressing need to commercialize the production and domestic use of cassava for many reasons. Increasing the production of a crop well-adapted to the local (and changing) climatic conditions would improve food security and livelihoods in the ESA region. Furthermore, the income-generation and employment opportunities for smallholder farmers, processors, marketers and other stakeholders; the easing of sourcing raw materials for import substitution by local industries; and the savings in foreign exchange expenditure by governments that can emanate from a commercialized sector are potentially significant. The special initiatives on commercialization that commenced in West Africa show that there is potentially great scope in ESA for successfully commercializing production, processing, and marketing, including its industrial use. A commercialization framework similar to that of West Africa can be suggested in ESA. Lessons from the pilot project in addition to past efforts of various national research institutions and universities, NGOs, policymakers and other activities of development partners can be leveraged for the commercialization programmes in the region.

3

Technical and economic considerations for establishing synchronized supply chains for cassava and its derivatives

Private and public investments are necessary preconditions for the integration of smallholders into the market. Agribusiness investments and programmes need serious research and planning to establish their technical feasibility, economic viability and social benefits. In the case of the cassava sector, the technologies for efficient production and processing at a mechanized scale are not widely known in most parts of Africa. Prospective entrepreneurs are often unaware of appropriate varieties and their yields, processing technologies, machine types, their costs and input or output capacities, markets and prices for the products, among other issues. Worse still, they do not know where to get such information. Investment prospects are therefore limited. The probability of failure is high where investments are made based on wrong or inadequate information. Many prospective investors in cassava processing had had unpleasant experiences by relying on information provided by service providers who are not knowledgeable in many aspects of the value chain. Equipment sellers that attempt to give advice on all aspects of the value chain from production to marketing are typical examples to pinpoint. To reverse this situation, prospective investors need to seek investment information from relevant institutions and experts. Similarly, relevant institutions need to develop approaches to improve the information flow. This section provides a useful investment guide to the private sector. By using a research-for-development approach we explored ways to improve the efficiency of the cassava value chain in selected pilot locations and to integrate its various sector agents in a vertical manner, such as could be adapted by prospective investors to make investment decisions.

During the pilot study, small-scale producers were organized and linked into identified upgraded value chains and the actors involved in marketing or in need of higher grade cassava products. Appropriate technologies, innovations and services were made accessible to the small producers to increase their general efficiency and competitiveness in the market. The performance of the system, including the small, cassava-based infant industry, was monitored through assessments of technical feasibility and financial profitability..

Steps were taken methodologically to: (i) establish the market potential for cassava and its higher grade derivative products; (ii) select sites in relation to the availability of fresh cassava, required infrastructure and labour; (iii) identify viable farmer-processor groups to adapt new processing technologies and to deliver high grade products to the market; (iv) select smallholder producers to deliver adequate amounts of roots for processing; (v) introduce appropriate scale-based technologies and machinery for mechanized processing; and (vi) introduce market and institutional innovations, such as standards, grades, market information, financing, etc. Figure 2 shows an overview of a value chain improvement for cassava.

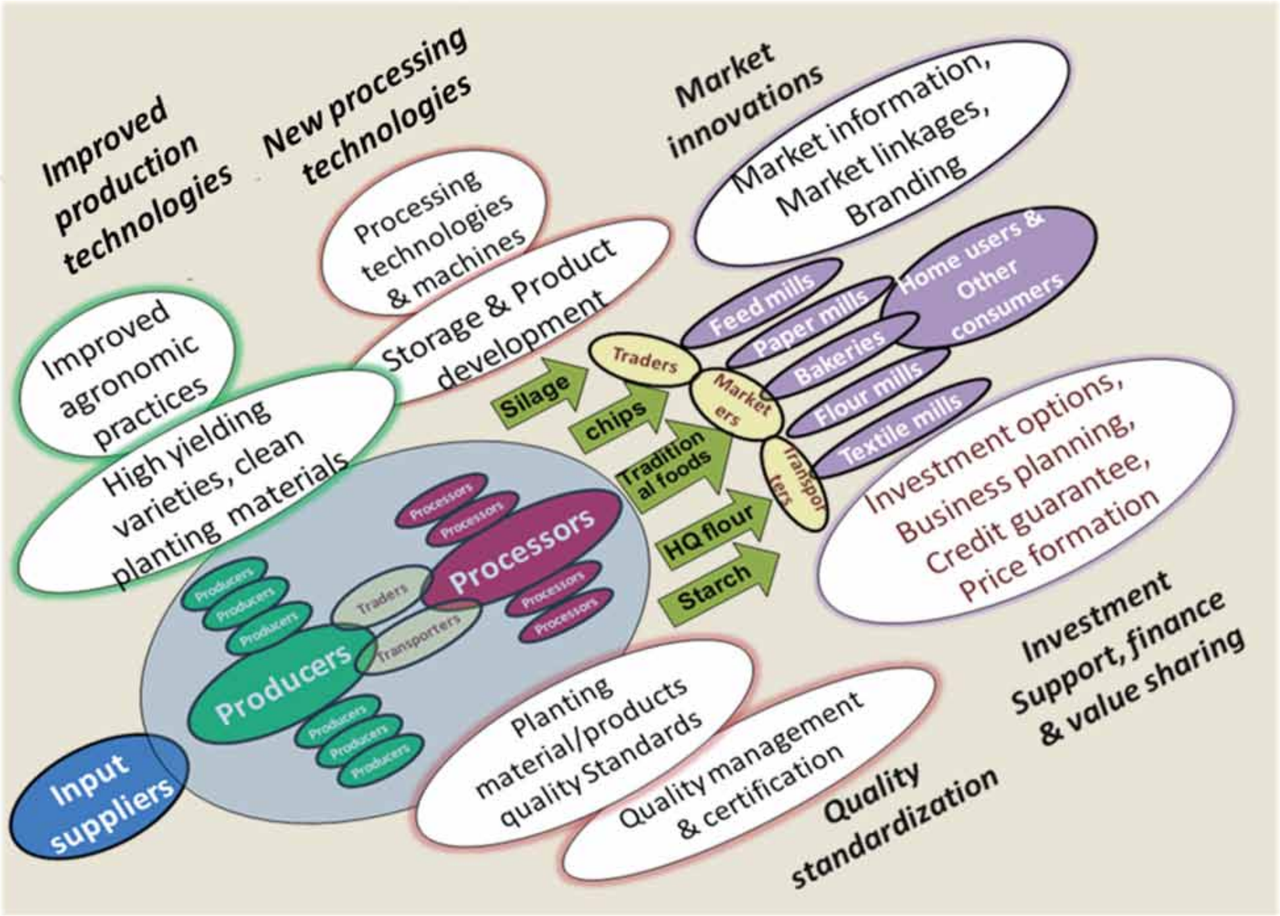

Figure 2: Illustrative model for using novel technologies, market innovations and actor-linkages to improve cassava value chains.

The value chains and innovation platforms established as pilots in different ESA countries allowed for real-time observation and analysis of the effectiveness of the options for improving the performance of markets; identifying constraints and opportunities; and testing options for increasing farmers' benefits by reducing the sector's constraints and taking advantage of the opportunities. From the perspective of agro-industries development, the approach is helpful in assessing necessary potential investment parameters to stimulate commercialization. These parameters include the real demand for an intended product and the market share attainable; the cost of investment in machinery in relation to the scale of operations (specific output volume); the cost and logistics for raw material delivery; prices of the inputs (fresh roots, fuel, water, etc.,) and outputs (final product); and the policy environment needed to support commercialization.

3.1 Assessing the dormant demand for cassava products

Understanding the market potential is a prerequisite for making an investment towards manufacturing the intended product. Such information assists in determining the scale of operations to be established, and the price and market share attainable. At the start of the pilot tests, a sector analysis which included a market quantification survey was carried out. The size of the market or potential demand for various cassava products, prices, competing imported products, and the quality and the regularity of supply required by the consumers were assessed.

Although cassava was being processed into diverse traditional food products in Tanzania (i.e., *makopa*, *shinyanya*, *kivunde*, etc.), Uganda (i.e., *busye* and *atap*), and Mozambique (i.e.. *rale*), most are of poor quality and below required safety standards. They do not comply with either national or international standards. As a result, industries avoid cassava as a raw material even in the face of the increasing costs of imported alternative raw materials.

On the other hand, global cassava consumption and industrial use exhibit a rising trend over the past two decades, mostly as a result of growing demand in Europe, and recently in China (FAO 2007; 2008). While in Asia and Europe, most of the increased demand is driven by non-food uses (mostly animal feed), in Africa, the demand emanates mostly from the human food sector. It was in fact this last sector that was determined to have the greatest growth potential for the use of cassava in Africa (FAO and IFAD 2004). It has been projected that the increasing trend in cassava consumption in Africa will continue well up to 2020 (FAO and IFAD 2004). This increase is predicted to be mostly driven by:

- growth in the consumption of cassava-based convenience foods;
- high population growth rates;
- high rates of urbanization; and,
- severe droughts, civil disturbances and other disasters.

In addition to the use as human food, the use of cassava in animal feed has been demonstrated in some parts of Africa (Tewe 2004). In 2004, the FAO and IFAD reported a 3.1% growth in the global demand for starch – with an increase of 2.3% in Africa. Cassava starch is of a high quality and can match – if not better – other starches (from maize, wheat, sweetpotato and rice); and it is relatively easy and cheap to extract. Lower quality starch is also an option for the paper and wood industry and requires less strict processing criteria. Discussions held with industries in 2005 suggest that the high wheat price was seriously hurting the local biscuit industry in Zambia's industrial town of Ndola, as the locally made biscuits could not compete with imported biscuits. The industry operators were struggling to keep the industry afloat. In Madagascar, cassava was found to be a substitute for maize and rice in locally produced animal feeds while HQCF had high potential for utilization in bread and biscuits.

The dormant demand found for the cassava products and the much higher prices of their substitute products (for example, US$150—00/t for wheat flour) could therefore inform a decision to invest. In 2004, market analysis showed that cassava had potential as starch, flour and chips in Tanzania, as *rale* in Mozambique, as chips for animal feed in Uganda, and as HQCF for bakeries in Madagascar and packaging industries in Zambia. Making the cassava products and testing their use in paper, biscuits and plywood in Ndola industrial area were considered to be useful in many ways: it established a real demand for cassava; and created strong linkages among value chain actors for delivering fresh roots from smallholder farmers to processors as well as the delivery of the intermediate products from processors to end-user industries and consumers.

3.2 Selecting a suitable site for mechanized agro-processing operations

The location of any cassava production or processing enterprise needs to be planned carefully to ensure that all necessary inputs are available and accessible at a low cost. The location of choice has the following conditions: it must be suitable for cassava production; there must be farmers already engaged in production; the producers should be able to supply or grow cassava in the quantity required. The absence of any disease that can devastate production is also important; labour and other necessary inputs for both production and processing need to be available. As cassava roots are very bulky, very perishable and expensive to transport, processing must be done near or at the centre of primary production. On the other hand, to minimize the transportation costs of products, the location must not be too far away from the market for the products. Yet, at the same time, processing must take place in a location where there is less competition for the roots (i.e., not too close to urban centres where consumption is predominantly in the fresh form); otherwise, cassava for processing may be too scarce and/or expensive, rendering the final product uncompetitive and the enterprise unprofitable. Identifying the right location for a processing enterprise can therefore be challenging and requires a systematic approach.

For the pilot study, the locations for the pilot tests were selected on the basis of particular development domains for cassava. These domains were identified by intersecting maps of market access with maps of cassava production potential. An example of this mapping exercise for Tanzania is shown in Figure 3. The indices followed for market access were population density, road networks and market locations; the indices for production potential were soils and climate/rainfall/temperature.

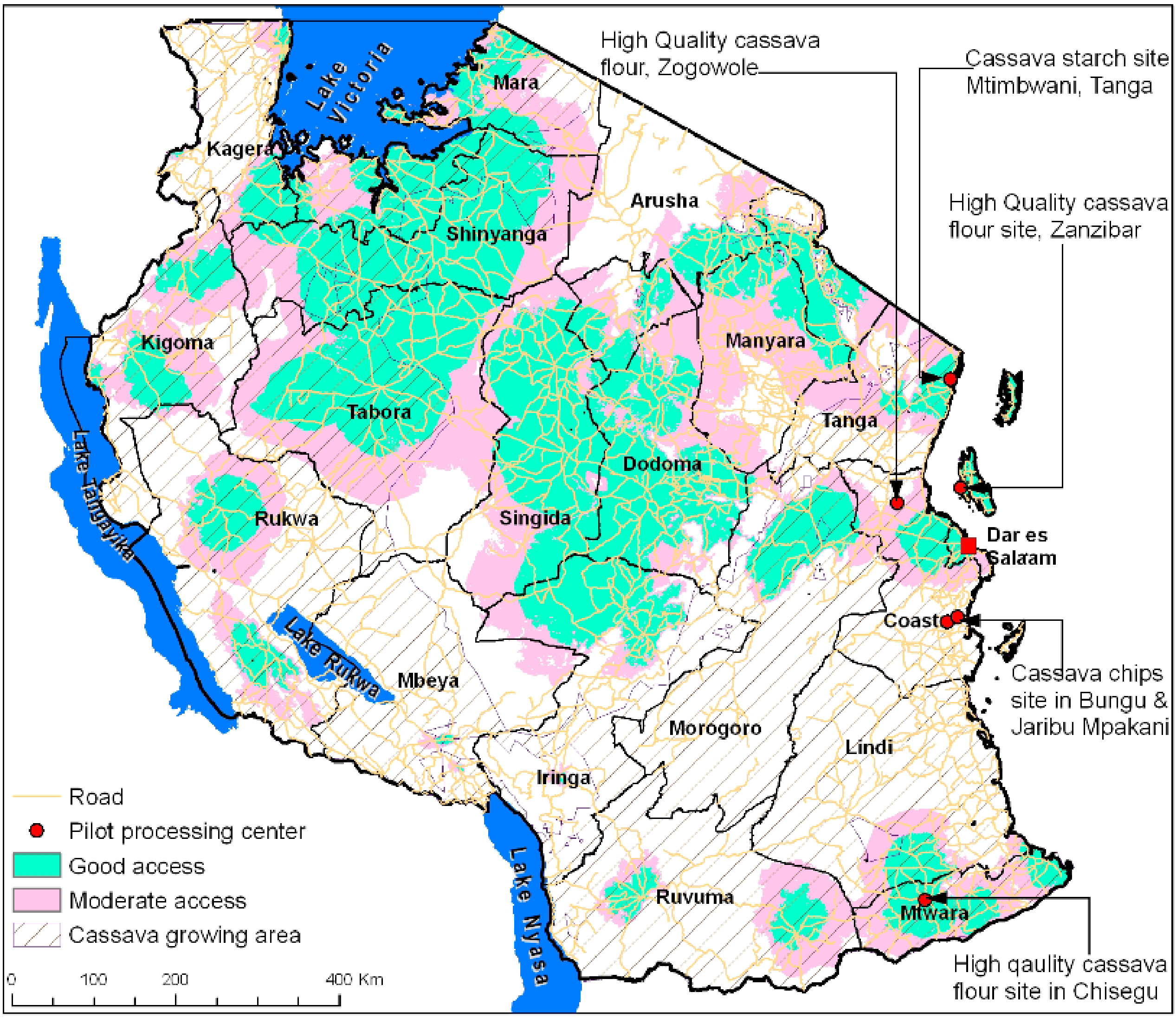

Figure 3: Six pilot sites identified in Tanzania according to market access and cassava production potential.

After the development domains had been identified, a geo-referenced survey of villages that fall within the development domain was carried out, to identify specific villages where processing plants could be placed. Selection criteria included sufficient or moderate production of cassava within a reachable distance, availability of water, accessibility of the village to a major road, and availability of a building for the installation of processing machines. In addition, analyses were made of the local cassava farm trade, local cassava markets, transport and handling costs, and output market for the product of interest.

Sites selected in Tanzania, Madagascar, Mozambique and Uganda

In Tanzania, Bungu village was selected It is about 150 km south of the capital, Dar es Salaam, in Rufiji district and bordering Mkuranga district. Cassava, cashew and coconut are the main crops in the ward. Here, cassava is both a food and cash crop. The average root yield is 20 t/ha and disease pressure is low. The processing and marketing of shelf-stable cassava products were already known due to previous IITA projects. Fresh root traders offer less attractive prices to farmers in the area than to farmers nearer the city of Dar es Salaam.

