

# C:AVA

Cassava: Adding Value for Africa



## **INVESTMENT STUDY FOR CASSAVA IN NIGERIA**

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**DRAFT REPORT**

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## Abbreviations/Acronyms/Exchange Rates

AADL	Allied & Atlantic Distillers Ltd
BMGF	The Bill and Melinda Gates Foundation
Capex	Capital Expenditure
C:AVA	Cassava Adding Value for Africa
CIF	Cost, Insurance and Freight
CTAP	Federal Government's Cassava Transformation Action Plan
CUF	Cassava Users Forum
FCR	Fresh Cassava Roots
FMN	Flour Mills of Nigeria
FUNAAB	Federal University of Agriculture Abeokuta
HFS	High Fructose Syrup
HQCF	High Quality Cassava Flour
IITA	International Institute of Tropical Agriculture
LPO	Local Purchase Order
NICAPMA	Nigerian Cassava Processors & Marketers Association
NRI	Natural Resources Institute
NSM	Nigeria Starch Mills
SME	Small and Medium Sized Enterprise
TFI	Thai Farm International
UK	United Kingdom
USA	United States of America
USAID	United States Agency for International Development
WB	World Bank

N	Naira
USD	US dollar
£	Pound Sterling
ha	Hectare
kg	Kilogram
t	Ton

### EXCHANGE RATES

Investment study: June 2013 = N155 to USD

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## Executive summary

Between November 2012 and March 2013 the C:AVA markets team conducted a detailed assessment of the various markets for cassava-based products in Nigeria (Graffham *et al.*, 2013). The outcomes of this concluded that there was potential for C:AVA2 to focus on HQCF, starch, industrial alcohol, aquaculture feed and ethanol for home-cooking. Other sub-sectors such as export of chips to China, chips for domestic poultry feed, clear beer, packaged garri & sugar syrups were found to be unattractive for inclusion under C:AVA2 for various technical and economic reasons.

Following on from the market studies a third trip to Nigeria was organised for May-June 2013 to enable the C:AVA Nigeria markets team to conduct the work necessary for completion of the investment study report. The objectives for this visit were:

- To refine the business, developmental & environmental case for inclusion of ethanol for home-cooking in C:AVA2;
- To convene the first meeting of the Cassava Users Forum (CUF) to discuss with private sector players their key concerns and involve the representatives of current cassava-based businesses in the design of the C:AVA2 proposal
- To complete collection of the necessary data to enable the profitability and return on investment to be calculated as accurately as possible and record in the form of a detailed financial model;
- For the C:AVA Nigeria project team consisting of personnel from FUNAAB & NRI to develop an outline for the proposed project and construct a first iteration of an indicative budget.

In this report we present the findings of the investment study and the rationale and strategic approach for C:AVA2. In comparison to the other C:AVA countries Nigeria has the widest range and most-developed set of sub-sectors for cassava-based business opportunities. Following on from the market studies we have identified 35 SME and large-scale businesses who either work with C:AVA already or would be keen to become involved in C:AVA2. These businesses cover a range of sub-sectors including HQCF/instant fufu, starch, industrial alcohol, aquaculture feed and biofuel. In addition there may be an opportunity to work with one or more of the major breweries on smallholder based procurement systems feeding into the production of clear beer. However, details and timescales for the big brewers' plans are not available so this area has been set aside and is not included in our plan for C:AVA2 in Nigeria.

Our primary objective is to increase the volume of cassava roots sold by smallholder farmers into the various cassava-based sub-sectors in Nigeria. This might be achieved by working with private sector players to encourage more smallholder inclusive raw material supply chains with more efficient and reliable production systems. There is also scope in some cases to work with processors to improve efficiency and cost effectiveness of processing and to work with end-users to make it easier and more

attractive to use cassava-based materials in their products. In practice we plan to take a different approach for the SME partners and large-scale businesses.

In the case of SME's (HQCF, aquaculture feed & ethanol for home-cooking) we plan to support all parts of the value-chain namely raw material supply, processing and marketing & end-user support.

In the case of the large-scale processors (HQCF, starch & industrial alcohol) we plan to focus effort on encouraging smallholder inclusive raw material supply systems. Our activities will not deal with the processors own operations or those of their customers in most circumstances. The only exception to this rule would be for end users of HQCF purchased from large-scale processors. We believe there is a valid case for supporting development and uptake of innovative bakery improvers for bread, biscuits and sausage rolls. Investment in this type of research requires larger commercial partners who have the facilities and capacity to help bring the research to the market. If successful these bakery improvers will become available to the smaller rural bakeries (as this is the obvious volume market with 470,000 bakeries nationally) who rely on HQCF SME's for their supplies and source 100% of their roots from smallholder farmers.

The geography of C:AVA2 is based on the fact that the majority of the potential private sector partners for C:AVA2 are located in South Western Nigeria with the biggest focus being in Ogun State with 8 HQCF SME's, 1 large-scale HQCF factory, 2 large-scale starch factories and one large-scale distiller of industrial alcohol. The neighbouring states of Lagos, Ondo, Oyo and Edo account for most of the other SME locations. This distribution justifies the location of the main C:AVA2 office with much of the resources and personnel at Abeokuta in Ogun State. The other area of interest is North Central where there are 2 HQCF SME's and one aquaculture feed mill in Kwara State and 2 HQCF SME's in Nasarawa State. Kwara and Nasarawa States are also important sources of fresh cassava roots with farmers from these states supplying some of the large-scale processing operations in Ogun and Ondo States.

If the market targets are achieved, it is expected that by the end of the project C:AVA2 will benefit a minimum of ~ 40,000 small-farmers, farm and factory workers. Each will benefit by almost US\$600/year (or about US\$2.6/day). It is interesting to note that in 2016 the rural HQCF and starch value chains produce the most beneficiaries; this is probably a reflection of the fact that the value chains are already working and because most of the roots are supplied by small-farmers. Even though more HQCF is produced for the urban than the rural market, it has fewer beneficiaries because it has to procure a significant portion of its raw material supply from highly mechanised commercial farmers. However, as the aquaculture and ethanol value chains develop, they also become more interesting. It is projected that by the end of C:AVA2, the total benefits will be just over US\$23 million/year.

The estimated budget to deliver the beneficiary figures for C:AVA2 Nigeria is estimated to be US\$D8.34 million over the five years. The biggest cost items are for the overheads that cover management and staff costs as well as office and management support (mainly per diems) and local and international consultants. In total, about US\$2.2 million is allocated to support field activities. More detail cost breakdowns are given in a spreadsheet(available electronically from the C:AVA Nigeria markets team).

The proposed budget of US\$8.34 million over five years would generate net income to the beneficiaries of almost US\$11 million in the second year of the project and US\$23.3 in the fifth year. This is obviously a good return for the investment. In terms of beneficiaries, in the final year of the project, the total number of beneficiaries would be almost 40,000; therefore the project investment would average at about US\$200/beneficiary over the entirety of the project and they would benefit by almost US\$600 per year.

## Introduction

In developing the proposal for C:AVA2 in Nigeria our main objective has been to identify the market opportunities/sub-sectors that will offer the most potential for the Bill & Melinda Gates Foundation (BMGF) to add value to existing investments by the private sector and maximise the positive impacts on the livelihood and wellbeing of as many smallholder farmers and entrepreneurs as possible. For development of C:AVA2 we were conscious of the need to:

- Build sustainable value chains for cassava-based products;
- Support smallholder inclusive raw material procurement systems;
- Work closely with existing private sector players as the drivers of cassava-based business in Nigeria;
- Take account of the fact that cassava is typically the second choice for nearly all of the sub-sectors/market opportunities, thus leading to consideration of the question as to where and how cassava-based products can be attractive?