Mitakawani, located at the central district of Zanzibar island, was also selected. The district produces up to 1,600 t/season of cassava. Mitakawani produces 960 t out of which 21% is sold to the urban market in fresh form. The most widely grown varieties are Boma, Agriculture, Kippusa, Ghassan, Kigoma and Kichane. Mitakawani is surrounded by many cassava-producing villages from which fresh roots could be sourced. These villages are Machui, Uzini, Mchangani, Kinyasini, Boma, Kichwele, Bambi, Mpapa, Majura and Tunduni.

Another site selected was Chisegu, 600 km south of Dar es Salaam. Chisegu farmers produce the highest amount of cassava in Masasi district, which is itself a leading cassava-producing area in Tanzania, with a low population density. Here, cashew is a cash crop; cassava is both a food and cash crop and is sold mainly in the form of traditional dried chips. In the late 1980s, the area was involved in the export of chips to the EU market through the southern port of Mtwara.

The fourth site was Mtimbwani – 370 km north of Dar es Salaam and along the Tanga-Mombasa (Kenya) road. The largest amount of cassava in Muheza district is produced at Mtimbwani, and Muheza is a leading cassava -producing community in the Tanga region.

The fifth location was Zogowale village in Kibaha district, 70 km east of Dar es Salaam. Zogowale has a moderate level of production, and its farmers were not selling flour or trading in fresh roots. However, there was a good quality water supply and a good road to Dar es Salaam. Raw cassava could also be purchased from three neighbouring villages.

In Madagascar, Ambatomanoina village was selected for the pilot activity because of the proximity to the capital, Antananarivo; located northeast of the capital, the village has the highest number of smallholder farmers and is the largest cassava-producing village around Antananarivo. The annual production in Ambatomanoina village is up to 44,000 t.

In Mozambique, a pilot-processing project for high quality *rale* production was initiated with the participation of smallholder farmers in Inharrime district of Inhambane province. This district produces large amounts of cassava roots, leaves and processed products. *Rale* is a product similar to *gari* in West Africa, but the quality of traditional *rale* is lower because of the lack of mechanization. Inhambane is the only location in ESA where *rale* is produced and consumed (Abass et al. 2011).

In Uganda, pilot activities were carried out in the Kibuku and Kibale sub-counties of Pallisa district, one of the major cassava-producing districts in this country. Cassava is the dominant starchy food crop, followed by finger millet, sorghum, millet, rice and maize. Cassava production in the district increased from 25,448 t in 2001, to 54,044 t in 2004. Kibuku and Kibale sub-counties produce the highest amounts and have many active farmers' groups.

Expert consultations at village level were carried out before starting pilot operations. A selection procedure was followed to identify and involve viable associations of farmers-*cum*-processors in the pilot operations. The outcome consistently showed that although many farmers' associations existed in the rural villages, the majority might not have a membership that could manage commercial operations. This was particularly critical in the case of mechanized operations which were new to a majority of rural farmers' organizations in ESA. By implication, local entrepreneurs or candidates for investment in mechanized processing operations at the rural level did not seem to have a good understanding or competence for initiating investments and managing the enterprises profitably.

Mechanized processing operations

Having a good understanding of the appropriate processing technology, type and capacity of machines for processing, knowing how to source the machines and the investment cost on plant and machinery are necessary for prospective entrepreneurs to take decisions and make estimates of the potential viability of their investment.

The derivative products to be produced (e.g., flour, starch, *gari*/*rale*, chips, etc.,) the desired levels of quality and safety and the variety to be processed (e.g., sweet, cool, mild or bitter in taste) are factors to be considered in selecting the processing methods to be used (e.g., chipping or grating, fermentation or no fermentation). These factors, in addition to the desired output volume, of the target products, influence the design and material of construction (e.g., mild steel or stainless steel) to be used. Machine capacity is mostly determined by the intended product output/unit of time. Different technologies for processing flour, chips, *gari*/*rale* and starch were tested during the pilot study, to process new products or to improve the quality of existing traditional products (see Fig. 4). Many farmers' associations in typically cassava-producing areas were trained in the processing of the various intermediate products.

Figure 4: Bread baking training course in Uganda.

In Mozambique, *rale* – a traditional, partially gelatinized cassava product – is popular in Inhambane province. Besides being similar to *gari* in West Africa, *rale* is equivalent to *farinha de mandioca* produced in Brazil. Inadequate knowledge and poor traditional processing methods affect the quality and the marketability of *rale*. It has been avoided by city consumers because of poor quality. In 2006, technology and machinery from Nigeria for processing *gari* were introduced to a group of farmers-*cum*-processors in Inhambane province to improve the quality of *rale* as a way of increasing consumption and improving markets for small producers.

In addition, processing technology for cassava chips' was tested at the Bungu and Jaribu Mpakani pilot sites in Tanzania; HQCF technology was tested at the Chisegu-Masasi, Mkatawani-Zanzibar and Zogowale sites. Starch processing was tested at the Mtimbwani-Tanga site. At the Cooperative Aintsoa in Ambatomanoina village in Madagascar, a group of 20 resource-poor farmers were involved in the pilot testing of HQCF processing. This was also introduced in Uganda to five pilot processing-groups in Kibuku and Kibale sub-counties.

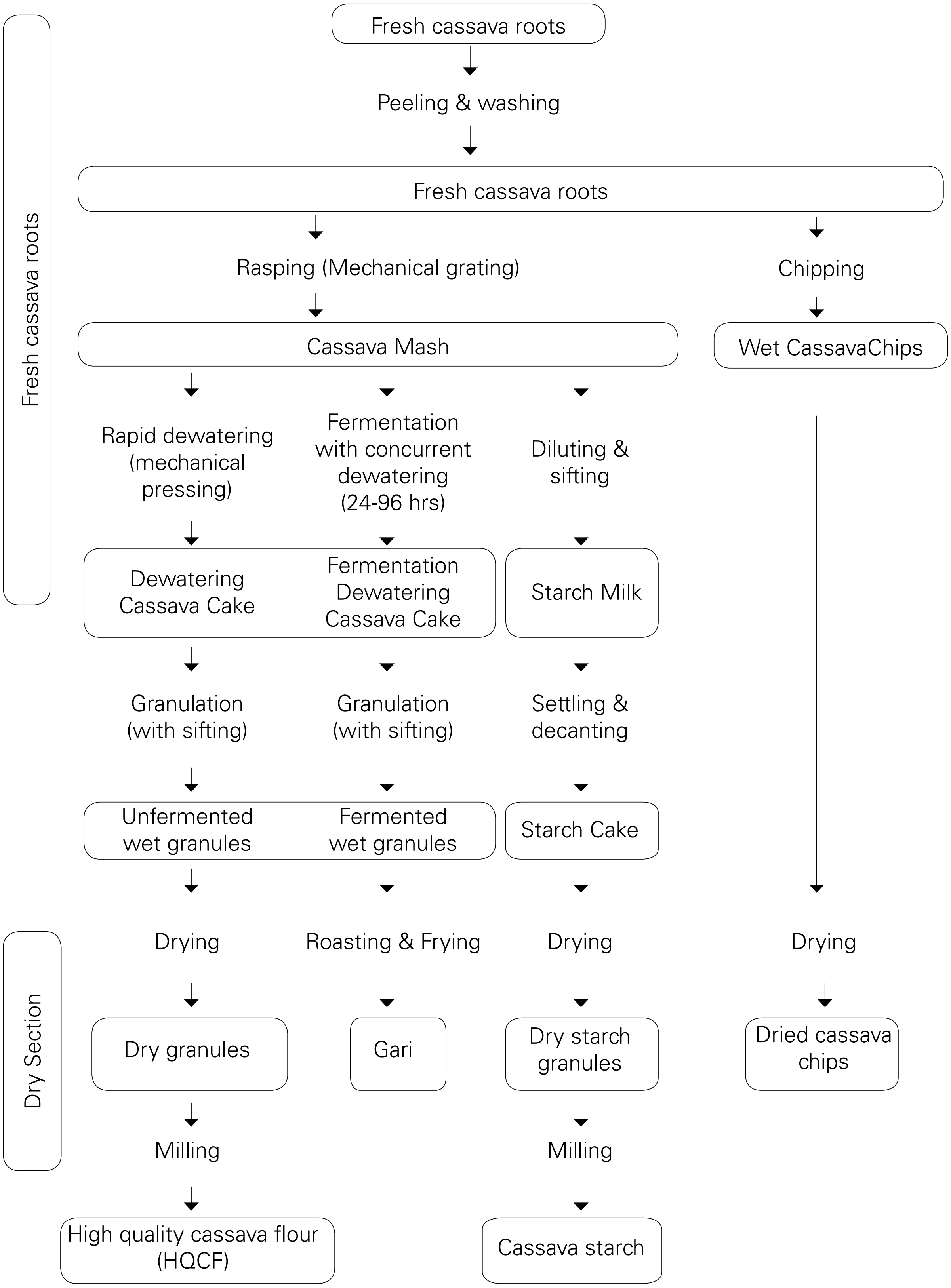

Figure 5: Flow charts for the mechanized production of HQCF, *gari,* starch and chips.

Figure 5 provides an overview of the various steps involved in processing cassava roots into different products. The technology for *gari* adapted for *rale* processing in Mozambique involves peeling roots, washing, grating, fermenting, dewatering to a semi-dry cake, breaking the cake into granules, sifting and roasting or frying the granules to gelatinize and dry them into *rale*. The *rale* is then graded by particle size for market by using sieves of different aperture size. Technology for making high-quality chips involves peeling and washing freshly harvested roots, sun-drying the chips on raised black rubber nets until crispy and fully dried, followed by bagging them for the market. HQCF is processed by peeling freshly harvested roots, washing, grating, dewatering and sun-drying, followed by milling and bagging in polypropylene bags. These are lined with thin polyethylene bags to avoid moisture absorption, maintain the moisture level (about 10%) and avoid spoilage. Processing of HQCF from harvesting fresh cassava up to final drying is done rapidly, within 24 hours (Onabolu et al. 2008). Starch is extracted from peeled and washed fresh roots, grating or rasping is followed by diluting with water and sifting out the starch with muslin cloth. The extracted starch milk is allowed to sediment; the water is decanted to collect the wet starch which is dried and milled before bagging.

Machines can be used for virtually all the unit operations involved in cassava processing; i.e., harvesting, peeling, washing, grating, chipping, drying, etc. Processing machines can be sourced from specific machine producers in each country but it is better for potential entrepreneurs in cassava processing to identify a specialist to design the processing flow line, choose the correct machines and then assess the machines made by each equipment manufacturer before taking a decision on which to buy from which supplier and what capacity to choose.

Estimated investment costs for the machinery and plant for a small-scale mechanized operation to process 1–2 t/day of fresh roots are presented (Table 1). At a small scale, with capacity to process just 1 t/day, machinery may cost about US$7,828 for *gari*, US$9,182 for flour, US$3,886 for chips and US$8,742 for starch.

Table 1: Investment costs for small-scale cassava–processing machinery.

Machinery	Unit Cost (US$)	Total cost (US$)				Service life (years)
		Gari	**flour**	**Chips**	**Starch**	
Cassava grater (stainless steel with 6.5HP engine)	1,012	1,012	1,012		1,012	6
Cassava chipper (stainless steel with 6.5HP engine)	726			726		6
Dewatering machines	910	3,640	3,640			8
Starch sifter	1,400				1,400	4
Fermentation platforms/stands	496	496				4
Washing basins, tools, etc.	560	560	560	560	560	4
Drying platforms			2,200	2,200	2,200	2
Frying stoves	400	1,600				4
Settling tank(s)	1,400				1,800	10
Weighing balances, scale and sealers	400	400	400	400	400	4
Grading or sifting screens	120	120	120		120	4
Milling machine			1,250		1,250	
TOTAL COSTS		**7,828**	**9,182**	**3,886**	**8,742**	

In addition to these costs, establishing a processing building, providing storage space for the products, a borehole to supply up to 10,000 litres/day of water and machine installation may cost about US$15,000. At the medium scale, in which about 10 t/day of fresh roots get processed, the machinery and plant (excluding mechanical dryers) may cost about US$35,000. Mechanical dryers needed at this scale of processing may cost a minimum range of US$35,000–40,000.

The right approach, opportunities, constraints and risks of private sector investments in cassava processing and the potential impact on the economies of cassava-producing countries have been documented during the pilot processing and marketing activities of the pilot groups or farmers' associations (Abass et al. 2001).

All products except *rale* in Mozambique require drying. The sun-drying needed to produce all other products turned out to be a major problem. Although most sites had machines that could process 800–1,000 kg/hour of cassava, the need to sun-dry in addition to some other factors reduced this potential capacity to at best 1 t/day for the whole processing operations. This capacity was reduced significantly during rainy seasons, when less than 150–200 kg/day could be sun-dried at most processing sites.

3.3 Improving cassava production systems to enhance processing operations

The success of an agro-processing venture depends on the existence of production systems capable of providing raw materials in the quantities required for efficient operations. For cassava, such production systems normally include the production of planting materials, good farm management or good agronomic practices—with or without mechanization —, the organization of harvesting, storage and collection and delivery to the processing plant.

It is ideal for the villages selected for mechanized operations to be at the centre of many other cassava-producing villages that provide optimal environments and potential for achieving the highest yields of new varieties. This was taken into consideration during the establishment of the pilot operations and the planning of the raw material delivery system.

A survey of villages to select the site for processing operations should be carried out with the objective of understanding the prevailing prices of traded cassava and cassava products. Taking an example from Tanzania, such a survey carried out in 2009 showed that prices of the products vary according to the extent of processing, product quality and how the products were used (see Table 2).

Table 2: Ongoing prices of cassava planting material, roots and products.

Cassava Products	**Price (US$/t)**
Cuttings (500)	1
Fresh roots (not yet harvested)	10
Peeled roots delivered to processing plants	33
Traditional dried chunks (e.g., *makopa*, *udaga*)	26.7–133
Machine-processed chips for animals	200
Machine-processed chips for humans	200–267

Such information is useful for estimating production costs during price negotiations with farmers on the supply of fresh cassava and for determining the price of final products.

As shown (Fig. 8) for the chips pilot site at Sululu village in Tanzania, buffer zones of 5 km and 10 km were developed for each pilot site to facilitate the organization of harvesting, collection, storage, transportation and delivery of roots to the processing centres from various surrounding villages.

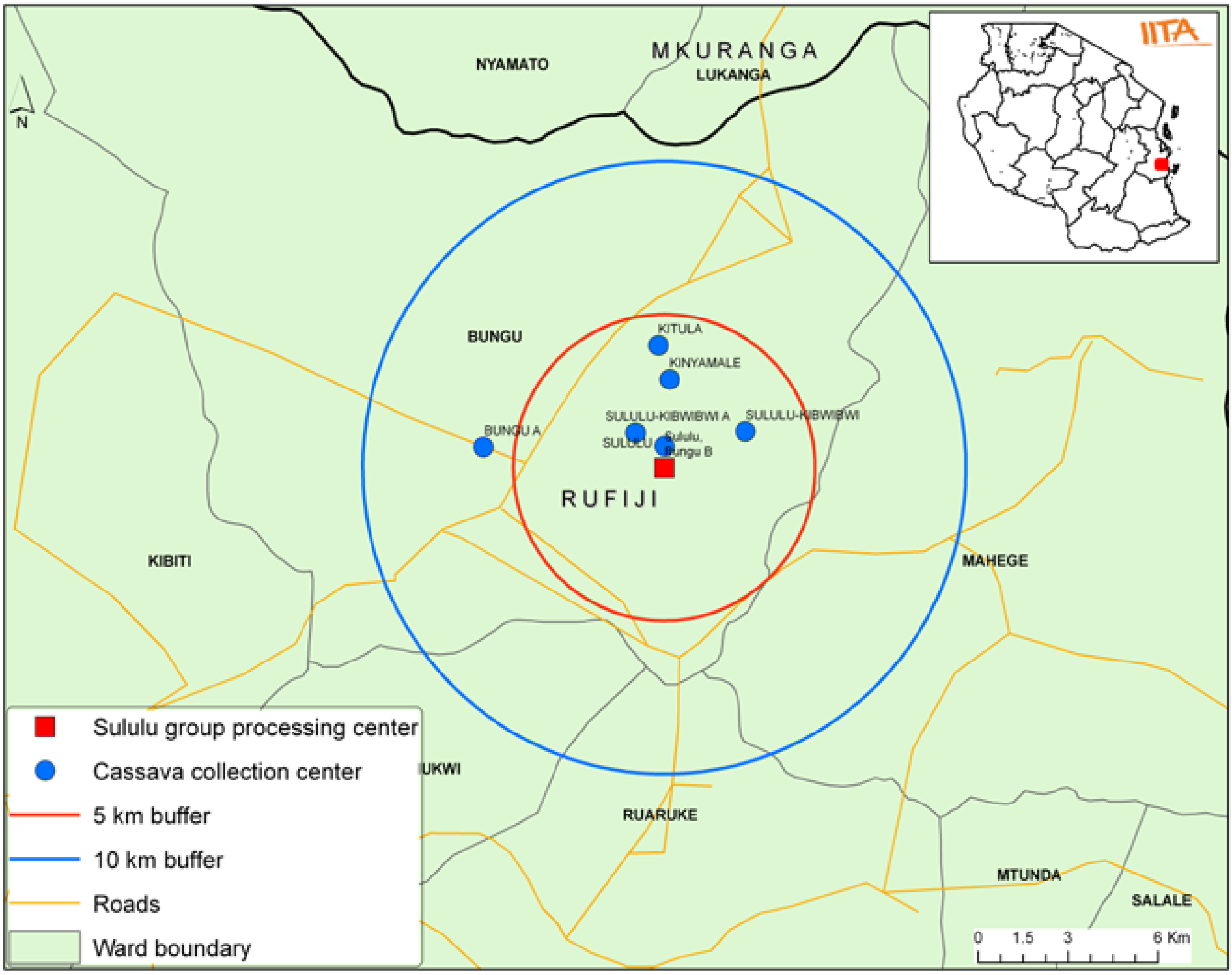

Figure 6: Villages from which smallholder farmers supply cassava to Sululu group.