The starting point for this work was a two phased assessment of the market opportunities for cassava in Nigeria that ran from November 2012 until March 2013 and an investment study in May 2013. The market studies characterised the current status of the various cassava-based value-chains (table 1) and medium-term prospects of the most promising sub-sectors that are recommended for inclusion in C:AVA2 (table 2). Following on from the market studies the C:AVA Nigeria team was able to prepare a list of sub-sectors for exclusion from C:AVA2 on the basis of having little or no prospect in the short to medium-term of delivering a useful return on the BGMF investment in C:AVA2 (table 3).

The findings of the market studies (table 1 & 2) showed that many of the cassava-based products have a lot of potential for growth but that the baseline reality is much more limited. HQCF remains the most interesting prospect in terms of volumes and numbers of smallholders involved but market uptake is constrained by the absence of suitable bakery improvers to allow HQCF to be used at higher percentages in the various bakery products. High wheat flour prices coupled by predictions of a generally upward trend in the cost of wheat flour is forcing many rural bakers to consider HQCF in bread but levels are limited to 10%. NRI has been partnering with a major manufacturer of bakery improvers. Results look very promising and it hoped that by early 2014 it will be possible to use much higher volumes of HQCF in bread, biscuits and sausage roll casings.

Cassava starch has a distinctly mixed history in Nigeria but over the last 12 months the two surviving mills have maintained and grown their market share due to the high cost of imported starch and pro-cassava policies by the Federal Government. In late 2012 and early 2013 two new starch factories opened in Ogun State mostly funded by foreign investment. These new mills tend to confirm the apparent confidence of industry players in the future potential of Nigerian cassava starch. Furthermore the C:AVA Nigeria team is aware on two other potential investments in starch one of which seems likely to be realised by mid-2015.

**Table 1** Summary of the status of existing markets for cassava-based products as of May 2013

<b>Sub-sector</b>	<b>Competing ingredient</b>	<b>Current market</b>	<b>Comment</b>
HQCF in bread	Hard wheat flour	2,500 tons/yr	Market growth limited by absence of suitable bakery improver
HQCF in sausage rolls	Hard wheat flour	12,500 tons/yr	Market as a filler but could treble volumes with access to suitable improver
Instant fufu	Wet fufu	500 tons/yr	Niche market with some potential for growth, additional income for some HQCF SME's
Starch	Imported maize starch	12,000 tons/yr	Two long established factories & two new investments operational in March 2013
Aquaculture feed	Imported maize-based feed	~1,000 tons/yr	New market experiencing rapid growth, prospects for cassava depend on access to extrusion cooker.
Industrial alcohol	Imported ethanol	1.8 million litres/yr	New investment experiencing rapid growth
Bio-fuel for home cooking	Firewood & kerosene	~40,500 litres/yr	Pilot scale operations first plant operational by mid 2014
Packaged garri	Traditional garri	50-100 tons/yr	Niche market little prospect for growth

**Table 2** Summary of the medium term prospects for the most promising sub-sectors recommended for inclusion as part of C:AVA2

<b>Sub-sector</b>	<b>Theoretical demand</b>	<b>Achievable demand</b>	<b>Potential FCR equivalents tons/yr</b>	<b>Potential for smallholder involvement</b>
HQCF bakery*	500,000	69,000	276,000	23,000
HQCF paperboard	6,000	6,000	24,000	2,000
Cassava starch	60,000	25,000	125,000	10,500
Industrial alcohol	60 million litres	20 million litres	141,000	12,000
Aquaculture feed	23,000 tons of floating pellets	23,000 tons of floating pellets	74,000	12,400 (0.5ha farms)
Biofuel for home cooking	>1 billion litres	7.5 million litres	53,000	4,500
<b>TOTAL</b>			<b>693,000</b>	<b>64,400</b>

Nigeria is the largest producer of aquaculture products in sub-Saharan Africa with a rapidly expanding smallholder dominated production system producing >200,000 tons per year of catfish and tilapia. The aquaculture industry has undergone a tenfold increase over the last decade and now accounts for 25% of Nigeria’s yearly fish production, this is set to continue to grow by 8-10% per annum driving an increasing demand for pelletised feeds. Nigeria has 10 aquaculture feed mills but only 4 of these are producing pellets locally (only one is using cassava currently but 2 of the others would use if suitable technology became available). These companies produce 4,000 tons of sinking pellets per annum but supplies are dominated by imported floating pellets which account for 23,000 tons per annum. The reason is that catfish and tilapia farmers prefer floating pellet. Cassava is an ideal carbohydrate source for inclusion in floating pellets but the Nigerian companies lack the technology for extrusion cooking of their pellets. Extrusion cooking is essential for production of floating pellets. Small-scale extrusion technology is available in South East Asia and there appears to be no reason why this could not be introduced into Nigeria as part of C:AVA2. Aquaculture feed is of particular interest as the feed millers rely on sun-dried chips from very small-scale farmers in the North Central region of Nigeria.

Nigeria has a well developed industrial sector that uses at least 60 million litres of imported ethanol per annum (some industry sources said this could be as high as 200 million litres but this could not be confirmed). Continued increases in the price of industrial alcohol and the appearance of a virtual import monopoly (one of the two importers has stopped trading) has stimulated one of the major industrial

groups to invest in a 20 million litre per annum cassava-based distillery near Lagos. This company invested 5 years in developing their raw material supply system before starting production of industrial alcohol in late November 2012. As of May 2013 the distillery had a capacity to use 250 tons of cassava roots per day but deliveries were around 50 tons per day. The company is involved with over 4,000 smallholder farmers located within a 150km radius of the factory who deliver between 60-70% of the current root supply. However, this company in common with all of the major cassava processors is having problems with relying on smallholders and could move towards a procurement model dominated by larger commercial growers in future. Industrial alcohol is attractive for C:AVA because the processor is making an effort to be smallholder inclusive and is willing to invest in ways to retain or increase smallholder involvement.

Denatured ethyl alcohol can be used to replace firewood and kerosene in domestic cooking. Ethanol has the advantage of being a very clean fuel thus reducing the negative health impacts associated with firewood and kerosene. Ethanol is produced from sustainable sources such as a cassava as opposed to relying on a fossil fuel source (kerosene) or collection of firewood leading to deforestation. Experience in Brazil, Madagascar and Mozambique has shown that micro-distilleries can offer a way to produce ethanol cost effectively at community level. The prospect of introducing community level micro-distilleries and locally fabricated clean-cook stoves is proving highly attractive for Nigeria. In the longer-term successful uptake of this technology could have serious livelihood and health benefits for some 30 million Nigerian households. In addition there would be positive environmental impacts in terms of less demand for firewood and an estimated 21 million ton per year reduction in greenhouse gas emissions. The main initiative is currently at a pilot stage but the business case for success is reasonable and the developmental & environmental case is very strong. There are also attractive synergies with other cassava-based value chains and hence we are recommending inclusion of this sub-sector under C:AVA2.