National institutions such as the national agricultural research and extension services and NGOs were involved in the multiplication of new high yielding varieties and the distribution of planting materials to nearby pilot farmers and other out-grower farmers. In Mozambique, for example, Helvetas, CARE Mozambique, UN Volunteers, Save the Children, and the Lutheran World Federation were involved. PAM in Zambia and the Root and Tuber Programme in Tanzania, in collaboration with the Prisons, multiplied planting materials for distribution or sale to farmers.

The introduced varieties were selected based on the desired traits of consumers or end-users. Improved management techniques for production were introduced to boost yield and profitability. Local varieties with high yield, acceptable taste, high dry matter and/or disease resistance were multiplied to provide further assurances for food and market.

As the utilization of cassava by simple boiling and mild processing is dominant in ESA, the taste and contents of the cyanogenic glucosides are important criteria used by breeders for variety selection.

Cassava tissues contain cyanogenic glucosides at varying amounts, depending on the variety and level of damage or processing of the roots. On hydrolysis, the cyanogenic compounds release free cyanide, (HCN), which is known to be toxic. The amount of free cyanide a variety has the potential to release is referred to as the cyanogenic potential (CNP), measured in mg of cyanide concentration/kg of tissue (mg/kg) or parts per million (ppm). The hydrolysis and liberation of free cyanide could continue during processing, storage, or after consumption. The CODEX Alimentarius Commission and the Bureaus of Standards of many countries put the maximum permissible level of CNP in cassava meals at 10 mg/kg. Therefore, the choice of method of size reduction (grating, chipping or slicing) and other processing operations (fermentation, no fermentation, dewatering, etc.) for making cassava foods depends partly on the initial CNP of the variety and the effectiveness of the processing methods in reducing the cyanide concentration to below 10 mg/kg. Under commercial operations, the choice of varieties to produce or introduce to out-growers may also depend on the processing methods already available and other quality criteria required in the target market for the processed products.

Some local varieties have been popular with farmers because they can keep them for up to 3 years in the soil. In Uganda, the local varieties (namely *teleka*, *opur*, *aditu* and *ogarara)* were very popular because of their high dry-matter content. A local variety in Tanzania, *kiroba*, is popular in the coastal zone for its eating quality and tolerance to diseases. In Uganda, TME 14, 2961, Nase 1 and Nase 4 are among the introduced improved varieties which are preferred by farmers because of their high yields, tolerance to diseases and suitability for processing. According to the national cassava programme in Uganda, TME 14 has a dry-matter content of 44%, yields 25–40 t/ha, and has a CNP or total cyanogen content of about 120 mgHCN/kgDW. Variety 2961 is good for eating boiled or roasted. Its dry-matter content is 38%; it has a yield potential of 25–40 t/ha and a CNP content of about 98 mgHCN/kgDW. To facilitate the transfer or spread of selected varieties to nearby farmers, communal multiplication sites could be created near the processing sites where most out-grower farmers are located and the preferred varieties planted in the communal multiplication sites. At the end of the first production season, stems can be cut to about 60 cm above ground level (i.e., "ratooned") to serve as planting materials for the out-grower farmers or primary producers of roots for the processing sites. The roots are left in the ground to produce planting materials for the second year. After a second year of ratooning and the distribution of the planting materials to more out-growers, the roots must be harvested and processed. However, some varieties may become woody or spoilt by the second year. Under a commercial planting material production scheme, it is necessary to know which varieties must be harvested to sell their stems as planting materials during the first year and which varieties can be retained for the second year's sales.

For a successful operation, it is critical to adopt a strategy that guarantees an adequate and regular supply of good quality fresh raw material for processing. The strategy may include the introduction and multiplication of high-yielding varieties to commercially oriented farmers, establishing an efficient planting material distribution mechanism as well as the organization of out-grower farmers. However, the varieties to introduce into an out-grower scheme should be selected in terms of the cyanogen levels, ease of peeling, and rate of postharvest deterioration, etc., and the available processing technology. Variety and technology must be well matched to ensure efficient operations and for the final products to meet established standards for quality and safety.

3.4 Cassava production costs

There are questions about the profitability of cassava production under traditional systems (based on food security) as opposed to commercial systems (based on market sales) and its influence on the sourcing of raw materials for processing plants. Under traditional systems, yields are often low. Mechanization or inputs such as fertilizers and pesticides are not used.

An analysis of farms and markets near selected pilot sites in Tanzania showed that no two production areas have the same characteristics. This presents different scenarios for sourcing raw materials for processing. For example, at the Bungu chips site, farm-gate prices in 2007 had an average of US$25/t leaving a margin of US$9/t. This suggests that more commercialized production systems may be more profitable than systems based on food security. Purchase prices in the local market around Bungu were found to be at US$66/t while farm sales/ quarter came to 25 t and purchases in the village, were 5 t/quarter.

This indicates that farmers sell relatively frequently, whereas they buy only small amounts, probably to cover their deficits. The price differential between farm-gate sales and market retail prices is explained by margins on local markets as well as the costs of importing cassava from elsewhere and, of course, by the excess supply at the farm-gate level, depending on seasonal fluctuations. The fresh cassava market structure around Chisegu in Tanzania suggests that Chisegu could be a major export spot for roots, with farm-gate prices averaging US$90/t throughout the year, with quarterly sales of 63 t of cassava on the local market. While Chisegu seemed to be an area with excess supply, this supply went mainly into higher-priced markets and to a lower extent back into the local households. Households seem to optimize their purchases through paying low prices and possibly buying from other households whatever is available at low prices.

Farm-gate prices (US$55/t) at the Mtimbwani starch site were higher than purchase prices, (US$13.7/t) whereas the purchased volume is almost five times the amount of the farm-gate sales volume (107 t/quarter vs 22 t/quarter). This could be explained by a steady inflow of and demand for cassava imported from other regions, whereas production seems to be low and marketed volumes are small and traded only at peak prices from farms. The farm-gate purchase price (US$94/t) was significantly higher than the farm-gate price (US$21/t) with average quarterly farm-gate volumes (3 t) being about half the tonnage of the market retails. The high purchase price is explained by the nearby competing cassava market of Dar es Salaam, whereas the comparatively low farm-gate sales price is a result of market margins and the fact that there is not much demand for the produce due to better opportunities for the regional traders elsewhere. The price data above show significant variations in the farm-gate and local market prices of roots in the different locations.

An analysis of the cost structure for remote or rural farms under the traditional or food security production system and the slightly more commercial production system (where farmers engage in sales of cassava to traders or directly to local or urban markets) shows that farmers make losses under traditional farming methods, especially when the cost of family labour is considered. Similarly, when family labour is taken into account, traditional processing was not profitable due to the low pricing of the final products, which are often of poor quality. Cassava processing was found to be more profitable in locations where markets exist for roots and products, and prices are higher (e.g., the eastern coast of Tanzania), than where both the production and processing systems are poor and inefficient and farmers do not have access to rewarding markets (e.g., in the southern and Lake Victoria areas of Tanzania). In the Lake zone, where production is more affected by biotic constraints, such as diseases and pests, sourcing of planting materials is difficult and both the production and processing systems are poor and inefficient. These contribute to high production costs, poor product quality, and consequently to low product prices, resulting in a lack of profitability under the traditional farming system.

However, a recent analysis of cassava production by some increasingly commercializing farmers in a total of 10 ha farms at Rufiji area of Coast Region in Tanzania in 2011 brought other results. The land, which had never been cultivated before, was cleared by farmers and a local variety, Kiroba,, was planted without fertilizer application. The cassava was harvested from 10 months to 12 months after planting. Average yield found in this area was 16.31 t/ha. The Tanzania average was 11.0 t/ha; yield in Nigeria 11.7 t/ha, and in Thailand 22.7 t/ha. See Table 3, with some analysis below the table.

Table 3: Cassava production cost under a traditional production system in Tanzania.

	Labour equivalent (person/day)	Number of days	Cost/ person (US$)	Total cost (US$)
Land preparation				
Clearing of bush and tree felling	3.0	17.3	2.2	112.2
Farm burning	1.0	2.5	15.9	39.4
Collection of dirt	1.0	7.4	5.4	39.9
Land clearing tractor	0.0	0.0	0.0	0.0
Cost of land preparation/ha				*191.4*
Planting materials and planting				
Planting materials (62 bundles)	0.0	0.0	0.0	39.9
Transportation of planting materials to the farm (62 bundles)		2.5	0.3	8.1
Cutting of planting material into small pieces	1.0	2.5	3.2	8.0
Planting	4.0	2.5	3.2	31.9
Cost of planting materials and planting/ha				*87.8*
Farm inputs				
Fertilizer	0.0	0.0	0.0	0.0
Fuel tractor	0.0	0.0	0.0	0.0
Pesticides	0.0	0.0	0.0	0.0
Other inputs	0.0	0.0	0.0	0.0
Cost of farm inputs				*0.0*
Farm management				
Repair and maintenance of tractor	0.0	0.0	0.0	0.0
Weeding 1	2.0	7.4	3.2	47.8
Weeding 2	2.0	7.4	2.7	39.9
Weeding 3	2.0	7.4	2.7	39.9
Cost of farm management				*127.6*
Total production cost/ha				**406.8**
Total production cost/t				**24.9**
Harvesting and root packing				
Cutting of stems (cassava plant)	4.9	1.0	1.6	8.0
Uprooting of plant	14.8	1.0	5.4	79.7
Cutting the roots from the uprooted plant	4.9	1.0	4.8	23.9
Collecting roots, packing into bags and carrying to truck collection point (farm gate)	14.8	1.0	3.2	47.8
Total cost of harvesting and packing/ha				**159.4**
Cost of harvesting/t				**9.6**
Total cost of production and harvesting /t				**34.5**
Root yield (t)	**16.3**			

The cost of sourcing planting materials from nearby farmers and planting was US$87.8/ha; management of the farm by weeding three times before maturity was US$ 127.6/ha. From the foregoing, the total cost of production of 1 t of cassava from bush-clearing up to maturity was US$24.9. Total production cost is reduced by almost 36% to US$16/t when farm lands have previously been cultivated, requiring simpler preparation without the need to clear bush or fell trees. The cost of harvesting and packing of the roots to a location accessible to trucks for onward transportation to processing plants or market was US$9.6/t. Therefore 1 t of harvested cassava at the farm gate costs US$34.5.

Considering the cost of producing roots based on the yield of 16.3 t/ha observed at the sampled locality, production can become rewarding to farmers if new high yielding varieties (yield potential up to 32 t/ha) and better farm management practices are adopted. The doubling of yield can increase profitability and farmers' income, and have a significant reduction effect on the price of fresh cassava at the processing plants' gate. Further analysis is provided in section 6.

3.5 Potential profitability of small-scale mechanized processing

Before making investments in the production, processing and marketing of cassava, pre-feasibility studies and/or pilot operations are required, for a full understanding of factors that can significantly affect the success of such investments.

In ESA, small- to medium-scale processing plants, with a machinery capacity in the range of 2–8 t/day of fresh cassava (Table 4), seem to be more appropriate than the large-scale types of operations introduced in the 1980s.

Table 4: Machinery for intermediate processing.

Unit Operation	Equipment	Capacity	Cost (US$)
Intermediate processing			
Peeling	Mechanical peeler (60–90% peel removal)	0.6–0.8 t fresh roots/hr	2,966
Grating	Cassava grater	0.30–0.50 t roots/hr	870
	High capacity grater	2.0–3.0 t fresh roots/hr	4,237
Chipping	Cassava chipper	0.75 t roots/hr	700
Dewatering	Double screw press	0.05–0.10 t fresh roots/hr	300
	Twin basket hydraulic press	8 t fresh roots/day (two units/plant)	11,017
	Filter bag (used with twin basket hydraulic press)	20 pieces/day	424
Final processing			
Drying	Solar dryer	0.125 t flour/day	NA
	Cabinet dryer	0.25 t flour/day	NA
	Bin dryer	0.25 t flour/day	NA
	Flash dryer	4 t flour/day	33,898
Milling	Hammer mill	0.25–0.40 t flour/hr	1,550
	High capacity hammer mill	5.0 t flour/day	5,508

(*Source:* Sanni et al. 2006; Abass et al. 2009.

In an intended large mechanized processing unit, the initial setting up of a small- or medium-scale processing (pilot-scale) operation will help to project the technical feasibility and financial profitability of a large-scale operation and to learn other preconditions for success. This approach can help prevent repeating the commercial failures of large-scale mechanized cassava operations that were experienced in the 1980s in Madagascar, Uganda, Tanzania and Zambia, among other countries.

To provide some general guidelines, an analysis of the potential profitability of such small processing enterprises was carried out using data from the pilot processing plants with 1 t/day capacity. Chisegu, an HQCF site, had a profitability level of US$1,876 and the internal rate of return (IRR[1]) was 77%. At Bungu, a chip site, although it was operating at 59% capacity utilization, the profitability was US$2,126 while the IRR was 135%. Although starch production is the most labour- and capital-intensive of the three technologies studied in Tanzania, the starch site at Mtimbwani had a total profit level of US$4,482, with an IRR of 91%.

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[1] Internal rate of return (IRR) is used to evaluate the profitability and desirability of investments or projects. The higher a project's internal rate of return, the more profitable or desirable it is to undertake the project.

An assessment of how capacity utilization might affect the profitability of such processing enterprises showed that the efficiency of processing operations had a remarkable effect; this is due to the fact that the profitability of such small-scale operations is very marginal. The HQCF site in Zogowale operated at 48% capacity utilization, getting profits of US$1,640 with a net present value (NPV[2]) of US$ 9,429. When the operations were adjusted to 100% capacity utilization, the NPV increased substantially to US$11,013 while the IRR also increased substantially to 177%. During the rainy season in 2009, an analysis of operations at Bungu showed that the site was profitably supplying chips to the biscuit factories (IRR was 67%) despite the difficulties of sun-drying and could be even more profitable if chips were sold at the processing plant's gate (IRR was estimated at 80%).

Many factors could contribute to the low profitability of processing plants. The most significant constraints are the ability of operators to optimize their operations by processing adequate volumes of cassava consistently on a daily basis with reference to the installed capacity of the plant, the difficulty of getting enough roots for such a level of operation, and the need to maximize yield by preventing losses during processing, particularly during peeling. Other factors include water availability, labour quality, and the processor's ability to sell the product through an effective marketing strategy. It was observed that the latter factor was mostly responsible for the failure of most cassava-processing enterprises in ESA.

Based on the lessons of the pilot tests, an assessment was carried out in 2011 of the potential profitability and labour returns of a sole-proprietor mechanized cassava flour-processing plant established in 2010 in Tanzania (see Table 5). Unlike the farmers' group approach during the pilot testing period, the new plant had more investment in infrastructure, such as a borehole, a bigger processing building and more storage space, and all labour was employed. The total initial investment made in the processing equipment was US$7,329; the building, storage and drying facilities cost $11,938. The total fixed investment including the water supply system was about $34,680.