**Table 3** Summary of sub-sectors omitted from C:AVA2 with rationale for non-selection

Sub-sector	Rationale for exclusion from C:AVA2
Chips for export to China	A huge opportunity globally, but Nigeria is unable to compete with existing supplies. This market opportunity is likely to develop in the longer-term (~10 years) but offers no prospects for C:AVA2.
Chips for use in poultry feed	The poultry feed sector is large and expanding rapidly but the business case for inclusion of cassava is very weak with serious economic and technical issues preventing investment. The developmental case is weak as we would be replacing locally grown maize with locally grown cassava rather than import substitution.
Ethanol E10	A potentially large opportunity but the economics of inclusion of ethanol are unfavourable. Investment is unlikely to occur.
Sugar syrups	A potentially large opportunity (>1 million tons FCR equivalent per annum) but the economics are unfavourable investment appears unlikely in the medium-term.
Clear beer	This sub-sector shows much promise for growth and could create an opportunity for BMGF to support smallholder inclusive raw material supplies for at least 5,000 families. One brewery is believed to be planning an investment and the others seem strongly interested but actual plans and timescales are unclear hence the non-inclusion in plans for C:AVA2.
Packaged garri for high-end markets	The market for packaged garri is only 50-100 tons per annum with very little prospect for significant growth. Product is mainly re-packaged material from traditional markets hence no real addition to the total volume produced.

The sectors which do not merit inclusion are summarised in table 3, with the possible exception of clear beer all of the other sectors appear to have almost no prospect of realisation within a 5-10 year timescale and hence have not been included in C:AVA2. Some brief comments are provided in table 3 but for a detailed analysis of the technical and economic aspects of each of these sub-sectors the reader is recommended to read the Nigerian market study report (Graffham *et al* 2013) and the chips for China report (Naziri & Lam, 2013).

Following on from the market studies a third trip to Nigeria was organised for May-June 2013 to enable the C:AVA Nigeria markets team to conduct the work necessary for completion of the investment study report. The objectives for this visit were:

- To refine the business, developmental & environmental case for inclusion of ethanol for home-cooking in C:AVA2;
- To convene the first meeting of the Cassava Users Forum (CUF) to discuss with private sector players their key concerns and involve the representatives of current cassava-based businesses in the design of the C:AVA2 proposal
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The report of the investment study has been divided into several sub-sections, the couple of sections outline our rationale and strategic approach and geography of our proposed intervention in Nigeria. This is followed by a section that presents the overall business case for C:AVA2 in Nigeria. In this section we look at the target market segments, assumptions for prices and root requirements, farm models, numbers of beneficiaries and returns on investment. We also include a brief outline of the first iteration of the budget for the proposed intervention (subject to modification as part of development of the C:AVA2 proposal) and indicative cost benefit for C:AVA2 in Nigeria. The final sections of the report provide more detailed business and developmental cases for the individual sub-sectors as appropriate.

In developing our individual sub-sector cases and overall business case for C:AVA2 in Nigeria we constructed a detailed model feeding into a modified version of the framework model developed for use by all of the countries involved in C:AVA2. This report only contains summaries of the data, for full details it would be useful to refer to the relevant section of the investment model for C:AVA2 Nigeria.

## Rationale and strategic approach for C:AVA2

In comparison to the other C:AVA countries Nigeria has the widest range and most-developed set of sub-sectors for cassava-based business opportunities. Following on from the market studies we have identified 35 SME and large-scale businesses who either work with C:AVA already or would be keen to become involved in C:AVA2 (see figure 2). These businesses cover a range of sub-sectors including HQCF/instant fufu, starch, industrial alcohol, aquaculture feed and biofuel. In addition there may be an opportunity to work with one or more of the major breweries on smallholder based procurement systems feeding into the production of clear beer. However, details and timescales for the big brewers' plans are not available so this area has been set aside and is not included in our plan for C:AVA2 in Nigeria.

Our primary objective is to increase the volume of cassava roots sold by smallholder farmers into the various cassava-based sub-sectors in Nigeria. This might be achieved by working with private sector players to encourage more smallholder inclusive raw material supply chains with more efficient and reliable production systems. There is also scope in some cases to work with processors to improve efficiency and cost effectiveness of processing and to work with end-users to make it easier and more attractive to use cassava-based materials in their products. In practice we plan to take a different approach for the SME partners and large-scale businesses. The sub-sectors for inclusion in C:AVA2 Nigeria and intended approach are summarised in table 4 and figure 1.

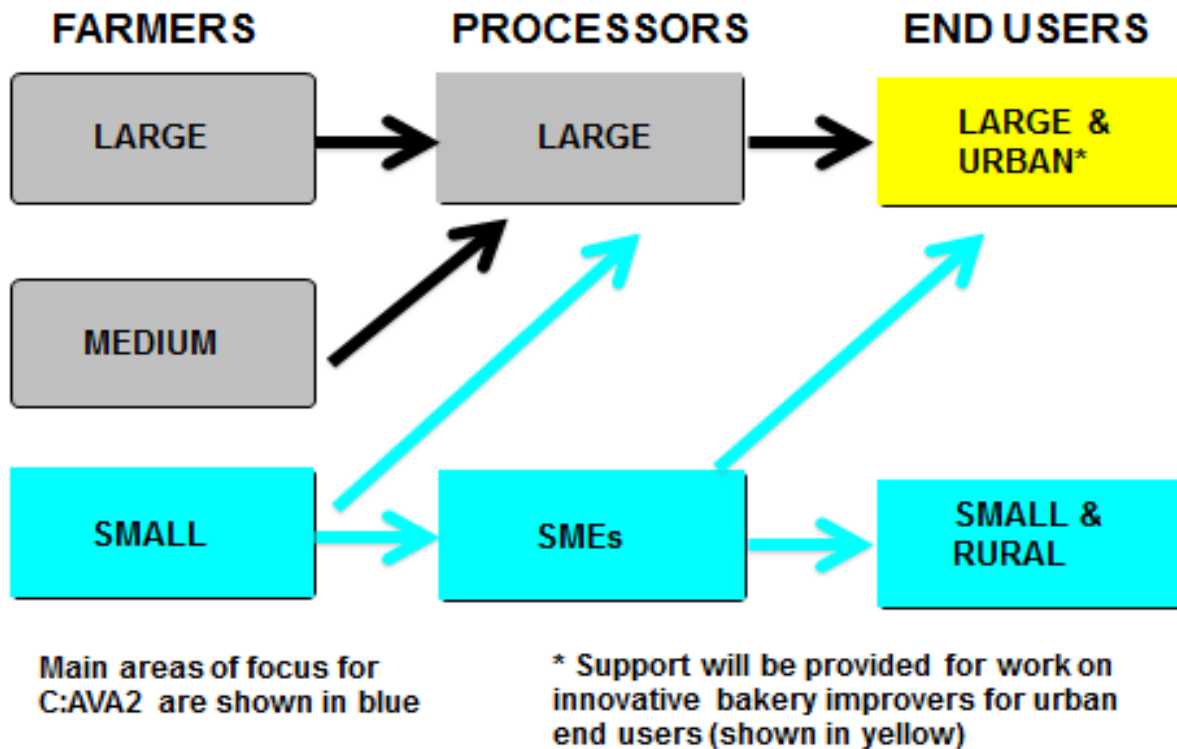
In the case of SME's we plan to support all parts of the value-chain namely raw material supply, processing and marketing & end-user support.

In the case of the large-scale processors we plan to focus effort on encouraging smallholder inclusive raw material supply systems. Our activities will not deal with the processors own operations or those of their customers in most circumstances. The only exception to this rule would be for end users of HQCF purchased from large-scale processors. We believe there is a valid case for supporting development and uptake of innovative bakery improvers for bread, biscuits and sausage rolls. Investment in this type of research requires larger commercial partners who have the facilities and capacity to help bring the research to the market. If successful these bakery improvers will become available to the smaller rural bakeries (as this is the obvious volume market with 470,000 bakeries nationally) who rely on HQCF SME's for their supplies and source 100% of their roots from smallholder farmers.

**Table 4** Summary of recommended sub-sectors for inclusion in C:AVA2 and intended approach for project support

<b>Whole chain support for SME processors</b>	<b>Support for smallholder inclusive raw material supplies for large-scale processors</b>
<ul style="list-style-type: none"><li>• HQCF</li><li>• Aquaculture feed</li><li>• Ethanol for home-cooking (biofuel)</li></ul>	<ul style="list-style-type: none"><li>• HQCF</li><li>• Starch</li><li>• Industrial alcohol</li></ul>

**Figure 1 Cassava-Based Value-Chains**



**SME production of HQCF, biofuel & aquaculture feed**

The Nigerian cassava-based SME’s are of particular interest partly because of larger numbers and wider geographical distribution (scattered distribution is an advantage for reaching the smaller rural bakeries that dominate Nigeria’s bread supplies) but also because they obtain 100% of their raw material supplies from smallholder farmers. However, these businesses have the lowest level of resources in terms of funds and capacity to innovate and improve their access to markets. For this reason we believe that there is justification for supporting all aspects of the SME value chains. This will include support for improvements to smallholder inclusive raw material supplies for all of the sub-sectors.

At the processing level support will be provided to enhance the efficiency and cost-effectiveness of processing technologies, quality assurance, production management and marketing. In the case of ethanol for home-cooking there is a strong case for supporting development of low-cost micro-scale anaerobic digesters for effluent treatment (this technology should also be of interest for Nigeria’s cassava starch industry). For aquaculture feed it will be necessary to support the development of appropriate small-scale pelletisation and extrusion technologies to enable cassava to be used in the

production of floating fish feed pellets. Currently two mills in Nigeria are producing non-floating pelletised feeds containing cassava but these pellets have limited appeal as the market demand is for floating pellets. To replace the imported floating pellets the mills will require a cost-effective small-scale extrusion cooking system (already available in South East Asia).

The final part of the SME value-chains will be end user support. To our understanding there is no need for C:AVA to become involved in clean cook stoves. However, there is a need to work with fish farmers to optimise formulation of cassava-based fish feeds and to work with small-scale rural & urban bakeries to enable them to use significant levels of HQCF in bread and other bakery products. The work with bakers is likely to involve continued support for the development and promotion of suitable bakery improvers and to provide training and mentoring support for bakers wishing to use HQCF in their products. We plan to continue the successful approach developed by C:AVA of working to link up small-scale bakers to an SME HQCF producer within a maximum of 1-2 hours' drive of their premises.

### **Large-scale production of HQCF, starch and industrial alcohol**

Nigeria is in the unique position among the C:AVA countries of having at least 5 successful large-scale investments in cassava processing facilities. In addition there is evidence of intent to invest in a second large-scale HQCF factory and a new starch/sugar syrup factory (both in Kwara State). It seems likely that these investments will be realised by mid- 2015 but they have not been included in the plan for C:AVA2 as there is nothing currently on the ground to work with.

The large-scale operators are well resourced both in terms of finances and personnel and there is no obvious case for C:AVA to work on processing at this level. There is also no case for working with end-users of starch or industrial alcohol as these firms are familiar with the cassava-based raw materials that go into their products. The only exceptions are the large-scale bakers, biscuit factories, sausage roll makers and the paperboard industry. There is a case with these end users to support trials with enhanced bakery improvers to enable HQCF to be used in bread, biscuits and sausage rolls. For the paperboard industry there is scope to help factories to develop HQCF or cassava-starch based paperboard glues. Without support from C:AVA on bakery improvers it seems very unlikely that HQCF will be used widely in bakery products. The outcome of this would be an unnecessary restriction to market demand for HQCF and consequent limiting of demand for cassava roots from smallholder farmers.

The major area to focus on for all of the large-scale producers is smallholder inclusive raw material supply. Unlike the SME's the large operators have access to larger commercial farms. Presently all of the larger businesses rely on smallholders for between 10 and 70% of their root supply. However, root procurement has often been badly organised and smallholder production is not being optimised. This has resulted in frustration for both farmers and processors resulting in a tendency for the big operators to think of alternative procurement strategies that minimise reliance on smallholders. We believe that smallholders can continue to play a significant role in supplying the large-scale processing industries typically accounting for at least 20% of supply with potential for much higher levels of supply in some-

cases. Following a meeting organised by C:AVA in May 2013 agreement was reached with the major processing industries to explore ways to support smallholder inclusive raw material supplies. C:AVA activities might include supporting development of systems for bulking of root supplies via collection centres and introduction of good agricultural practice (GAP) systems to improve yields and efficiency of land utilisation with training programmes for extension staff (private & public sector inclusive).

In every case the bulk of the investment will come from the private sector partner as the owner of the raw material procurement system. C:AVA's role will be to support the process with technical inputs and training deriving from our extensive experience of cassava in many countries around the world. At farm level we would work with smallholder farmers & extension officers to ensure supplies of clean planting material, and training on good agricultural practices to maximise returns from the land. We might have demonstration and multiplication plots linked to the rural collection centres. In the area of training we will seek to transfer farmer to farmer type peer group training techniques which have proved highly successful in other commercial systems involving smallholder farmers. Much of the training will actually be trainer of trainer courses to increase the capacity of commercial and government extension staff and leading farmers to provide appropriate advice and training to their peers.

We believe support for smallholder inclusive raw material supplies for large-scale processors should be a key component of C:AVA2 as these businesses deal with the largest volumes of roots and therefore have the most potential for involvement of a high number of smallholder farmers. To put it in context 20% smallholder inclusion for a large business will involve larger numbers than 100% from several SME processors. The large-scale commercial businesses are driving investment in cassava-based value chains. It would be fair to say that the continued operation and expansion of Thai Farms International's (TFI) large HQCF factory coupled with Flour Mills of Nigeria's investments in TFI has done much to restore market confidence in the future for HQCF in Nigeria. Increased market confidence in HQCF has been reflected by increased demand for HQCF from the SME processors as TFI cannot meet the total market requirement.

### **The role of C:AVA & C:AVA2 in advocacy**

Cassava is a highly important crop for Nigeria and long been part of the political agenda with several governments giving special focus to development of policies and initiatives designed to promote cassava-based products. All of these efforts have been well intentioned with the primary objective of enhancing the livelihood of the rural poor and reducing reliance on imported commodities such as wheat. Sadly as with any top-down approach there have been many mistakes made, outcomes have often not met expectations and some of the efforts have not proved sustainable.

One of the key successes of the current C:AVA team in Nigeria has been to bring an independent and objective voice of reason to the debate. The C:AVA Country Manager for Nigeria has made valuable contributions to the design of major initiatives such as the Federal Governments Cassava Transformation Agenda Project (CTAP). During the implementation of CTAP the C:AVA Nigeria team have provided help and advice on the best approach for rehabilitation of Nigeria's HQCF SME processors

and ways to encourage adoption of HQCF by rural bakers to name but two of their inputs. In a recent meeting of private sector players organised by C:AVA, one of the major cassava-based businesses complemented the work of the C:AVA team on policy guidance stating that he believed that C:AVA's inputs has bought balance and helped to avoid potentially serious negative economic implications from poorly advised policy decisions.