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[2] Net present value (NPV) is used as an index of time value of money in appraising long-term projects or investments. It compares the value of an investment today to the value of that same investment in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected Read more: http://www.investopedia.com/terms/n/npv.asp#ixzz1ucHegyPs

Table 5: Plant and machinery investment cost of a sole-proprietor small-scale cassava flour processing plant.

Plant and machinery	**Total US$**
Machinery	
Milling machine	2,000
Grating machine	929
Dewatering (2 pressing machines)	1,400
Drying facilities	2,500
Packing tools and materials	500
Total Machinery	*7,329*
Plant (Building and store)	*11,938*
Total fixed cost (machinery and plant)	**19,267**
Plant and machinery maintenance over a life span of 10 years (8% p.a.)	15,413
Interest on fixed cost over a life span of 10 years (13% p.a.)	25,046
Total investment in 10 years with no interest on fixed cost	34,680
Total investment in 10-year period with interest rate	**59,726**
Depreciation/year on total investment	**5,973**

The processing capacity of the machinery is the same as that used for the pilot tests. The machines are on trial for a limited period of time. The processing capacity was planned to increase over time by replacing the trial machines with those of a higher capacity. The trial period should help the processor and staff in gaining experience of the flour-processing technology, managing the logistics of cassava processing operations and establishing a supply chain and market share, which should increase over time.

In terms of efficiency of operation, it was observed that the processing operation was done at a capacity utilization slightly higher than that of the pilot farmers' groups. Unlike the 150–250 kg/day for the pilot groups, an average of 800 kg of fresh cassava was processed daily, still by sun-drying, for the first 7-months of operation. Although this is still far below the actual installed capacity of the plant due to technical issues, far fewer non-technical constraints were observed than experienced by the farmers' groups.

An assessment of the profitability of this new plant based on a production cycle of 7 sun-drying months/year, with 11 staff and a processing rate of 800 kg/day of fresh cassava, saw 168 t of fresh roots processed to 42 t of flour in 210 days/year and a 15% interest rate on the Bank overdraft for the working capital (Table 6).

Table 6: Analysis of profitability and labour returns of a sole-proprietor small-scale cassava flour processing plant.

Inputs and outputs for cassava flour production	**Cost US$**
Plant and machinery cost, maintenance and depreciation	5,973
Labour cost, permanent and casual staff (11)	4,577
Fresh roots, (168 t/year @ US$ 34.5/t	5796
Diesel and oil (grating and flour milling)	497
Water	215
Dewatering bags (50 kg size)	145
Interest on bank overdraft (3 months, 15% p.a.)	645
Packaging bags (1 kg size)	4,167
Annual cost of production of flour	**22,015**
Cost/t of production of flour	**524.17**
Annual cost of delivery to the retail market (US$64/t)	2,692
Annual cost production and delivery to the market	**24,707**
Cost of production and delivery of flour/t to the market	**588**
Sales price/t, 2011 Tanzania market-based	**769.23**
Revenue from sale of flour	**32,308**
Income from milling, (20 t/year)y	**700**
Profit	**10,962**

Although the ongoing purchase price of fresh cassava by processors was US$ 20–33/t, the processing plant relied on its own roots produced at the cost of US$ 34.5/t.

Out of the total cost of producing and delivering HQCF to the market (Fig. 7) fixed costs constituted 24% (processing infrastructure and machines), 18% (labour) and 23% (fresh cassava). Packaging materials constituted 17% of the costs.

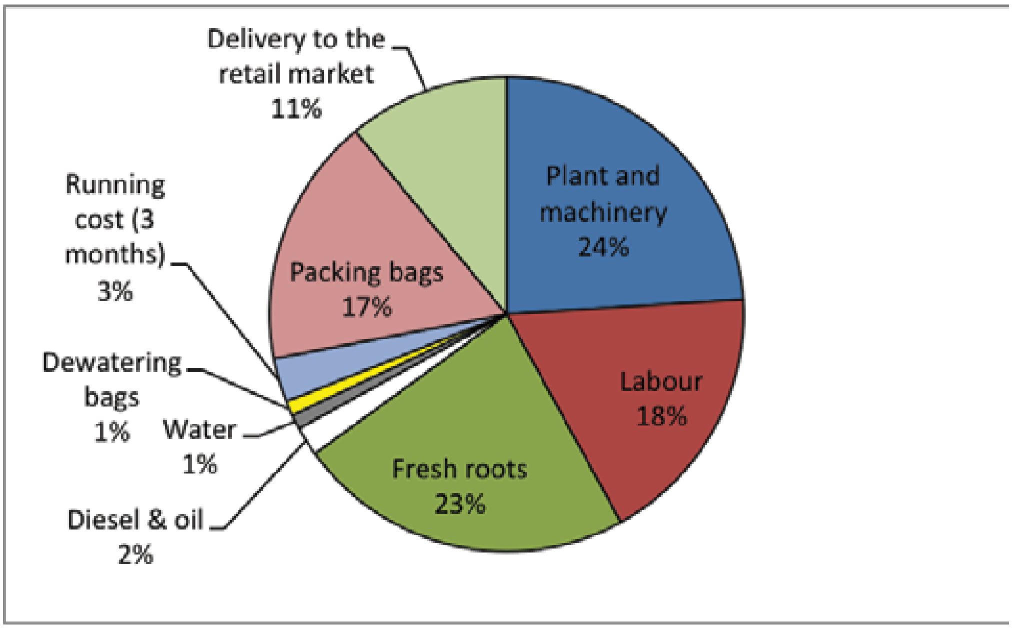

Figure 7: Percentage distribution of costs of medium-scale mechanized cassava processing.

The processing cost was US$22,015/year (US$524.17/t); delivery to the market was estimated at US$2696/year (US$ 64/t), which was 11% of the total processing and delivery cost. The selling price of the flour to the retail market was US$769.23/t while the prices of maize and wheat flour in the market ranged from US$778–820/t. The results suggest that cassava flour processing and direct sale into the retail markets had 26% profitability (US$8, 300/year).

However, when the profitability analysis was done based on the ongoing price of fresh roots offered by other processors, the cost of roots constituted 16% of the total processing and delivery cost, US$19,354/year (US$460.80/t) The profitability of the operation was 34% (US$10, 962/year).

Based on this analysis, it is possible to improve the profitability of mechanized processing with a lower price of fresh roots, higher processing capacity (e.g., 1.5 t/day fresh cassava) and efficiency of operation, and the use of mechanical drying technology that allows more days of operation in a year (e.g., 240 days).

On the other hand, smallholder farmers are the losers when prices are low without a corresponding increase in yield/unit area. Based on the production cost of US$ 34.5/t of fresh roots, the current purchase price of US$20–33/t is a loss to the farmers. Similarly, the US$10–25/t that traders offer for fresh roots that are not yet harvested is also not of any financial benefit to the smallholder farmer.

Indeed, the pilot study and results suggest that mechanizing cassava-processing operations through investments by the private sector can increase the opportunities for nearby farmers to sell larger quantities of fresh cassava for a decent income. However, the farmers-*cum*-processors can benefit from such supply arrangements only if higher yielding varieties that have the potential to significantly reduce production cost are adopted. In addition, higher efficiency is required in the operation of processing plants to maximize the benefits and increase profitability for all the value chain actors, particularly the smallholder producers.

Our experience in the past showed that excessive plant capacity compared to the available supply of fresh roots, inadequate infrastructure and low managerial competence were mostly responsible for the failures of previous large-scale starch and flour-processing plants in Nigeria, Ghana, Tanzania, Uganda and Madagascar. Hence, to increase efficiency, an appropriate scale of operation (small, medium or large) suitable for each location must be identified in terms of raw material availability, infrastructure, market for final products, and available managerial capacity. Nonetheless, there are indications that, if farmers are able to double yield/unit area and supply large quantities to nearby processing plants through properly planned out-grower arrangements, they may be able to reduce cost while at the same time becoming commercialized. Hence, propping up the commercialization of production through increasing rural processing operations may enhance the competitiveness of cassava, increase the supply of food products, and increase the incomes of smallholders and other value chain actors. The role of the other value chain actors in the path of commercializing the sector will be treated in depth in the coming sections, and particularly in section 5.

3.6. Potential for private sector-led mechanized processing of cassava-derivative products in ESA

Past experiences in international development suggest that if today's solutions to current problems are not made sustainable, the same problems are bound to reappear in the future. The lessons of early attempts to commercialize cassava processing in many countries accentuate critical issues related to private investments and agro-industrial development in Africa. There are questions about the appropriate scale of agro-processing operations; the matching set of technologies that should be introduced to new areas and new people; the level of expertise needed for the operation-related logistics; the extent of coordination among the stakeholders; and the level of market linkages necessary for attaining sustainable agro-industrial development and delivering benefits to stakeholders.

Many institutions, agencies of government and development organizations in ESA have made efforts to develop cassava commercialization in different countries. In the 1980/1990s, attempts to introduce large-scale cassava starch processing industries in Sengerema-Tanzania and Lira-Uganda failed as a result of poor production logistics, disease epidemics and uncoordinated marketing systems. The introduction of processing plants with a machinery capacity in excess of the available raw materials, combined with limited human capacity to properly organize the operations of the plants, contributed significantly to the failure. The subsequent introduction of cassava chipping technology to farmers' groups in Tanzania in 2000/2001 to make chips and supply animal feed mills did not make significant progress, partly because of the small-scale nature of the technology introduced. The chipping machines introduced were the small manual types but the feed industry wanted large volumes of the chips. The feed mills soon lost the enthusiasm to use cassava chips because of a lack of a sufficient amount to support their operations. The feed millers wanted the raw material delivered immediately while the farmers' associations were still learning how to use the new technology.

In Uganda, the successful rehabilitation of the cassava sector from the mosaic virus epidemic (1990 and 1997) through the distribution of tolerant varieties (most of which were high cyanide varieties) led to surplus production. Consequently, a price depression took place and farmers were advised not to eat fresh roots, but instead to process them. To mechanize the processing, research institutions, NGOs and CBOs distributed manual graters for household processing, and powered graters to over 20 processing groups between 1997 and 1998. By 2005, an assessment of some beneficiaries of the mechanization efforts in Kamuli, Iganga, Tororo, Busia, Kumi and Katakwi districts showed that most machines were not used on a regular basis. The technologies were successful at the beginning as farmers' income improved, but several of the processing sites encountered difficulties in continuing to use this technology for various reasons. The most critical difficulty was that the processing technologies introduced were not delivered as a full package – since the drying component was left out. Other technology-related issues constrained the introduction of cassava mechanization into Uganda. The new machine producers were still in their learning curves. The machines were not sufficiently efficient to ease usage and there was no expertise in the localities to repair the faulty machines. The farmers found some of the unit operations too tedious (particularly that of dewatering); and most did not attain sufficient know-how of the processing and marketing of the new products (such as *gari* and HQCF) that could be produced by the machines. Market linkage activities were not included in the projects that introduced mechanized operations into Uganda and there were no stable markets for most of the new products. The assumptions that demand for the new products would develop rapidly within the localities where mechanized processing was introduced, and that it would be large enough to absorb the new products produced, did not hold. In some places where mechanization was initially successful and large quantities of cassava were processed, the supply of fresh roots soon ran out. It was found that some local and improved genotypes gave low quality processed products: some newly introduced early maturing genotypes deteriorated fast after harvesting, therefore affecting the quality of processed products that could not be marketed. In addition, most of the farmers-*cum*-processors groups were poorly organized and lacked entrepreneurship skills and transparency. Their traditional attitudes and values affected their ability to take advantage of the new mechanization opportunities to sell cassava products. Uncompetitive prices, lack of linkages among the stakeholders and unorganized markets forced farmers to revert to selling fresh cassava to tricky traders.

The pilot activities from 2003 to 2008 and subsequent commercialization projects in ESA brought new experiences. The results from the latest efforts provided some evidence of the potential to commercialize the sector and information about what would be required to attain sustainability.

During the pilot project, technologies for processing some intermediate shelf-stable cassava products – starch, flour, chips and *rale* – were introduced to farmers-*cum*-processor groups at the farm level. This was done concurrently with the adaptation of the relevant processing machine designs in partnership with private equipment manufacturers. The adapted processing machines, mainly mechanical pressing and grating machines, were introduced to the rural areas through the pilot groups. In all cases, packaging and product marketing innovations were introduced to enhance the uptake of cassava products. A series of training sessions was organized to build the capacity of equipment manufacturers and the pilot associations to engage in mechanical processing. In addition, other institutional arrangements, such as out-grower schemes, standards for intermediate products, market information, linkage to the end-users, and advocacy for supportive policies were put in place.

In Tanzania, IITA collaborated with Tanzania Food and Nutrition Centre (TFNC), the Ministry of Agriculture, Food Security and Cooperatives (MAFSC), Sokoine University of Agriculture (SUA) and Intermech Engineering to test this approach that was quickly adopted by many NGOs and governmental institutions. New farmers' groups or associations were quickly formed and supported by the delivery of new processing machines. Subsequently, other agencies such as Tanzania Industrial Research and Development Organization (TIRDO), Small Industries Development Organization (SIDO), College of Engineering Technology of the University of Dar es Salaam (UDS-CoET) and other governmental institutions replicated the approach in new areas. Initial results from these activities demonstrated the possibility of improving the livelihoods of the rural poor through the promotion of rural-based mechanized cassava processing and marketing. Many other development organizations and NGOs, such as VECO (*Vredeseilanden* Country Office, a Belgian NGO), Tanzania Development Navigation Trust (TADENA), Tanzania Women Leaders in Agriculture and Extension (TAWLAE), Care International, Plan–Tanzania, Plan International, Women and Youth, Environment and Gender (WOYEGE), Action Aid, Tambani Rural Community Development Fund (TARUCODEF), and Concern Worldwide, among others, subsequently developed similar programmes and projects across the country.

At the start of the pilot activities in Tanzania, few processing machines existed, apart from those mainly in the research institutes for research at a laboratory scale or for training. As new groups of farmers-*cum*-processors were formed in rural villages, different types of processing machines were purchased and used (Fig. 8). Although the grating technology was not in use commercially before the project, it was gradually adopted as well. Manual chipping of cassava (chipping technology), previously introduced, was mostly adopted.

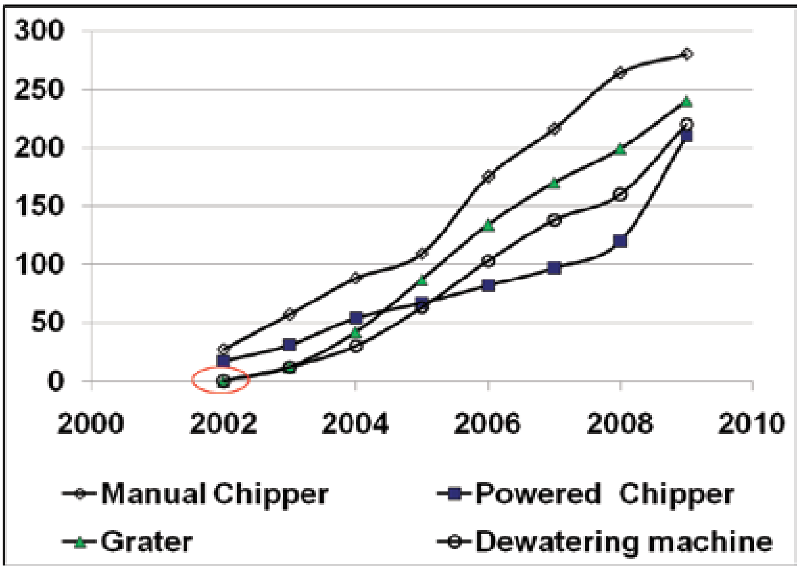

Figure 8: Machine types and numbers used by groups of processors.

An assessment of mechanized cassava-processing groups in Tanzania showed that the number of such groups increased from about 8 in 2003 to more than 120 in 2010 (Fig. 9).

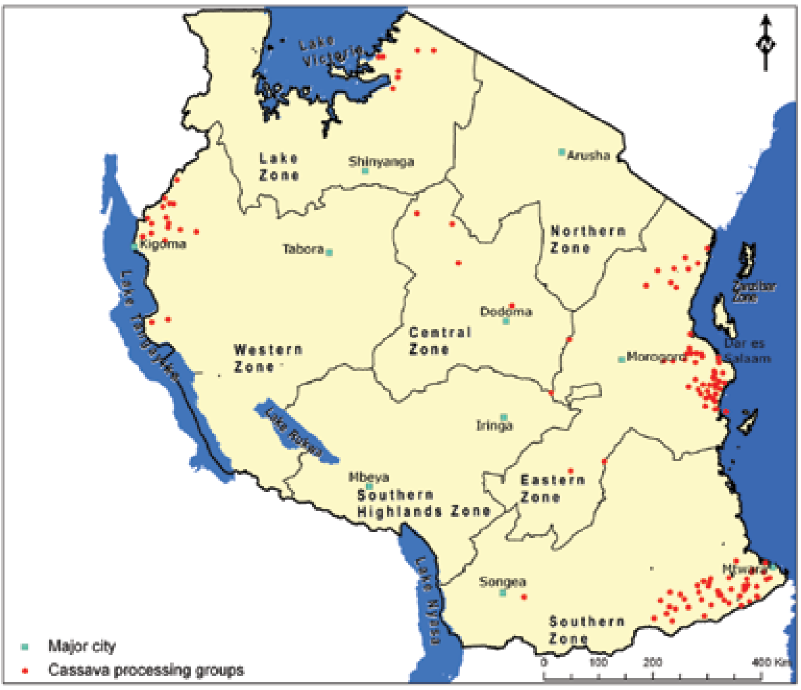

Figure9: Spread of mechanized cassava processing by 2010.

Most of the mechanized processing groups were established in the Eastern and Southern zones of Tanzania where the pilot project was implemented and where both chipping and grating technologies were adopted.

The rapid growth in mechanized activities seems to be an indication of the long-time unfulfilled desire to mechanize cassava processing; and the realization by local governments, NGOs and development agencies of the opportunities to improve livelihoods through mechanized processing. The adoption of processing machines, an indicator of the mechanization of processing operations, was highest in the Eastern zone of Tanzania followed by the Southern zone (see Fig. 10). The Lake zone, where cassava is mostly produced in Tanzania, lagged behind in the rate of mechanization. This is possibly because of the high incidences of diseases, cassava brown streak disease (CBSD) and cassava mosaic disease (CMD), in the region. Halting the spread and devastating effects of the diseases was the main focus of the farmers and other agencies in the region. This suggests that mechanization is unlikely to be adopted in disease prevalent locations as farmers may not be able to produce enough roots to rationalize the mechanization of processing operations.

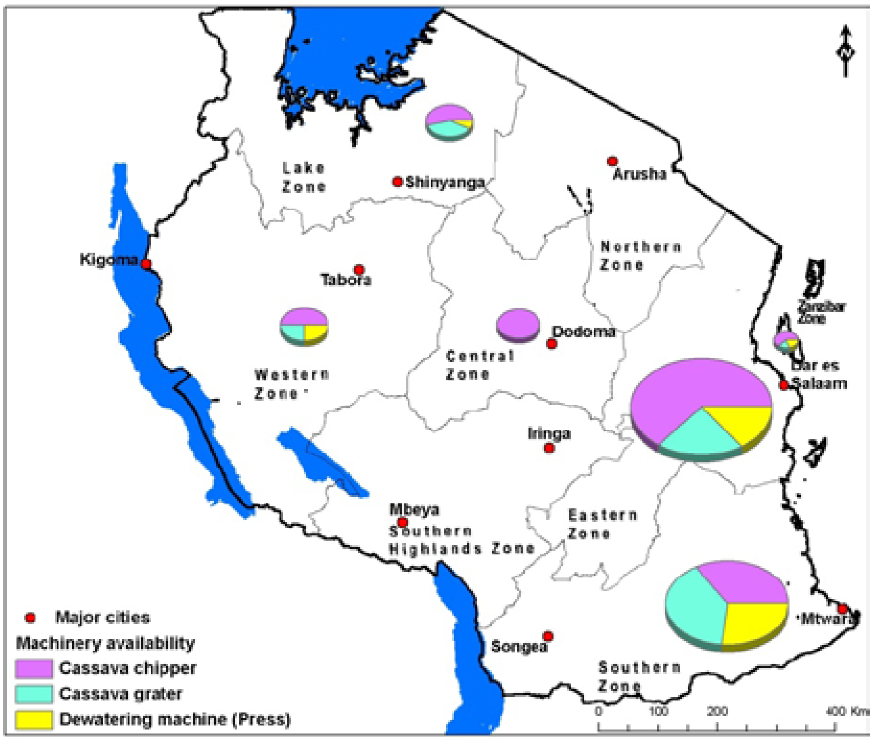

Figure 10: Spread of different types of cassavaprocessing machinery in Tanzania, 2008.

A rapid appraisal of Tanzanian institutions and their roles in the spread of mechanized processing, conducted in 2008, showed that research centres and development agencies/NGOs jump-started mechanization by organizing farmers' groups and supporting them with processing machines (see Fig. 11).

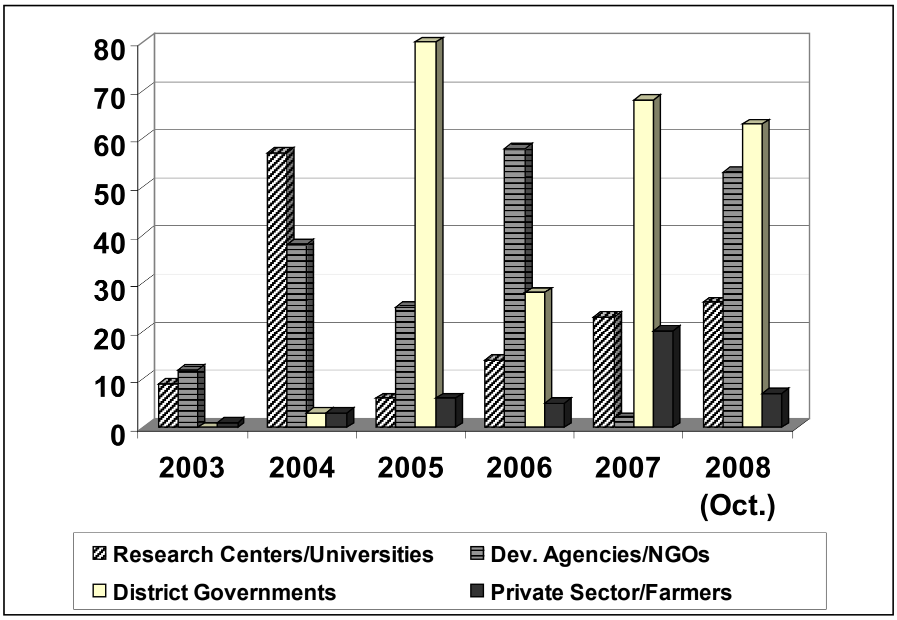

Figure 11: Categories of stakeholder institutions and sequence of involvement in promoting mechanized cassava processing in Tanzania.

Local governments were later prompted to make investments in the purchase of machines to further promote village-based processing to improve the quality of rural cassava-based foods and reduce rural poverty. The farmers-*cum*-processor groups could not purchase the machines as they lacked the financial resources required to make such investments.

4 Potential for the industrial use and marketing of cassava-derivative products

During the pilot tests, flour, chips and native starch from the pilot groups were delivered to potential end-users, such as home bakers and industries, for trials in making consumer items such as bread, biscuits, textiles, paper and cardboard. Artisanal bakers, biscuit and noodle factories in Tanzania, Madagascar and Zambia conducted trials with HQCF as a substitute for wheat flour in producing leavened bread, *baguette* (French bread), biscuits, noodles and wafers. Consumers who were already familiar with traditional cassava foods but were seeking higher-quality products were able to buy the HQCF in supermarkets for trial. In Mozambique, the improved *rale* was graded, packaged, branded and bar-coded for sale in one of the country's biggest supermarkets, Shoprite.

The first round of tests conducted in Madagascar in 2005 involved 23 artisanal bread bakers, a biscuit and a noodle factory. Loaves of bread were baked using different percentages of HQCF (10 and 25%), 50% HQCF for biscuits and 10% HQCF for wafers. For bread, the quantities of other ingredients such as sugar, water, yeast, and salt remained unchanged even when the composite flour was used. After the assessment of the products, the bakers and other fast-food makers affirmed that bread can be baked commercially with cassava–wheat composite flour.

Figure 12: Bread bakers' training on how to use HQCF in Madagascar

A series of training sessions was subsequently organized for bakers in many countries to improve their ability to bake bread and make pastries with cassava–wheat composite flour. While the bakeries and other industries continued the testing of cassava in their products using flour from the pilot groups, supermarkets and stores placed the flour on their shelves.

In Tanzania, supermarkets, textile manufacturers and food processors including two biscuit factories that tested HQCF and starch collectively demanded over 2,350 t of HQCF and over 500 t of starch (Table 7). These represented an annual market opportunity for about 7,000 t of fresh roots. This is a huge demand pull for fresh cassava to be produced by smallholder farmers. While the price of wheat flour was US$264/t in 2005, cassava flour from the pilot plants was sold at US$169–253/t in Dar es Salaam supermarkets and at US$350/t to textile factories that import starch at US$400/t.

Table 7: Demand for HQCF and starch during pilot testing in Tanzania.

Type of industry	Name of firm	Demand (t/year)
Food markets, Supermarkets and stores	Shoprite Checkers Tanzania, Imalaseko supermarket, Tito enterprises, Hemed enterprise, Mwanza market, Kisutu market, Magembe family, Power Foods.	1,150
Biscuit factories	Bakers Food International, Bakresa Foods	1,200
Textile mills	Namira Textile Group (2 Textile factories)	(starch) 504

Other potential users include wheat and maize flour mills, breweries, animal feed mills, food and beverage processors, paper mills, makers of paper-based packages, matchboxes and adhesives. Table 8 shows examples from Tanzania.

Table 8: Other potential users of cassava in Tanzania.

Type of Industry	Name of firm
Cereal milling plants	Flour Princes Mills; Coast Millers; Ben es-Haq Ltd; Mzizima Flour Mill; Azania Wheat Flour
Biscuit factories	Britannia Biscuits Limited; BIBI Biscuit Factory; Tabisco Biscuits
Breweries	Darbrew limited, TBL
Animal Feed formulation & Livestock farming	Farmers' Centre Ltd; A&Z Animal Feeds; Mkuza Chicks Ltd; Ilala Animal Feeds
Bread bakeries	Azam bakery
Other food processors	Upendo Food processors; Dabaga Veg. and Fruit Canning Co.; Noble Foods and Beverages Ltd; Kimara Sausage Processing Co. Ltd, Dagaba Veg. and Fruit canning Co. Ltd.
Paper and packaging factories	TanPak; Mufindi paper Mills Ltd; Omar Packaging Industries Ltd, TLL Printing and packaging, Jumbo Packaging, Twiga Paper

Matchbox factory	Alfa Match Box
Paints	Berger paints
Textile	Tanzania China Friendship Textile Co. Ltd
Adhesives	Kudus

In Madagascar, JB Biscuits, the largest biscuit factory in the country, imports about 6,000–7,000 t/year of wheat at an average price of US$820 t. The company tested HQCF at a commercial level and found it to be better than starch for the hardening of wafers. The company began to incorporate cassava flour in wafers at 8% inclusion. The estimated HQCF requirement of the company to continue the test for biscuit and wafer manufacturing was 112 t/year. The factory developed a new product (mould biscuit) using the HQCF supplied by the Malagasy pilot plant and wanted an assurance of its availability at the right volume and quality before commencing commercial production of the new biscuits. In addition, a large-scale bread baker, Bakery les Grippons, with a wheat usage level of 170 t/year and other smaller bread bakers with usage levels of 15–25 t/year import the wheat flour at a price range of US$690–910/t for the production of bread, *croissants,* and all kinds of cakes. On testing the use of HQCF, the estimated demand of these bakers and other Antananarivo city-based pastry makers for HQCF was about 1,400 t/year (Table 9). These quantities were much higher than the cooperative group involved in the pilot processing had the capacity to produce.

Table 9: Demand for HQCF during pilot testing in Madagascar.

Type of industry	**Name of firm**	**Demand (t/year)**
Biscuit and wafer factories	*Biscuiterie* JB	112
Bread bakeries	Avaradrano Bakery, Andraisora Bakery, *Les Grillons* (Bakery), Maefa Bakery, Analamahitsy Bakery, Bakery *au Pain d'Ami*, Zokibe Bakery, A. Bakery	425
Pastry manufacturers	Pastry makers in Antananarivo	1,000

Cassava was found to be a highly competitive partial substitute for wheat in bread and biscuit baking. Nonetheless, there are many other industries in Madagascar that are open to the use of cassava for food, brewing, textiles, papers, animal feeds, wood, adhesives and other chemicals (Table 10).

Table 10: Other potential users of cassava in Madagascar.

Type of Industry	**Name of firm**
Food industry	Amical bakery, Gerbor bakery, N'ami bakery, Point Chaud bakery, Ideal bakery, Pain dore bakery, Mamitina bakery, Bledipain bakery, Pap's bakery, 3epis bakery, bakery, Andraisora bakery, Probo industry, Ravel bakery, *Boulangerie* Lido, *Boulangerie* Zokibe, Boulangerie Lock Daniel, *Biscuiteries artisanales* (Raharimampianina Saholy, Raharimalala Saholy, Rahajason Jean Paul), *Charcuterie* Codalsa, *Charcuterie* Lewis Sarl, *Charcuterie La Hutte Canadienne*, *Charcuterie* Transcovia, *Charcuterie* Sava.
Brewing/Ethanol	Factory Morondava
Textile	*Cotonnière d'Antsirabe*
Paper, Printing and Packaging	*Papeterie* de Madagascar (Padmad), *Papier* Antaimoro, Newpack, Cartomad, Graphoprint, MSM
Paints	Upema, Gamo, Acticolor, Aurelac, Propeints, Sfepi, Sopemad
Feeds and Livestock farming	Picor, *La Hutte Canadienne*, FIM, Sava , Eleveurs
Supermarkets	Shoprite, Jumbo score, Leaderprice, Pavillon Analakely, Pavillon Andravoahangy
Wood processing, Match box manufacture	Panomad
Adhesives	JB (Tsaralalàna), EMFI, Sicor, *Société* Ballou, DIPCO
Chemicals and others	Ofafa

In Zambia, end-users involved in the testing of HQCF found it very useful in baking biscuits and making glue or binder for packaging materials (corrugated cardboard boxes, brown paper) tissue paper, core pipe, plywood panels and particle boards, laminated boards and doors. To continue the test, seven of these industries (Wood Processing Industry, Monterey Printing & Packaging Ltd, Unity Packages, Bisonite Company, Peco Ltd., Trishul Ltd., and Zambezi Paper) required 505 t/year of HQCF at a price range of US$220–320/t, giving an opportunity for smallholder farmers to supply about 2,000 t of fresh cassava. Many other industries in Zambia had made attempts to source cassava for use and are still willing to use it as a total or partial substitute for imported raw materials (Table 11).

Table 11: Other potential users of cassava in Zambia.

Type of Industry	Name of firm
Food industry	Stumbles Investment, Musekawaya Technologies, Lufimba Enterprises (Chomba Mwali), PECO Limited, Sunrise Biscuit Company Ltd, Liberty Biscuits, Chunno Enterprise, Musa Bakery, Lamise Biscuits
Textile	Mulungushi Textiles
Paper, Printing and Packaging	Monterey Printing and Packaging LTD, Unity Packages LTD, Zambezi Paper Mills
Paints	
Feeds and Livestock farming	Tiger feeds, National milling and Meadow feeds
Supermarkets	Various supermarkets in Lusaka
Wood processing, Matchbox manufacture	Bisonite (Z) PLC, Wood Processing LTD

During the industrial trials, the three feed mills in Zambia used up to 90,000 t/year of maize at a purchase price of US$365. After initial testing, these mills demanded cassava for making poultry feeds. At 10% replacement for maize, 9,000 t/year of cassava or 36,000 t/year of fresh roots would be needed but this amount could not be sourced.

Past experience of the use of cassava chips in the Tanzania feed industry also showed that the potential demand was high, but use was constrained by insufficient supply.