C:AVA has always take an integrated approach working closely with the partners in the HQCF value chains. For C:AVA2 we wish to widen and strengthen the role of private sector players in C:AVA's advocacy work. Rather than waiting for the new project a decision was made to bring together as many representatives of those involved in cassava-value chains as possible to discuss key issues and make inputs into the design of C:AVA2 in Nigeria. (table 5)

The meeting which was convened on 4<sup>th</sup> June 2013 was given the title Cassava Users Forum (CUF) to distinguish it from the more usual workshops. With the exception of FUNAAB and NRI all of the participants were from the private sector.

**Table 5** Summary of participation in the first meeting of the Cassava Users Forum

<b>SME Businesses</b>	<b>Large-scale Businesses</b>
<ul style="list-style-type: none"> <li>• HQCF processors (4)</li> <li>• Dry chip processor (1)</li> <li>• Ethanol for home-cooking (1)</li> <li>• Aquaculture feed mills (3)</li> <li>• Rural bakeries (4)</li> </ul>	<ul style="list-style-type: none"> <li>• HQCF processor (1)</li> <li>• Industrial alcohol processor (1)</li> <li>• Starch processor (3)</li> <li>• Wheat flour mills (2)</li> <li>• Urban bakeries (3)</li> <li>• Starch user –food applications (1)</li> <li>• Sausage roll makers (2)</li> <li>• Biscuit makers (2)</li> <li>• Breweries (2)</li> <li>• Paperboard packaging (1)</li> </ul>

At the CUF a summary of the C:AVA Nigeria market studies was presented and discussions were initiated as to the priority needs and best approach for development and delivery of C:AVA2. Discussions focused around problems and issues associated with raw material supply accounted for virtually 90% of the discussion section of the meeting. It was clear that all scales of processor rely heavily on smallholder farmers for root supplies. Inefficiencies in the current system revolving mostly on absence of good agricultural practices resulted in supplies not meeting expectations. Some companies face serious problems with management of procurement. It was clear that smallholder inclusive raw material supply should be a key component of C:AVA2. It was also clear that much scope exists for sharing experiences of successful approaches to smallholder procurement schemes operated by commercial fruit and vegetable growers in other parts of Africa.

The other major issue raised by participants at the CUF was advocacy, many companies criticised government efforts to force adoption of HQCF via increased duties and taxes as counter-productive. All agreed that efforts being made by some NGO's to fix an artificially high price for cassava (possibly via government subsidy) was misguided and unsustainable.







The participants concluded that there was a real need to make the Cassava Users Form (CUF) a formal part of C:AVA2 to create a common platform for presentation of industry concerns on key non-competitive issues and also as a way to collect some of the M&E data to guide the project management team on progress and allow for optimisation of project delivery. Participants suggested that members of the forum be selected from each of the sub-sectors to collect this information. Basic data would be provided electronically on a monthly basis and former formal quarter reports would be prepared on a quarterly based to feed into the project reporting basis of C:AVA2.

With this in mind we recommend inclusion of the Cassava Users Forum as part of C:AVA2 with meetings every 6 months and electronic contact with the Country Manager for Nigeria on emerging issues of concern for the cassava-based industries. We feel that a possible way to collect the M&E data and "stories" of project outcomes might be to select persons from each of the sub-sectors and commission them for 1 day per month to collect and present this data to the C:AVA Nigeria team.

## **Geographic distribution of C:AVA2**

The key factor for C:AVA2 in Nigeria is to adopt an integrated value-chain approach working closely with existing value-chains to increase smallholder involvement in raw material supply and enhance output via support for SME processors and end-users of cassava-based products where appropriate. On this basis it is clear that the geography of C:AVA2 will be determined by the locations of the potential private sector partners. Figure 2 provides a summary of the types of sub-sectors and proposed locations for C:AVA2.



Key to figure 2 Locations of private sector partners for C:AVA2						
State	HQCF SME 	Ethanol SME 	Aqua-Feed SME 	HQCF LS 	StarchLS 	Ethanol LS 
Ogun	8			1	2	1
Kwara	2		1			
Edo	3					
Delta	3					
Ondo	3				1	
Lagos	3	1				
Oyo	1	1				
Nasarawa	2					
Ekiti	1					
Abia	1					
<b>TOTAL</b>	<b>27</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>

A look at figure 2 shows that the majority of the potential private sector partners for C:AVA2 are located in South Western Nigeria with the biggest focus being in Ogun State with 8 HQCF SME's, 1 large-scale HQCF factory, 2 large-scale starch factories and one large-scale distiller of industrial alcohol. The neighbouring states of Lagos, Ondo, Oyo and Edo account for most of the other SME locations. This distribution justifies the location of the main C:AVA2 office with much of the resources and personnel at Abeokuta in Ogun State.

The other area of interest is North Central where there are 2 HQCF SME's and one aquaculture feed mill in Kwara State and 2 HQCF SME's in Nasarawa State. Kwara and Nasarawa States are also important sources of fresh cassava roots with farmers from these states supplying some of the large-scale processing operations in Ogun and Ondo States. The aquaculture feed mill is of particular interest as this mill is already using cassava in their feed formulations, is well connected with an expanding aquaculture sector that currently relies on imported feeds and also because this sub-sector offers an opportunity for involvement of a larger number of much smaller-scale farmers producing sun-dried cassava chips. We are also aware of plans for two large-scale private sector investments in cassava-based industries in Kwara State that could be operational by mid 2015. In our tentative budget for

C:AVA2 we have made provision for a regional office in the North Central region of Nigeria most probably in Kwara State.

## Overall business case

### Basic assumptions

The overall business case focuses on three distinct market sub-sectors, namely High Quality Cassava Flour (HQCF) for the large-scale users in the urban centres, HQCF for rural markets, dried chips for the aquaculture market, ethanol production for industrial & home-cooking applications and native starch production. The HQCF for the urban market will be produced by factories such as Thai Farm International (TFI); the HQCF rural market will be supplied by SME flash dryer factories; the starch market will be supplied by medium to large-scale factories (Matna, Green-Tech & Psaltry International); the industrial ethanol by a large-scale distillery (Allied Atlantic Distilleries Ltd (AADL) and the chips for the aquaculture market will come from sun-drying operations feeding into one or more aquaculture feed mills (Ideal Feed Mill will be the first mill involved in C:AVA2). Initial support for ethanol for home-cooking will focus on the Project GAIA/NABDA site at Obamoshu in Oyo State. However, we will also look at privately owned pilot distillery close to Lagos to assess potential for wider uptake of this lower cost technology possibly via existing HQCF SME sites.

The model assumes three basic farm sizes for producing fresh cassava roots for processing, ie, smallholder production (1ha of cassava)<sup>1</sup>, medium-scale farms (5ha) and large-scale commercial units (1,000ha). One of the recurring themes of interviews with the cassava processors has been the difficulties with trying to get reliable supplies of roots from small farmers; companies that have established contracts with them were supplied when the contract price was higher than the market price, when the situation was reversed, they had difficulties in getting sufficient roots to keep their factories operational. The 5ha model farm was chosen because some of the large-scale processors are hoping to establish outgrower schemes adjacent to their large scale commercial farms and the Cassava Transformation Agenda Programme (CTAP) also has aims to establish small-scale commercial cassava production units of about this size. It is also assumed that all the processors buy fresh cassava roots direct from farmers; in Nigeria there are virtually no efforts to make wet mash for supplying processors.

It is also assumed that the processors will buy different proportions from different size farms according to their business requirements. One of the objectives of C:AVA2 will be to support their efforts to buy from small-farmers so that a higher proportion comes from smallholders than if the project was not implemented.