Similarly in Uganda, Ugachick feed mill had previously carried out research to demonstrate that dried cassava chips could replace part of the cereal-based energy component of their brand of livestock feed ration. Further tests led to the demand for a total 8,576 t/year of chips by Ugachick and two flour millers at a price range of US$83–22/t. The animal-feed industry in Uganda required chips the equivalent of approximately 19,000 t/year of fresh cassava. Ugachick alone at a 10% substitution level required 8,000 t/year of dried chips. This was a huge order that the small pilot groups in Uganda could not possibly supply. Nonetheless, Ugachick feed millers, Maganjo millers, Family diet, Kagodo millers and other feed mills ordered chips from the pilot groups regularly and a price regime based on 75% of the price of maize was fixed to buy chips from the pilot processors. However, an overwhelming increase in the demand for flour for human consumption occurred in Uganda in 2006/2007. This made the pilot processors sell chips or flour to the food market instead of the animal feed mills. The processors sold cassava flour to local flour millers at prices far above the maize flour price. Whilst Ugandan maize was sold at US$0.11/kg local millers of flour were buying high-quality chips at $0.14/kg to make a composite for human food. This indicates that the HQCF had relatively more value than maize or wheat flour for some uses and at some periods of the year.

Market opportunity for cassava as biofuel

Proponents of the use of ethanol fuel from cassava for household cooking, heating, lighting, refrigeration and small-scale power generation argue that it will not compromise the food security of the people. The New York Times reported that new demand for cassava as an input for biofuel production has, since 2008, increased the export of chips from Thailand fourfold; in 2010, 98% of chips exported from Thailand to China was used to make biofuel, thereby almost doubling the price of cassava.

While sub-Saharan Africa suffers from extreme energy deficiencies, charcoal and firewood constitute the major fuels for cooking, especially in poor households. These households suffer from indoor air pollution caused by the burning of wood as fuel. There is little recognition of the use of cassava for the production of ethanol in the ESA region, despite the potential for an increased market access for smallholder farmers through the use of cassava-derived ethanol in many industries. The use of ethanol for home cooking is encouraged in Nigeria; the replacement of Methyl Tertiary-Butyl Ether (MTBE) in all petroleum products has been legislated through the E-10 policy in Nigeria. MTBE oxygenator is added to gasoline to reduce emissions of smog, carbon monoxide and other ozone-depleting chemicals. However, because of its toxicity, Nigeria opted to replace MTBE by blending ethanol with gasoline. A 10% blending of ethanol with gasoline in Nigeria alone was estimated to create a demand for about 1.2 billion litres/year of ethanol. At 150 litres of ethanol produced from 1 t of fresh cassava, this will create a demand for over 8 million t of roots which will be produced and sold by smallholder farmers. In addition, the ethanol worth over US$700 million/year imported by Nigerian industries can be produced from cassava. The E-10 policy has encouraged investments in new ethanol plants. In addition the production of ethanol from cassava can be used in liquor blending, plastics, pharmaceuticals, petro-chemicals, cosmetics, paints and brewing; glucose syrup is being produced for use in the food industry. In Mozambique, attempts were recently made to use cassava for ethanol production and in beer brewing. A new plant, Greenstar, is currently being established to produce a million litres/year of ethanol from cassava in Sofala province; a Dutch company produces dewatered cassava cake for brewing beer. It is estimated that deforestation can be reduced through the use of ethanol as a cooking fuel by reducing the use of charcoal and firewood; estimates are up to 87.30% in Ghana, 53.56% in Nigeria, 0.11% in Zambia, 6.59% in Uganda, 7.18% in Tanzania, 24.74% in Mozambique, 21.03% in Malawi and 8.49% in Madagascar.

Indeed, cleaner options are needed that reduce the use of fossil fuels as well as greenhouse gas emissions and may also attract carbon concessional finance to promote agricultural growth in Africa. The use of ethanol from cassava for various industrial applications, including biofuel production, could be an option if the approach or policy gives priority to first meeting the food needs of the people, thereby ensuring food security and increased income for the smallholders who will produce the cassava for sale to industries.

Factors promoting market demand for cassava products

In all the countries, the industrial demand for products derived from cassava exceeded the production capacity of the small pilot groups; these groups mostly rely on sun-drying for the production of HQCF, starch and chips in much smaller quantities than those required by the industries. However, the number of potential end-users that tested the use of cassava derivatives represents a small proportion of the potential end-users in each country. Indeed, the dormant demand is much higher than the capacities of the smallholder farmers-*cum*-processors using pilot-scale machinery.

There are two main factors that encourage the demand: quality and price. The cassava derivatives made through mechanized processing operations have better quality, safety and aesthetic appeal than traditional products. For HQCF, the resulting dried cassava granules which are milled are white, odourless, sweet or bland in taste, and without contaminants (Figs 11 and 12). Feedback from Tanzanian markets showed that, for home cooking, consumers appreciated HQCF more than traditional flour because of its quality, if it is made according to the IITA technology and if the proper quality precautions are followed (according to Dziedzoave et al. 2006).

Figure 13: High-quality grits before milling to flour.

Experience from the pilot tests, however, showed that small-scale processors were unable to make cassava products at the right quality level demanded by the users. Some minimum quality requirements were therefore necessary for the use of cassava in specific products and to standardize trade.

Previous studies showed that end-users in West Africa used some quality criteria for the purchase and use of HQCF in various food products (Abass et al. 1998). Similar criteria were established by end-user industries in Zambia (Table 12). These criteria included fine particle size, absence of contaminants, and high starch content, In addition, price competitiveness, consistency of quality, and year-round availability are important considerations.

Table 12: Quality requirements and inclusion levels of HQCF in different industrial products.

Type of industry	**Quality and purchase requirements**	**Inclusion levels**
Paper, Packaging industry (corrugated cardboard boxes, brown paper), tissue paper and core pipe.	For making glue used as a binder: • very fine particle size (0.2 to 0.25 microns); • no contaminants or particles–avoids blockage of machinery pipes; • delivery by order and payment by cheque; and • no fermentation – guarantees longer gel/gum stability.	≤ 96%
Matches	• As a binding agent; • Starch residue preferred – quickens spark and aids combustibility.	
Textile		10–50%
Plywood, plywood panels, particle boards, laminated boards, Milenine-coated particle boards and door	• 13–14% moisture content; • very fine texture; • packaged in sealed polythene bags; and • colour not critical.	30–100%
Feed mill	• As energy source; and • 70% starch.	10–40%

The price regime for cassava products in the supermarkets suggests that the HQCF had relatively more market value than wheat flour in some niche markets. Textile mills appreciated the use of HQCF and demanded higher volumes at a commercial scale due to the cost-saving benefits over the use of imported corn starch. Prices offered for HQCF varied from country to country depending on the price of the material for which they are the substitute. Bakers in Madagascar offered higher prices for HQCF than in Tanzania and Zambia (Table 13). Because of the high price of wheat flour in the retail market in Madagascar, US$900–1,080/t, small bakers and pastry makers who could not purchase wheat flour at a wholesale price (US$670/t) were willing to pay more than US$556/t for HQCF and required even more. In Zambia, flour was requested at a price range from US$200 to 320/t.

Table 13: Prices offered for HQCF by different industrial users.

Country	**Price of wheat flour used by baking industry (US$/t)**	**Price paid by baking industry for HQCF (US$/t)**
Tanzania	410	330
Zambia	480	298
Madagascar	670	556
	Price of corn starch used by paper industry (US$/t)	Price paid by paper industry for HQCF (US$/t)
Zambia	670	298

Estimating dormant demand in food and non-food sectors on a national scale

An analysis of the respective market sizes was carried out in 2007 for cassava products in Madagascar, Tanzania and Zambia. Based on FAO and official statistics for country imports for wheat and starch, the amount of maize used by feed mills and conversion factors determined by the project for fresh cassava to cassava products showed that a large dormant demand exists.

To estimate this dormant demand on a national scale, using HQCF as an example, we supposed as follows:

- HQCF can replace wheat imports by 10% in Tanzania and Zambia and by 20% in Madagascar where more HQCF is included in biscuit and wafer manufacturing. Previous reports (Abass et al. 2001; FAO and IFAD 2004) showed that, in reality, the actual replacement levels could range from 10 to 50% for the different products (biscuits, wafers, bread, noodles, etc.).
- 10% of maize in poultry feed can be replaced by cassava chips, although this is a relatively low inclusion rate compared with that of end-users in Nigeria.

Based on the above suppositions, the potential demand for HQCF in 2007 was estimated at 47,500 t in Tanzania, 9,400 t in Madagascar and 7,720 t in Zambia (Table 14).

Table 14: Estimated market potential for HQCF and cassava chips.

	HQCF (t)	Cassava chips for animal Feed (t)	Raw cassava equivalent (t)	Percentage of annual raw material supply
Tanzania	47,500	45,000	370,000	6.0
Madagascar	9,400	36,000	181,600	8.0
Zambia	7,720	45,000	210,900	22.0

As can be seen in Table 14, Tanzania had the highest estimated market potential for both HQCF and chips; Madagascar and Zambia also had a substantial market potential in both products. Supposing the HQCF demand was met in 2007, the HQCF chains in the three countries would have created a demand pull for about 260,000 t of fresh cassava, giving market opportunities to around 30,000 smallholder farmers. In addition, the animal feed requirement for chips translated to about 504,000 t of fresh cassava, representing market opportunities for an additional 135,000 smallholder farmers in the three countries. The market for these two processed products represented an absorption capacity or production increment of about 6% of the 2007 cassava production in Tanzania, 8% in Madagascar and 22% in Zambia.

To summarize, evidence from the testing of cassava in industrial processes demonstrates the existence of a huge, latent and unexploited market opportunity for novel intermediate products in the areas of food (fresh, waxed and frozen roots, fresh and frozen leaves, flour, granules), feed (dried chips, leaf meal and pellets), energy (fuel, industrial, portable and pharmaceutical ethanol and gel cooking fuel) and starch (native, modified, sweeteners).

The best opportunities are found in the food sector, suggesting that African countries would be inclined to support development programmes that give priority to the use of cassava for food. As shown (Fig. 1), wheat consumption in Madagascar, Tanzania and Zambia has been following an upward trend and the consumption volume is much greater than domestic production, leading to significant imports – particularly for Tanzania. However, considerable constraints still hinder the high demand for cassava-based primary products from being met. Again, assuming a substitution of 10% HQCF for imported wheat, the market demand for HQCF by 2013 is projected to be at least 73,000 t in Tanzania, 19,700 t in Madagascar and 10,500 t in Zambia. This suggests that if Tanzania will adopt the replacement of 10% of its projected wheat imports in 2013, the country will have to increase cassava production immediately to 292,000 t, representing 5% of the total cassava output in 2010. This would be a challenge, considering the current low level of commercialization, despite the efforts currently being made by many development organizations and NGOs to increase awareness of the cassava sector. In addition, the production and processing capacity of the existing processors is too small to cater for the upsurge in demand. Processors in the three countries have not increased their processing capacity above the pilot scale that was introduced nearly a decade ago. This situation is the same in other ESA countries where NGOs, governments, etc., have recently introduced the mechanized processing technologies to smallholders.

It is clear that to achieve a sustainable commercialization of the cassava sector on a national scale, the supply of products must match their demand. Primary production, village-level processing and marketing of processed products need to be coordinated and be based on an appropriate scale of operation.

5
Attaining a sustainable commercialized cassava value chain

To put a sustainable value chain structure in place it is necessary to ensure that all stakeholders along the chain will play their respective roles and get adequately rewarded for them. Lack of commitment from any of those concerned along the chain could, ultimately, lead to weakened links and, as the saying goes, "the chain is as strong as its weakest link". Therefore, all the challenges need to be resolved to enable the ESA countries to sustainably convert their cassava sectors from subsistence to commercial operations. These challenges include biophysical, human and social capital constraints.

Below is an examination of some of the challenges, identified during the pilot tests that may limit the commercialization of the sector. Alongside this, possible measures to mitigate these challenges are elaborated.

5.1 Cassava production system inefficiencies

Much has been learned from the small-scale cassava-processing project and other follow-up projects, i.e., the CFC-funded project led by IITA in West Africa; the USAID-funded project *Unleashing the power of cassava in Africa* implemented by IITA in seven countries; and the NRI-led project on value addition to cassava in five countries, funded by the Bill and Melinda Gates Foundation. These experiences show that raw material supply is one of the weakest links in all the industrialization schemes tested, with the other weak link being market access.

Around the villages and locations where small-scale processing operations were introduced, the supply of fresh roots was found to be inadequate after a few days of continuous processing, suggesting that production is still very low, and insufficient to support commercial processing. This can be partly attributed to the predominantly subsistence nature of agriculture in the region in general, and the specific role of cassava as a food-security crop. It reflects the fact that cassava has not traditionally been a cash crop or a raw material for industry, to be produced at a medium or large scale and marketed to processing industries to earn a decent income. In effect, cassava has long been stigmatized as an inferior low-protein food that is meant to be consumed by the poorest strata of the population. Governments have also not paid the crop the attention needed for the promotion of commercial cultivation. These factors have therefore limited production to smallholder farming systems that generate low yields, are inefficient and achieve poor economies of scale. Consequently, production suffers from substantial seasonal variation from time to time (FAO and IFAD 2004). Such subsistence production systems present a serious obstacle to reaching a level of productivity that can assure the regular supplies of the substantial volumes required by industry. This inferior situation is reflected in the fact that, although Africa accounts for about 64% of the global cassava area harvested, it accounts for only around 51% of world production. The rising production trend recently observed in Africa is mostly explained by the use of more land for cultivation rather than by any improvement in yields.

To reach a sustainable level of commercialization of the sector, all the productivity constraints need to be overcome to achieve the production potential. Given the current scenario, a 1% improvement in African yields could lead to about a 10% increase in production, without the cultivated area being necessarily expanded. Such is the potential for Africa to boost cassava production.

The major productivity constraints responsible for the low yields are associated with a combination of pests, diseases and poor farming practices. In Africa, these combined constraints cause yield losses that may be as high as 50%, largely due to: i) reliance on traditional low yielding varieties that are susceptible to a wide range of pests and diseases; ii) use of marginal land which is often acidic, low in nutrients, and subject to soil erosion; iii) reliance on low and erratic rainfall; and iv) the fact that the principal objective of a subsistence farming system is to grow cassava as an insurance crop against significant yield losses in the largely cereal staples (IITA 2006). The devastating effects of mosaic disease and brown streak disease on yields in Africa have reached epidemic status in recent years. In addition to these, bacterial blight, anthracnose disease, and root rot are causing serious economic losses to cassava farmers in many parts of Africa.

Furthermore, unlike many other starchy staple crops, the production of cassava is dependent on a supply of stem cuttings. The multiplication rate of these vegetative planting materials is very low compared to that of grain crops which are propagated by true seeds. In recent years, access to good quality stems has become difficult due to the increasing spread of brown streak disease epidemics, particularly in ESA. In addition, cuttings are bulky and highly perishable, as they dry up within a few days (FAO and IFAD 2001; IITA 2006). Regrettably, most farmers lack the knowledge of how to preserve the cuttings to maintain their viability long enough until the often unpredictable weather is sufficiently favourable for planting.

5.2 Improving the efficiency of cassava production systems

For significant commercialization to occur in small-scale cassava food systems, roots must be available at a sufficiently low price to undercut both domestic and imported wheat, maize and rice. For this to happen, it was recommended that small-scale farmers need to increase output/unit area by improving production efficiencies.

Whilst figures vary considerably, it is our estimate that for cassava to be produced commercially, farmers must achieve yields of between 25 and 35 t/ha.

These yields are considerably higher than the averages achieved in the ESA countries.

In addition, new technologies and a combination of institutional arrangements/ management innovations need to offer significant potential for small-scale producers to efficiently and profitably scale up their operations. The approaches are required to increase productivity and enhance the efficiency of the cassava value chain from production to market.

For a sustainable linkage between smallholder farmers and processors, the supply of fresh roots should be arranged, based on the premise that small-scale producers will be able to negotiate favourable contracts with processors for the supply of set volumes of quality raw cassava at predetermined prices. Such arrangements include the following:

i. Farmers will plant carefully selected improved varieties which are both high yielding and produce high-quality processed products.
ii. They will use some fertilizer and machinery inputs, especially if they have access to a credit facility.
iii. They will adopt improved farming practices for which they will receive training.

During the pilot tests, some varieties with the potential for a high yield and suitable for home cooking were identified for different locations in Madagascar, Tanzania and Zambia. If producers at the identified locations adopted these varieties, aimed at segmented markets depending on specific end-uses, it would help to increase productivity and enhance commercialization.

For example, in Tanzania, varieties that are sweet and used for home cooking are Kizimbani (yield potential 25 t/ha) and Mahonda (20 t/ha). Both are adapted to the coastal lowlands. Mkombozi, with a potential yield of 25 t/ha and adapted to mid-altitudes, especially the Lake Zone, is sweet and can be marketed for home boiling. The non-sweet Kibaha varieties (KBH 2002/066 and KBH 2002/028) are also well adapted to the coastal lowlands, and are very suitable for processing into flour or chips, rather than for boiling. Variety I92B/00073 20 is suitable for the coastal lowlands as well, has a mild taste, and is good for flour and chip processing. In the Dodoma region of Tanzania, Mumba (yield potential 29 t/ha) and Hombolo (HBL 95/05, 15–17 t/ha) are well accepted for home cooking. In the coast region, Kiroba is well adapted, tolerant to CBSD, and has a yield potential of 16–17 t/ha; it is also the most popular variety for the fresh market. In Naliendele and Mtwara regions, Naliendele (NDL 90/34) has a yield potential of 19 t/ha and is preferred by farmers as it is tolerant to CBSD and has the best taste and cooking quality.

The constraint of low productivity or production and delivery to processors can be overcome by adopting even higher yielding non-sweet varieties which are more suitable for processing. These ensure that the production cost and price will fall, and that the production output will not be diverted away from the processing plants to the fresh root market. To be profitable, processing enterprises must give priority to organizing farmers into out-grower schemes, using varieties with high yield potentials, and giving less priority to their taste or popularity among local consumers. Specifically, a combination of institutional arrangements and productivity-enhancing strategies should be planned. These may include working with pre-screened farmers with the necessary motivation and capability for success; delivering specific disease resistant high yielding varieties with preferred end-user traits; developing community primary multiplication sites and organized planting material distribution systems; organizing out-grower schemes with groups of smallholder farmers; using rural bulking centres for the prompt delivery of fresh roots for processing; and providing smallholder farmers with access to farm credits through local microfinance banks.

In some countries, the high yielding varieties which would enhance profitability already exist. For example, there are varieties in Madagascar with yields four times the national average and already in commercial use in the Marovitsika starch plant. According to IITA cassava breeder, Mrs Isabelle Ralimanana, the varieties include Bougor (yield potential 50 t/ha), H58 and H54 (yield potentials 35–40 t/ha) and Hybride Creolina and Hybride branta (yield potentials 25–30 t/ha).

In Zambia, improved varieties with yield potentials ranging from 22 to 41 t/ha) have been released for Mansa and Solwezi (agro-ecological zone 3). According to Barratt et al. (2006), the varieties include Mweru (sweet; 41 t/ha), Kampolombo (sweet; 39 t/ha), Tanganyika (sweet; 36 t/ha), Chila (bitter; 35 t/ha), Bangweulu (bitter; 31 t/ha), Nalumino (flat; t/ha), and Kapumba (sweet; 22 t/ha).

The wide use of these varieties can significantly increase the national average yield or productivity and the production volume at smallholder levels. In addition to adopting the high yielding varieties, producers need to take advantage of modern agronomic practices to effectively increase profitability. An enterprise with a supply strategy based on the application of modern production technologies and market innovations is likely to gain through a competitive production situation unlike the traditional food security-focused systems – assuming that adequate inputs and training are provided.

5.3. Potential gains from an efficient production system

To demonstrate this gain, a simulated profitability analysis of production under traditional methods and improved methods was carried out using field production data from Tanzania and Uganda (Table 15). Under the improved method a yield of 32 t/ha is possible, compared with 16.3 t/ha achieved in current best-managed traditional farms.

Table 15: Comparison of indicative costs of cassava production under well-managed traditional and improved production methods.

Cost Item	Well-managed traditional production system	Improved varieties and production method
Yield (Fresh; t/ha)	16.3	32
Total cost of production/ha	407	407
Unit cost of production (US$/t)	25.0	12.7
Total cost of manual harvesting and root collection; at farm gate (US$/ha)	159	311
Unit cost of manual harvesting and root collection; at farm gate (US$/t)	9.8	9.7
Total cost of production, harvesting and root collection US$/ha)	566	718
Unit cost of production, harvesting and root collection; at farm gate (US$/t)	34.7	22.4

The unit cost of production up to root maturity for the improved method is lower (US$12.7/t) than for the traditional method (US$25.0/t). When the costs of manual harvesting and root collection are considered, the unit cost of harvested roots at the farm gate increased to US$34.7/t for the well-managed traditional production system and US$22.4/t when an improved variety is planted. In both modes of production, the cost of root harvesting and collection is a substantial component (28–43%), which needs to be reduced to reduce the farm gate-price of harvested roots and increase competitiveness.

Although this analysis was based on a well-managed production system in a project location, giving a yield of 16.3 t/ha, the yield under the traditional management system is lower (12 t/ha, max.) and the production cost of cassava/t will be much higher. In comparison, the average production cost in Nigeria is US$ 38/t fresh roots (US$ 450–800/ha) and in Thailand 29 US $/t (US$650-800 /ha). Nonetheless, this analysis suggests that if improved varieties and modern production systems could be widely spread in ESA, the price of fresh roots could be low enough for ESA to become competitive in the global market. In this respect, mechanical harvesting would be needed to reduce the total cost. Under such commercialized systems, smallholders are more likely to receive more revenue from the same farm size while the cost of raw materials for processing will be lower, reducing the costs of foods and raw materials from cassava. Ultimately, production and the dependent manufacturing industries in ESA may be more competitive.

5.4 Improving postharvest management systems

The perishable nature of roots presents another serious impediment to the commercialization of production. As roots contain 60 to 70% of moisture, they have a shelf-life of only 2–3 days. Once harvested, they have to be either consumed immediately after cooking or processed into more stable product forms (IITA 2006). Due to low knowledge about 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. A typical scenario is that traders buy the cassava on the farms before it is harvested. Farmers often resort to this method of sale when they need money. Traders capitalize on such farmers' situation, while the farmers have less bargaining power than the traders. With this method of sales, the farmers have little control over when the cassava gets harvested, thereby limiting their immediate access to the land. During certain periods of the planting season, fresh root traders offer prices that are more attractive to farmers than the prices offered by processing plants. However, the traders select roots suitable for sale in the fresh roots market and thereby reject roots mostly on account of not being tender or juicy. Large quantities of roots may be rejected when the cassava is fully mature and too big for fresh root marketing. Traders cannot tolerate over-aged and disease infected roots.

Even if farmers were able to process cassava, they lack the financial resources to acquire machines that would enable processing their crop into good quality, shelf-stable products. Alas, they lack the basic technologies to store cassava as well (CFC 2002). Due to these problems, most farmers plant less than they could, and this sometimes leads to insufficient supplies for the market or processing plants. When cassava is scarce, the price goes up, which encourages farmers to plant more than they can store in the next season; the excess production then leads to a drop in prices. The farmers respond to this drop by then planting less the following season. The resulting inadequate supplies in the subsequent season cause prices to again go up – in a cycle of approximately 2–3 years (Nweke et al. 1994). This vicious cycle causes major distortions in the farmers' production system and leads to disincentives and lack of confidence in cassava as a cash crop. Most farmers then resort to subsistence production, irrespective of good market prospects.

There is no doubt that the combination of the perishable nature of roots after harvest, poor postharvest processing knowledge, and farmers' lack of access to processing machinery in many countries of ESA contribute significantly to the low production observed in the region. In comparison, countries with adequate processing knowledge and machinery, such as Thailand, Nigeria and Ghana, are able to convert high volumes of harvested cassava into various products and are able to increase primary production (Nweke et al. 2002).

In places where partial mechanization of processing was introduced, the need for sun-drying significantly affected the ability of farmers-*cum*-processors to guarantee supplies throughout the year because there are certain months (rainy seasons) when they cannot dry the product. In addition, sun-drying makes it difficult for farmers to maintain the required quality level since the method, by its very nature, is open to different means of aerial contamination.

On the other hand, a number of end-users were able to determine that the use of derivative products as a raw material in their lines of production was technically and economically feasible. This led to a huge demand from industries. Consequently, a significant gap emerged in the supply of products coming from the rural processors. From 2005 to 2007, an assessment of the processing activities of small farmers-*cum*-processors was carried out in Tanzania, Madagascar and Zambia to identify factors that could contribute to the success or failure of small-scale processing enterprises (Abass et al. 2009). The assessment was based on economic, financial and even managerial or social criteria. The most prominent factors were found to be: i) unavailability of a sufficient and steady supply of raw materials at low cost and stable prices; ii) inability of small farmers' associations to operate the processing machinery at high capacity utilization; iii) limited managerial skills and difficulties in maintaining the quality of products; iv) inefficient use of inputs such as labour; v) inefficient or lack of supporting infrastructure (water, roads and transport systems); vi) limited ability of smallholder processors to have access to the existing product market; and vii) poor group-organization of the processor associations. Group management problems and poor processing and management skills were responsible for inefficient processing operations. Some of the small processing groups were unable to effectively manage mechanized processing enterprises and to market their products outside the familiar rural settings to more advanced market environments such as urban-based industries; this inability limits their chances of deriving benefits from mechanized processing operations. Whilst these associations complained of a lack of market for the products, the industries complained of not getting a regular supply of the products.

The constraints of poor postharvest management practices can be overcome by making available processing technologies and strategies suitable for use by smallholder farmers and village processor-cooperatives that do not have adequate processing infrastructure and expertise. Managerial and entrepreneurial skills need to be improved for mechanized postharvest processing enterprises to be managed at rural farmers' levels. This would enable them to convert their produce into more shelf-stable products that would earn them more income.

To transform cassava into an industrial commodity through the development of a value chain, processing technologies must be profitable and attractive to the private sector. For the sector to be commercialized in a sustainable manner, mechanical means of drying must be introduced. Also, to attract the industrial users, the scale of processing must also be suitable to achieve the quantity, quality, and continuity of supply at a competitive price. This would ensure a regular and consistent supply of good-quality products to end-users.

By putting a supply chain in place that would enable small-scale farmers/processors to produce good-quality semi-processed/processed products at competitive prices, end-users would also need to be facilitated to adapt their respective lines of production to include cassava products (HQCF, chips, starch, etc.) as a raw material. Once this is done, the next step would be to facilitate supply contract agreements between end-users and the producers/processors of the products.

This approach was tested during the pilot phase by working with a number of end-users to test the use of cassava products as a raw material. While all the products produced and tested during the pilot phase showed a big "takeoff" potential, HQCF exhibited the highest potential. Its adoption as a substitute for imported raw materials such as wheat flour at the national level presents huge opportunities for commercializing the sector and generating income. Many of the end-users are already convinced about the usability and profitability of such products. However, as explained in previous sections, constraints posed by sun-drying led to inconsistent supply and low quality. It was indeed risky for large industrial and other end-users and users with strict quality requirements and huge demands to rely on small-capacity processors depending on sun-drying.

To avert these kinds of problems, mechanical drying, which eliminates the sun-drying method, needs to be introduced. For example, a two-stage processing approach for production of HQCF is ideal. This approach involves setting up an out-grower scheme to supply roots to village-based intermediate processors. The intermediate processors will engage in on-farm processing into semi-dry grits, through rapid peeling, washing, grating (or chipping), and dewatering steps. This allows small-scale processors with inadequate drying infrastructure and expertise to avoid sun-drying. The semi-dried cassava can then be supplied to final processors who will dry the intermediate products using mechanical dryers (flash, bin or cabinet), mill and pack for sale. This arrangement, however, requires significant capacity building in managerial, logistics, planning and entrepreneurial skills at all levels of the supply chain – from the out-growers to the processors.

5.5 Improving product development and marketing

According to the FAO and IFAD (2001), small-scale producers and processors lack the financial, physical and human capital to be able to develop new products and markets. In addition, the subsistence mind-set continues and prioritizes the production of traditional products using traditional methods instead of commercial production methods.

Where product development has occurred in the past, innovative producers and processors have achieved mixed results largely due to: i) lack of consumers' confidence in the quality and safety of products; cultural perceptions of cassava being the food of the poor and displaced; ii) lack of appropriate marketing channels; iii) poor transport infrastructure; iv) poor market information; v) low and fluctuating volumes of marketable cassava; vi) variable quality; and vii) uncompetitive prices of cassava-based primary and consumer products (CFC 2002). For example, in the early 1990s, both Tanzania and Madagascar exported significant volumes of cassava pellets to the European Community (EC).However, as the price of cereals fell within the EC, the pellets quickly became uncompetitive; and the volume of cassava exported by, and produced in both Tanzania and Madagascar declined dramatically (FAO and IFAD 2001). According to the FAO (2001), Africa does not currently have any apparent comparative advantage in selling relevant quantities of cassava starch to the rest of the world.

Although several African countries have attempted to increase the export and use of locally produced cassava chips in the commercial feed sector, it has been with little success. For instance, in Tanzania in the mid-1980s, cassava was utilized for poultry and pig feeds by the Tanzania Feeds Company. This practice was later discontinued as prices were found to be high compared those of with grains. In Madagascar, cassava pellets are used by the industrial feed sector but in relatively small quantities - not exceeding 10,000 t/year (FAO 2001).

Inconsistent supply and quality problems have seriously impeded a wider commercial utilization of cassava in producing countries. Most countries in the ESA region face a number of constraints along the supply chains that make the costs soar to levels that render cassava products uncompetitive, not only in foreign but also in domestic markets.

However, it has been shown that a large dormant demand for shelf-stable derivative products exists. Cassava can be produced and fed into rural and urban-based industries for use in the manufacture of a variety of end-products; food, livestock feed, textiles, adhesives, etc., (Abass et al. 2001). Transferring research and knowledge to increase the technical usability of cassava in a wide range of applications will contribute to increasing the demand for the products and the market for fresh cassava. Innovations in product and process development, grading, packaging and branding are therefore needed, to catalyze the marketing of cassava products in an increasingly commercialized system.

Project experience shows that most potential end-users require technical assistance on how to incorporate cassava into their processes. Adapting cassava to various industrial processes and training potential end-users of derivative products can increase the "demand pull" and improve prices at the farmers' level. Industrial users need knowledge on how best to retool their machinery to accommodate higher amounts of cassava without compromising the quality of their consumer products. This will help to reduce scepticism about the suitability of cassava as a raw material.

Research is needed on low-cost drying systems that ensure the regular supply to the end-users. Mechanization can ensure the intermediate products possess the quality characteristics required for their incorporation into various manufactured products. The technical expertise of end-users can be improved through collaborative testing of appropriate inclusion rates and grades best suited for the consumer products. In addition, they need to be assured of a consistent supply of the required quantity and quality at competitive prices whilst ensuring that local processing remains profitable.

5.6 Increasing access to affordable credit facilities

Logic dictates that if a business idea makes economic sense, people will want to invest in the venture. However, many of the stakeholders along the lower section of the cassava supply chain in ESA operate under less than ideal economic conditions and lack the financial means needed to engage in a given business venture. In addition, even if they have what would be considered tangible collateral to gain access to credit from commercial financial institutions the prevailing high costs of borrowing would prove prohibitive and make the business venture unviable.

The lack of private collateral and low-interest credit implies that producers and processors cannot bear much of the risk associated with the development of new products and markets (FAO and IFAD 2001; CFC 2002). Poor credit facilities and high interest rates make investments risky and financially unattractive, and thus hinder commercialization (FAO 2001). This greatly affects the newly evolving HQCF sector. Most smallholders willing to invest seem unable to make progress without access to credits, at least to purchase machinery which may be unfamiliar or even not available locally. To commercialize cassava, credit institutions need to be encouraged to offer loan facilities to people willing to invest in the value chain. A plan of action to facilitate loan access and some suggestions are provided below.

Access to low-priced loans from affordable credit facilities is a key requirement for farmers, processors, traders and village communities to invest in the cassava chain and develop more profitable marketing mechanisms. Government support through the provision of a credit guarantee can increase the access of smallholder farmers to affordable credits, thereby enhancing their participation in the market economy. More efforts are required to inform financial institutions about the low risk involved in these enterprises to increase their willingness to provide loans.

During the pilot test, some intermediary financial institutions collaborated in helping farmers to have access to credits. Although credit opportunity in an exploratory or pilot and non-commercial system may be limited, it has been shown that the profitability of processing enterprises under a commercial environment is high (at a 20–50% profitability index). Also, the majority of processors should not have any difficulties in repaying bank loans, especially when operating efficiently with access to a rewarding market.

Nevertheless, special concessions for lower interest rates, possibly under special arrangements which may include credit-guarantee systems, are required to support the sector. Responses in Madagascar, Tanzania and Zambia have demonstrated that some financial institutions are interested and have the competence to provide loans to cassava farmers and processors at reduced rates under a credit-guarantee system.