Two basic models have been developed. The first calculates the number of beneficiaries and the amount of money that is returned to the beneficiaries. This includes the margin that the small and medium-sized farmers make and the employment generated in the factories. The margin made by the

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<sup>1</sup> It is assumed that the small-farmers supplying the roots for grit production for the aquaculture market will come from smaller farms with an average size of 0.5ha.

large-scale commercial farms is not included, but the wages earned by their workers is counted. The second model estimates the cost of establishing C:AVA2 in Nigeria to meet these targets.

In line with the other C:AVA countries, the analysis of benefits is made for three years; 2016, 2019 and 2024.

### Target market segments

Five market segments have been chosen and realistic targets have been set for the three years (Table 6). The HQCF urban market includes snack food companies who make, for example sausage rolls, biscuit companies and some large-scale bakeries. All these businesses are looking to buy HQCF to partially substitute wheat flour to reduce their costs. It is assumed that 36,000t will be supplied to this market – which is well below their potential demand. Large-scale producers of HQCF, like TFI, will supply this market. In fact, it is assumed that when TFI gets its raw material supply more reliably established, it will be able to achieve approaching 18,000t/year of HQCF. It is anticipated that Flour Mills of Nigeria, the majority shareholders in TFI, will probably establish a second large-scale HQCF factory during the life of C:AVA2.

**Table 6** Market target for each of the segments, 2016 to 2024

<b>Market targets (t/year)</b>	<b>2016</b>	<b>2019</b>	<b>2024</b>
<b>HQCF - urban</b>	18,000	36,000	36,000
<b>HQCF - Rural</b>	11,000	17,600	35,200
<b>Aquaculture</b>	2,000	23,000	35,000
<b>Starch</b>	12,000	30,000	60,000
<b>Ethanol (thousand l/yr)</b>	7,000	20,000	40,000

During the Obasanjo era, a considerable number of flash dryers were established, but only 27 of these are still operational. Most are still inefficient although 10 have been upgraded to international standards in terms of output & cost energy efficiency under C:AVA. The Nigerian flash dryers will always find it difficult to compete in the urban HQCF market with the larger processors because they are less efficient at converting roots into HQCF (due to a different type of technology which is not replicable at small-scale). Flash dryers needed about 4t of roots to make a ton of HQCF, whilst larger processors use about 3.7t and the larger factory is able to achieve economies of scale and have a reputation for producing better and more consistent quality. However, the first C:AVA project made good progress at identifying higher priced rural markets which are nearer to the flash dryer factories so therefore transport costs to their customers are less. The C:AVA project has therefore adopted a policy of helping the flash dryer owners identify nearby buyers coupled with reducing their drying costs and providing

quality training to support. It is assumed that by 2016, 25 flash dryers will be operating efficiently and by 2019, this will rise to 40. If these dryers operate profitably, it can be assumed that further investment in new dryers will occur and the number would double to 80 by 2024.

The opportunity for using cassava chips for livestock was evaluated during the market study. This concluded that the opportunity for animal feed was limited but there was an interesting opportunity for use as a fish feed. This market might be smaller, but an opportunity for 23,000t/year was identified; and given the rapid increase in demand for fish, it was assumed that this could double by 2024. This is only a viable opportunity if the chips are sun dried; unlike the HQCF, it is assumed that the chips are not peeled. Therefore, the production of chips would take place in the North Central region of Nigeria where there are much longer rain-free periods. One of the advantages of supporting the dried chips for the aquaculture industry is that if the relative prices of maize, cassava and protein change, such that the use of cassava chips in livestock feed becomes profitable, then C:AVA2 could easily expand dried chip production to cover this opportunity.

Currently there are four operational starch factories in Nigeria, Matna Starch, Nigerian Starch Mills, Green-Tech and Psaltry International. These factories are believed to have a capacity to produce around 25,000t to 30,000t of starch per year. Three of these factories have had serious difficulties obtaining sufficient cassava roots to achieve anything like their full capacity. It is estimated that the shortage of roots and possibly other issues has resulted in the current level of starch production being constrained to about 8,000t/year. However, if the root supply issues can be successfully addressed, then there is a good chance that their output will expand. Targets used in the projections are for a modest increase to 10-12,000t by 2016, and then as supply issues become sorted, this will rise to 30,000t by 2019. In addition, it is reported that there are at least two **possible** investments in new and probably much larger factories in Kwara and Kogi states. Given the length of time needed to establish the viability of such new ventures and obtain land and permissions needed to establish new large factories, it is assumed that even if these investments are made, they will probably not be operating at full capacity before 2019, but may well be operating by 2024.

The final major segment to be supported is ethanol for industrial use. One factory is already established, ie AADL. This factory only started production towards the end of 2012 and has the capacity to produce 20 million litres per year. So far it is operating at well below full capacity because of root supply problems despite spending five years before the factory started operations trying to establish contract farming operations. Most of the ethanol produced by AADL will be purchased by a sister company, so there is not a marketing issue for them. The market projections assume C:AVA2 will help AADL will solve their root supply issues and it will be operating at full capacity by 2019 and that an investment in another factory will be made before 2024. However, because of root supply problems, AADL are negotiating to lease large tracts of land to grow some of their own roots or will look to have contracts with large commercial farms to supply a significant portion of their requirements.

The market prices assumed in the business plan are based on data collected during the market research (Table 7). Two different prices are assumed for the two different HQCF markets; N90,000 and

N100,000/t. The price paid for the dried chips to produce feed for the aquaculture market is N50,000/t. It is assumed that the starch factories will sell native starch for N150,000/t and the ethanol will be sold for N200,000/thousand litres.

**Table 7** Target prices for processed cassava products

Price	US\$/Mt	N/Mt
HQCF - urban	581	90,000
HQCF - Rural	645	100,000
Aquaculture	323	50,000
Starch	968	150,000
Ethanol (thousand l/yr)	1,290	200,000

#### Tonnage of roots needed

In order to achieve the market targets discussed above, it would require about a quarter of a million tonnes of fresh cassava in 2016, rising to just over half a million tonnes in 2019 and almost one million tonnes by 2024 (Table 8). In the early years of C:AVA2, the HQCF markets would be the biggest opportunities for fresh cassava roots; probably a reflection of the success of C:AVA. Then starch and ethanol become more important; which is probably a reflection that these industries are potentially more profitable.

**Table 8** Tonnage of roots required to meet market targets

Cassava roots required	FCR ratio	2016	2019	2024
HQCF - urban	3.7	66,600	133,200	133,200
HQCF - Rural	4	44,000	70,400	140,800
Aquaculture	2.5	5,000	57,500	87,500
Starch	5	60,000	150,000	300,000
Ethanol (thousand l/yr)	6.5	45,500	130,000	260,000
<b>Total</b>		<b>223,116</b>	<b>543,119</b>	<b>923,524</b>

## Farm models assumed for cassava production

It is often reported that the yields of cassava grown in Nigeria are low compared with, for example, Thailand. In the models it is assumed that small-farmer yields are slightly above the national average at 13t/ha, the 5ha farmers have more management skills and get yields of 18t/ha whilst the commercial farmers get 35t/ha (Table 9). To achieve the higher yields, the medium and commercial scale farmers will use more inputs, eg fertiliser, agrochemicals and mechanisation, and consequently their costs will be greater. What is interesting is that the costs per tonne are reasonably similar at between US\$30 to 33/t; and the margins are similar. However, when compared on an area basis, the medium and, especially the large commercial farmers have better returns because of their much higher yields. The net income per farmer is much greater for the larger farming units than the small-farmers. In reality, their profits will not be as high as stated because the model does not make allowances for management costs. The model also assumes that the transport costs from farm-gate to factory are the same for all farm sizes. If the smaller-farmers are a significant distance from the factory, they will sometimes have to pay for aggregating their roots with other farmers. However, this will be one of the challenges for C:AVA2 to design effective solutions to reduce the cost of aggregation and transport to the processing factories.