5.7 Improving the image, and creating supporting institutional and policy environments for cassava

Together with the impediments of inefficient and low-output production, processing, marketing and distribution, the inferior image of cassava and unsupportive institutional and policy environments also constrain successful commercialization.

Cassava is Africa's second most important staple food. But, it has always carried an inferior image as a non-nutritious food, the choice of last resort when everything else is unavailable – either due to unfavourable weather or lack of financial means. This has been perpetrated (sometimes inadvertently) by the policymakers choosing to promote crops widely considered as the more convenient staple foods. The low productivity observed in most African countries is partly a consequence.

Historically, cassava as a human food, animal feed or a source of industrial starch has been neglected by the government departments responsible for agricultural and rural development in most African nations. As a result, the development of improved varieties, production and processing practices and more efficient marketing approaches has been limited until the last decade. As an example, over-valued exchanged rates (FAO 2001) set by governments have often significantly disadvantaged the growth and commercialization of cassava food systems and stifled opportunities for expanding the cassava trade in domestic and international markets.

In most countries in Africa, cassava has traditionally been marginalized by already over-stretched agricultural and rural development extension services, leading to the under-provision or non-provision of the technical and financial support needed by producers, processors and traders (CFC 2002). Indeed, where trade in cassava has managed to evolve, it has often been stifled by the absence of government quality grades and standards through which price and the value of primary products can be determined. In addition, the absence of private-sector lobbyists has also contributed to the traditional political invisibility of cassava (CFC 2009).

Until recently, there has been little endorsement of the acceptability of cassava for consumption by the middle class. Its use as animal feed and industrial starches was not expressly endorsed by national governments, except in Nigeria, Ghana, Mozambique, and one or two other countries. Many potential end-users have not been sure that the use of cassava would be acceptable in their processes. There were no standards for cassava products in some countries, and they were not included in the approved raw material lists for industrial products.

Nevertheless, commercialization of the sector in several African countries has become a necessary objective. Countries in ESA have realized that institutional, policy and image issues need to be addressed. The sector is increasingly receiving much-needed attention, as the image of cassava is changing. However, to keep up the momentum with the general public, awareness campaigns are still necessary. People need to be informed of the various uses associated with cassava and know that it can be profitably produced and marketed as a cash crop.

These issues were explored during pilot tests in the project countries in collaboration with the relevant government agencies. Achievements were made in the area of food standards and norms. The project countries' food and standard administration authorities formed technical committees and set standards for cassava products. As a result, nationally approved standards for flour, starch, edible chips, etc., became available.

In addition, through the collaborative work of ASARECA and national and international agencies such as IITA, at least 13 standards for cassava, potato and their products were successfully harmonized and approved by the EAC Standards Committee as "East African Standards" (EAS). These include specifications on HQCF, dried cassava chips, food grade cassava starch, cassava–wheat composite flour, fresh sweet cassava crisps; and the determination of total cyanogens in cassava. These standards are now operational and should ease cross-border trade within the EAC and enhance export outside the region. These EAC standards have further been adopted by Tanzania and are referenced as TZS 466:2010 (flour), TZS 465:2010 (chips), TZS 964:2010 (starch) and TZS 472:2010 (total cyanogens).

It is expected that such an approach will eventually improve the image of cassava, create a supportive institutional and policy environment, and improve trade and export opportunities in ESA. Although the process for the harmonization of standards has been successful in East Africa with the approval of the EAS, the process is lagging in West Africa where commercialization is more advanced. Similarly, it is vital to initiate and complete the process in Southern and Central Africa to advance the process to a continental level. Harmonized standards and grades for cassava products are expected to accelerate cross-border trade in Africa and improve the ability of small producers to process cassava for export.

5.8 Promoting grading, packaging and branding to stimulate demand

Grading and branding are also needed, to ensure that every grade or standard of a product has its own market channel and value.

Uses require diverse quality requirements for the cassava-derivative products. Grading of products, based on the nationally approved specifications, could increase differentiation in various markets, and increase the market share since the different grades would meet the requirements of a diversified range of consumers and wider market channels.

Use of products in niche markets can be enhanced through strategic social marketing or branding. The approach can change the attitudes of the populace towards cassava in general, so that more consumers will benefit by consuming high-quality and safe cassava products. Branding products, apart from improving the image, can as well increase market-segmented demand and ensure that benefits are derived by all categories of stakeholders.

Packaging could help in the use of standard measures in product marketing, and increase the keeping quality, aesthetic appeal and market value. It facilitates the branding and coding of products to be sold through supermarket chains.

5.9 Improving price transmission

One of the key issues in the sustainability of a given supply chain is the nature by which the price gets transmitted along the chain. Price is the central mechanism by which markets function. Price signals contain information on a plethora of factors related to market fundamentals, such as: i) changes in the quantities produced and consumed; ii) changes in the efficiency of production and processing; iii) shifts in the pattern of consumption; iv) future expectations of the economic agents; and v) changes in quality of the product (Mbabaali and Rapsomanikis 2005). Along an efficient supply chain, the price conveys information on the market, based on which economic agents decide to alter their behaviour and maximize their profits. However, there are many factors that can impede the efficient and sustainable functioning of the supply chain. These, according to Mbabaali and Rapsomanikis (2005) include the following:

- Large marketing margins that arise due to high transfer costs may insulate producers. Especially in developing countries, poor infrastructure, transport and communication services give rise to large marketing margins due to the high costs of delivering the locally produced commodity to the processing plants or the border for export. High transfer costs and marketing margins hinder the transmission of price signals and prohibit transactions and arbitrage. Consequently, changes in prices downstream are not fully transmitted to the producers, resulting in economic agents adjusting, if at all, partly to shifts in demand.

- Non-competitive behaviour in market structures (such as oligopoly where there are few sellers) and oligopsony (few buyers)) can also hinder the integration of producers and other agents in the supply chain. For example, a single trader, or a small number of cassava (or cassava product) traders in a particular region, may result in prices offered in this region being lower than the national average by an amount that is in excess of the transfer costs. Relatively low prices may weaken the incentive to increase the volume of offered for sale and improve quality.
- A large number of links in a supply chain, often identified by a large number of intermediaries, can also weaken the price signal to producers. Long and disorganized supply chains result in the slow passage of information from one end to the other, thus obscuring the price signal to the producers and resulting in inefficiencies and unsynchronized responses.

Thus, it is crucial to streamline the value chain in a way that permits the efficiency of price transmission and equitable financial benefits among value chain actors.

5.10 Increasing the effectiveness of sector interventions through stakeholder platforms

The formation of cassava producers', processors' and traders' associations, lobby groups and commodity development bodies has yet to begin in the region. This approach has been effective in Nigeria to engage private sector rather than the public sector in organizing the cassava sector more efficiently and sustainably. This approach needs to be explored in the region, particularly in Madagascar, Tanzania and Zambia. Small-scale farmers/processors need to be organized (through associations/cooperatives) to deal with issues that affect them collectively. Capacity building is a necessity if lessons learnt during the process of commercialization are to be passed on to a wider clientele. This can best be done when stakeholders are in a form of organization.

It is also important to maximize the involvement of the private sector during technology testing since private companies are those to adopt and propagate the successfully tested technologies and techniques. Hence, the formation of a stakeholder platform from pilot operations will greatly increase theinvolvement of the private sector and uptake of the tested technologies. This was demonstrated in Uganda where the pilot groups were later transformed into bigger and stronger cassava associations – Kibale Cassava Processors' Forum (KICAFA) and Kibuku Cassava Processors' Association (KICAPA). Research institutions need to ensure that appropriate varieties are made available, through extension services or by dealing directly with farmers' associations/cooperatives.

Lastly, there is a need for close collaboration and cooperation between key stakeholder groups and the different agencies (national and international) that are implementing cassava sector development programmes. This will not only increase the efficiency of programme delivery but will also help to increase the positive impact on smallholders while conserving resources and avoiding the duplication of efforts.

6

Possible benefits of public investments in a commercialized cassava sector

Cassava in ESA has traditionally been considered a poor man's crop, of little financial value and low in nutrition. There is evidence that the image can be changed. Cassava can be profitably produced and processed into high-quality products that can serve as a raw material in several industrial processes.

Therefore, the transformation of the cassava sector from subsistence to a commercial operation through public investment could help to integrate smallholder farmers into a commercialized, more profitable value chain. Public investment in infrastructure such as water and electricity, research to increase productivity and machinery options, extension, market promotion, etc., should promote investment by the private sector in the establishment of a supply chain. However, demand for a product and the possible profits that result are the strongest motivations for investment. Because of the proven profitability, commercialization is expected to stimulate private-sector investment and increase the uptake of derivative products. . An increase in demand is expected to stimulate the uptake of new and more efficient production technologies from research, leading to lower costs of production, an improvement in productivity, as well as better incomes for smallholder farmers.

For example, in a situation in which all the demand for HQCF in 2013 gets fully met, it would mean that at least 252,000 farmers in Tanzania, 78,800 in Madagascar and 42,000 in Zambia would each be producing 10 t of cassava and supplying 10%/year of their production (or 1 t) to the village-level processing units (for farmers with a farm size of 1 ha and yields of 10 t/ha) Supposing that over time, farmers adapt higher yielding varieties and apply more appropriate agronomic practices, this may result in a boost in yields to 20 t/ha or more. Also, the underlying profitability could induce farmers to expand their average farm holdings from the current 0.5 to 5–10 ha. Over time, the production would become more efficient, labour costs may fall and the process become more competitive.

In terms of financial benefits to farmers and other stakeholders there are benefits to be shared when large volumes, especially of HQCF or starch, are used to replace imports. For example, the use of 10% HQCF as a composite for bread baking in Nigeria was analyzed in 2010. Results showed that the smallholder farmers could get benefits of US$14.92/t, HQCF processors US$14.92/t, HQCF distributors US$4.47/t and bread bakers US$48.47/t from 1 t/HQCF or 4 t/fresh roots traded. The monetary benefits appear to be directly proportional to the quantity of HQCF likely to be traded or used for the manufacture of other products. Hence, the use of HQCF could provide opportunities for farmers to negotiate better prices for supplying a larger quantity of roots to the processors while at least US$24 out of the US$48.47 savings by bread bakers could be redistributed to consumers through a reduction in prices. At the national level, considering the high price of wheat and the quantity imported by Madagascar, Tanzania and Zambia in 2007/2008, a 10% replacement of imported wheat with HQCF could have saved the three countries up to US$29.6 million in foreign exchange expenditure.

In addition to the increased competitiveness, the direct integration of farmers into the supply chains would yield financial benefits to them and create more employment opportunities in rural areas at the farms (maintenance, harvesting, transportation, etc.) and village-level processing units (peeling, washing, chipping, grating, pressing, loading/unloading, transportation, drying, packaging, etc.). Although it is difficult to determine the exact number of people who will be directly employed in a commercialized sector, assumptions have been made and used to provide indicative numbers of potential jobs that can be created based on the 2007 market demand (Table 16). From this, it is estimated that a commercialized sector in Madagascar, Tanzania and Zambia could have provided job opportunities for 32,433 people, which, based on a 2013 demand projection, could translate to about 53,124 people in 2013.

Table 16: Estimated number of potential beneficiaries based on projected market demand for HQCF in 2013.

Processing and marketing activities	Tanzania	Madagascar	Zambia
Farm maintenance – number of farmers (@ a rate of 1 person/2 ha/year)	31,500	9,850	5,250
Harvesting and transporting of fresh cassava (@ a rate of 1 person/100 t/year)	2,520	788	420
Grit processing (@ a rate of 1/125 t grits/year)	1,008	315	168
Transporting of cassava grits, including loading and unloading (@ a rate of 1 person/ 250 t grits/year)	504	158	84
Processing of final product (@ a rate of 1 person/250 t HQCF/year)	252	79	42
Transporting of HQCF, including loading and unloading (@ a rate of 1 person/500 t HQCF/year)	126	39	21
TOTAL	**35,910**	**11,229**	**5,985**

Traders would also be part of the chain and would benefit from increased trade in intermediate and final products. End-users of cassava products s would benefit from the availability of regular supplies which would come at comparatively more affordable prices, payable in local currencies.

National economies would not only indirectly benefit from the jobs created and the multiplier effect of such jobs, but would also directly benefit from foreign exchange savings emanating from partly replacing imported food and raw materials. Improved employment and income-earning opportunities in rural areas where production and intermediate processing of cassava are to take place would result in improved livelihoods. It may also contribute to reducing the exodus of young people to urban areas, therefore easing urban congestion and crime.

To summarize, the positive effects on smallholder farmers could be phenomenal if cassava-derivatives became available to urban consumers and more end-user industries – their supplies reliable and prices competitive. The industrial trials have suggested that the most important factor for a potentially sustainable growth market is the use of cassava for manufacturing high-grade foods, for wipe sizing operation during textile manufacture, and as extender for plywood glues. Discussions held in 2010 with wheat-milling plants in Tanzania showed that the millers are willing to adopt the blending of wheat and maize with HQCF. In addition, both the small maize millers and big maize milling plants specifically requested further research to determine the inclusion rates for HQCF to maize flour, and the home cooking methods, thus providing evidence that a composite flour policy is possible and will help to reduce the cost of food at the consumers' level. As practised in Nigeria, a broad-based substitution policy will provide significant market opportunities for small farmers and job opportunities for millions of people. Experience from Nigeria suggests that for a policy on the industrial blending of HQCF with wheat or maize to succeed and be of benefit to the population, HQCF delivered to the millers must be of a good quality, at sufficient quantity and at a price acceptable to both the processors and the millers.

7
Conclusion

The local production of the preferred staple foods in ESA (i.e., wheat, rice and maize) is affected by frequent and severe drought conditions. A majority of the population therefore depend on imported foods. However, the burden of foreign exchange expenditure to sustain high food imports overwhelms many countries' budgets. Increasing the availability and consumption of locally produced alternative food products have become a priority.

In West Africa, particularly Nigeria, cassava has already demonstrated its potential to replace most imported staples and cereal-based industrial raw materials. Efforts towards commercialization of the cassava systems are currently transforming the subsistence-level operations into a private sector-led commercialized value chain.

Luckily, the market for cassava products in ESA signals a possible high potential for growth in the food and starch sectors. Market signals serve as an inducement for investment by the private sector. Such industrialization has the potential to stimulate a "demand pull" and increase the potential for income growth for smallholders but the characteristic low efficiency and profitability of the sector serve as constraints to investment.

Therefore, a suitable approach to increase the efficiency and profitability of the sector is required. Results showed that a combination of institutional arrangements and productivity-enhancing strategies, such as the use of improved varieties, fertilizer, mechanized production techniques, and improved agronomic practices, is required to increase production efficiency. As an example, it was found that the adoption of new high yielding varieties (up to 32 t/ha yield potential) and better farm management practices could more than double the profitability and income of smallholder farmers. It can have significant reduction effect on the price of fresh cassava for processing, which is an important cost element that influences the competitiveness of cassava products against the imported substitutes. In addition to improved production technologies and relevant inputs, appropriate technologies for the mechanization of processing and packaging are needed. Credit access and the continuous linkage of processors to the market, diversification of use in various manufacturing sectors, meaningful training, and a high flow of relevant market information to all stakeholders will help move the sector in ESA towards true commercialization.

Most importantly, policies that de-emphasize the importation of food and raw materials but promote the use of locally grown cassava as urban food and industrial raw material will engender private investments in commercial medium- to large-scale production, processing and utilization. However, the financial and managerial capacity of entrepreneurs in ESA needs to be improved to make them better able to transform cassava into shelf-stable intermediate products at the right quantity, quality, and regularity of supply as required by the market.

Technical assistance in increasing the technical usability of cassava in a wide range of applications will expand the market and sustain demand. In addition, the application of market innovations, such as quality standards, product grading, branding and certification will improve the image of cassava and its marketability and further catalyze market-segmented demand. Such demand can stimulate the participation of more value chain actors, particularly if price transmission and financial benefits are equitably allocated.

Indeed, all stakeholders along a commercialized cassava value chain would benefit from a commercialized sector.

To achieve this, it is vital that ESA countries develop national strategies based on an assessment of existing dormant market demand for different cassava products; the right quality of the products and the supply schedule required by the identified markets; the right scale of primary production that matches the market demand; the appropriate scale of mechanized processing systems; the right approach to link smallholder producers to the organized processing systems; and the potential benefits of all of these to resource-poor cassava-dependent families. Such an assessment and steadfast implementation of the strategies can provide the impetus for the emergence of an efficient, competitive and truly commercialized cassava sector.

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