**Table 9** Costs, yields and margins for different production systems

	Farm size (ha)	Yield (t/ha)	Root costs (\$/t)	Margin (\$/t)	Net income (per ha)	Annual income (\$/year)
<b>Small-scale farmers</b>	1	13	33	32	473	473
<b>Medium-scale farmer/outgrower</b>	5	18	36	29	516	2,581
<b>Commercial farmer</b>	1,000	35	30	34	1,198	1,198,226

All three farming models make use of casual labour. It is assumed that the small-farmers hire in 60 labour days/ha to supplement family labour, medium scale-farmers 80 labour days/ha because they get higher yields<sup>2</sup> whilst the commercial farmers are only 25 labour days per ha because they make much more use of mechanisation. All these casual and full-time labourers are counted as beneficiaries. It should be noted, the production model to supply the sun-drying factories in the aquaculture value-chain

<sup>2</sup> Also, they have less family labour per ha.

assumes that the average farm size is only 0.5ha and therefore all the farm work is undertaken by family labour.

In addition to the farm workers, the factory employees are also beneficiaries. In the case of HQCF made by the flash dryers, there are workers who manually peel the roots; in all the other processes, the roots are not hand-peeled. Not surprisingly, the larger-scale factories use less labour per ton of cassava processed than the flash and sun drying operations (Table 10).

**Table 10** Labour employed by different processes

<b>Process</b>	<b>FCR per day (t/day)</b>	<b>Shifts/day</b>	<b>Factory labour No. per day</b>	<b>Factory labour (t/person day)</b>
<b>HQCF - urban</b>	333	3	117	2.85
<b>HQCF - Rural, general</b>	8	1	9	0.89
<b>HQCF - Rural, peelers</b>	8	1	16	0.50
<b>Aquaculture</b>	10	1	14	0.71
<b>Starch</b>	180	3	87	2.07
<b>Ethanol (thousand l/yr)</b>	243	3	102	2.38

#### **Total number of beneficiaries and returns**

If the market targets are achieved, it is expected that by the end of the project C:AVA2 will benefit a minimum of ~ 40,000 small-farmers, farm and factory workers. Each will benefit by almost US\$600/year (or about US\$2.6/day). It is interesting to note that in 2016 the rural HQCF and starch value chains produce the most beneficiaries (Table 11); this is probably a reflection of the fact that the value chains are already working and because most of the roots are supplied by small-farmers. Even though more HQCF is produced for the urban than the rural market, it has fewer beneficiaries because it has to procure a significant portion of its raw material supply from highly mechanised commercial farmers. However, as the aquaculture and ethanol value chains develop, they also become more interesting. It is projected that by the end of C:AVA2, the total benefits will be just over US\$23 million/year.

**Table 11** Total number of beneficiaries and returns to beneficiaries

	Year	2016	2019	2024
<b>Total No. Beneficiaries</b>				
HQCF – urban		1,948	4,378	4,859
HQCF – Rural		5,185	8,296	16,592
Aquaculture		853	9,810	14,928
Starch		4,598	10,954	20,822
Ethanol (thousand l/yr)		1,987	6,326	13,951
<b>Total</b>		<b>14,571</b>	<b>39,763</b>	<b>71,153</b>
<b>Total return to beneficiaries (\$)</b>				
HQCF – urban		2,251,042	4,582,677	4,663,270
HQCF – Rural		3,213,509	5,141,615	10,283,230
Aquaculture		247,355	2,844,581	4,328,710
Starch		3,452,801	8,541,245	16,900,975
Ethanol (thousand l/yr)		1,719,046	2,220,586	4,930,673
<b>Total</b>		<b>10,883,754</b>	<b>23,330,704</b>	<b>41,106,858</b>
<b>Average return per beneficiary</b>				
HQCF – urban		1,156	1,047	960
HQCF – Rural		620	620	620
Aquaculture		290	290	290
Starch		751	780	812
Ethanol (thousand l/yr)		865	351	353
<b>Average</b>		<b>747</b>	<b>587</b>	<b>578</b>

## Project costs

An estimated budget (Table 12) was developed to deliver the beneficiary figures described in the previous section. The budget was for the costs that would need to be spent by the Nigerian project staff; it does not include the overhead for the Project Directors office. The total cost is estimated to be US\$8.34 million over the five years. The biggest cost items are for the overheads that cover management and staff costs as well as office and management support (mainly per diems) and local and international consultants. In total, about US\$2.2 million is allocated to support field activities. More detail cost breakdowns are given in a spreadsheet(available electronically from the C:AVA Nigeria markets team).

**Table 12** Estimated project costs

Year	2014/5	2015/6	2016/7	2017/8	2018/9	Total
<b>Overheads</b>						
Management & staff costs	447,500	477,500	477,500	477,500	477,500	2,357,500
Office & management support	205,400	207,300	204,800	207,300	207,300	1,032,100
Consultants, staff training	460,375	474,375	336,875	336,875	336,875	1,945,375
Vehicle running costs	45,500	45,500	45,500	45,500	45,500	227,500
<b>Capital costs</b>						
	312,500	110,000	115,000	50,000	35,000	622,500
<b>Activities</b>						
Support to raw material supply	149,000	168,500	150,500	162,500	162,500	793,000
Support to value chains	235,000	225,000	171,000	127,000	127,000	885,000
Advocacy	101,500	94,000	94,000	94,000	94,000	477,500
<b>Total</b>	1,956,775	1,802,175	1,595,175	1,500,675	1,485,675	8,340,475

The proposed staffing structure is to have a full time country manager (UA\$100,000/year) and two senior executives to head the Raw Material Supply (RMS) and Value Chain departments (US\$55,000/year each). Both these executives will have two or three officers reporting to them to help carry out the project activities (US\$30,000/year each). In addition to giving the Nigerian part of C:AVA2 direction and management, it is assumed that the country manager will oversee a range of advocacy activities. In addition to these positions, the staffing will be completed by an accountant (US\$60,000/year), a secretary (US\$17,500/year) and a payment to FUNAAB to cover administrative functions such as drivers etc (US\$40,000/year).

It is assumed that office space will be rented from FUNAAB and allowances have been made for electricity, insurance, telecommunications and office consumables. It is assumed that there might be two regional officer for two of the RMS officers will be based; the exact location of these offices will probably be where some of the processors want to obtain their raw material supplies (possibly either

Kwara or Kogi) and the main location for producing sun dried chips for the aquaculture value chain (probably in the Central region, eg Nassarawa). US\$76,500 has been allowed to cover local and international air travel as well as per diems. It is assumed that the project will need to hire local and international consultants to support their efforts. Over the five years US\$ 1.2 million has been allocated for international consultants<sup>3</sup>; it is assumed that most of this will be for NRI staff to provide technical and M&E support. However, some would be used for non-NRI staff. There would be an increasing use of local consultants and over the five years a budget of US\$500,000 has been allocated for this.

The allocation for capital costs includes staff vehicles, motor bikes for the officers, office and telecommunication equipment. An allowance for running and maintaining the vehicles and equipment has been allocated to the overheads.

A significant amount of the budget has been allocated to the main activities of the project. The budget for the RMS department (US\$790,000 over five years) covers providing support and training for private sector extension services, undertaking on-farm agronomic trials to demonstrate best practices, holding of field days, establish rural buying centres, collect, disseminate best practices for inclusive agri-business (eg contract farming) and working with other donor projects to involve them in encouraging processors to buy more roots from small-farmers (for example working with the USAID Markets project, IFAD etc).

The budget for the Value Chain Department (US\$885,000 over the five years) covers the marketing training for the SMEs, training for the rural bakeries linked to flash driers, quality training and establishment of laboratories to undertake quality analysis. The budget would also cover some development work on instant fufu, small-scale production of ethanol to be used for home consumption, work with the paperboard industry as well as the development of new products and technologies.

Almost US\$500,000 has been allocated for advocacy work. At the private sector Cassava Users Forum organised by C:AVA in June 2013, one of the clear recommendations was that C:AVA2 should maintain and expand on C:AVA's work on representing the entire HQCF industry. Therefore, a budget has been allocated to facilitate this. Activities could include holding regular cassava users fora to gain a consensus of the industries issues, establish a network of industry informants to provide regular updates of what is happening in each of the cassava market segments<sup>4</sup>. There is also an allocation for stakeholders meetings and general communications.

### **Cost benefit**

The proposed budget of US\$8.34 million over five years would generate net income to the beneficiaries of almost US\$11 million in the second year of the project and US\$23.3 in the fifth year. This is obviously a good return for the investment.

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<sup>3</sup> The budget for international consultants is an "all in" cost and would therefore include airfares, per diems etc.

<sup>4</sup> This industry network could provide very valuable key information to any project supervision missions.

In terms of beneficiaries, in the final year of the project, the total number of beneficiaries would be almost 40,000; therefore the project investment would average at about US\$200/beneficiary over the entirety of the project and they would benefit by almost US\$600 per year.

### **Individual business, developmental & environmental cases**

The following sections provide more details on the business, developmental and environmental cases for the sub-sectors recommended for inclusion under C:AVA2. It is not the intention to repeat details already covered in the market study report (Graffham *et al* 2013) but rather to provide the rationale and supporting information for each sub-sector. The sub-sectors for starch, industrial alcohol and large-scale HQCF production are grouped together as these three all focus on the common issue of support for smallholder inclusive raw material supply. The rural (SME) HQCF and aquaculture sub-sectors have their own sections. The section for ethanol in home-cooking is rather more detailed than the rest as this sub-sector was not as well characterised at the time of the market studies.

### **Smallholder inclusive raw material supply to large-scale industries**

#### **Introduction**

Nigeria is unique among the C:AVA countries in having a developed and functional cassava-based products industry consisting of 1 large-scale HQCF factory, 4 large-scale starch factories (one of these is Nigerian Starch Mills in Anambra State which is outside the geographical focus for C:AVA2) and 1 large-scale producer of industrial alcohol. If they were operating at capacity the HQCF factory, 3 starch mills (within the project area) and 1 producer of industrial alcohol would produce 18,000 tons of HQCF, 20 million litres of industrial alcohol and 25,000 tons of starch per annum. This output would require 337,850 tons of fresh cassava roots per year. If 100% of the cassava root requirement was met by smallholders this would involve at least 28,500 smallholders.

However, the reality is quite different, as of July 2013, the large-scale industries are producing approximately 12,000 tons of HQCF per annum, 8,000 tons of starch and 5 million litres of industrial alcohol. In theory this output could be supporting the livelihoods of 10,500 smallholders but this is not the case. In practice from discussions with the various companies that they source roots from ~1,250 smallholder farmers with the balance of raw material supply coming from medium and large-scale growers. One of the companies relies on smallholders for 100% of their root supplies but the others source anything from 5 to 40% of their roots from smallholder farmers. All of these companies have to rely on smallholders to some extent and most started with ambitious plans for smallholder inclusive raw material supply systems. Unfortunately the companies' experiences have been very mixed and most would give up on smallholders if sufficient supplies could be guaranteed from larger farms.

Following on from detailed discussions of smallholder procurement systems with several of the companies and a visit to the field operations of one of the most active companies (in terms of smallholder procurement) the C:AVA team came to the conclusion that most of the present difficulties with smallholder procurement could be sorted out by adopting adapted versions of some of the

practices that have been used successfully in Africa for procurement of fruits and vegetables from smallholder out-growers for high-value export markets. All of the prospective large-scale partners have shown strong interest in partnering with C:AVA2 to try and not only retain but increase the percentage of roots that they source from smallholders.

### **Developmental & Environmental case**

The developmental case for working with large-scale cassava processing industries centres around the potential to link relatively large numbers of smallholder farmers to much larger players who have the resources to drive the development and expansion of Nigeria's cassava-based industries. To ignore these players risks marginalising the smallholder farmers into only supply SME businesses which cannot in themselves ensure the future of any of the sub-sectors.

We believe that by supporting smallholder inclusive raw material supply systems operated by the larger processors we can dramatically increase smallholder involvement in the supply of cassava roots. Based on our discussions with the potential private sector partners we developed our model which predicts that by 2016 smallholder involvement will have increased from its present level to ~8,550 smallholders, by 2019 we envisage 21,660 smallholders will be involved in delivering roots to large-scale processors. Under current conditions of low efficiency on farm the net income benefit per smallholder will be US\$473 per annum. However, part of our programme will involve supporting the introduction and promotion of good agricultural practices to increase efficiency of the farms and improve yields per unit area of land planted with cassava.

The environmental impacts of these larger industries could be considered to be outside the remit of C:AVA2 as the companies are well resourced and should take responsibility for their actions. In practice we are satisfied that the industrial alcohol and HQCF factories have put in place ample measures to cope with liquid effluents. Some of the starch factories have also introduced appropriate treatment systems. However, in cases where effluent treatment is insufficient C:AVA2 could offer access to expert advice provided by personnel employed to ensure proper treatment systems are introduced for the micro-distilleries supplying the ethanol for home-cooking sub-sector.

### **Business case**

All of the prospective partners in C:AVA2 have been in operation for between 2 and 10 years. In our model we calculate conservatively that the profit margins for large-scale HQCF, starch and industrial alcohol are US\$110, US\$122 and US\$360 respectively given current market prices for these products and a cassava root price of US\$65 per ton. Sensitivity analysis for each of these sub-sectors indicates that all of these sub-sectors are sufficiently robust to remain profitable in even the most extreme circumstances encountered to date in Nigeria.

### **Entry point for C:AVA2**

The main entry point for C:AVA2 is to provide support to the companies and smallholders farmers to improve the management of smallholder procurement systems, including good agricultural practices on farm, input supplies, buying centres, relationship farming techniques and improved systems for

knowledge transfer such as peer group training techniques. It is not our intention to purchase capital items such as tractors, build buying centres or provide subsidised farm inputs.

In the case of HQCF we also intend to work with a major producer of innovative bakery improvers, major producers of bakery products, flour mills and the large processor HQCF to complete development and introduction of novel bakery improvers that will enable high levels of HQCF to be used in bakery products. This work will have an initial focus among the large industries as they have the resources and capacity to support the research and development work. However, it should be understood that the major market for the improvers will be the rural bakers supplied by the HQCF SME's. We believe that it will be in the interest of those developing the bakery improvers to ensure that affordable solutions are developed for this market.

## HQCF SME's

### Introduction

High Quality Cassava Flour (HQCF) has long been attractive as a possible partial substitute for wheat flour with potential to reduce Nigeria's reliance on imported wheat flour. During the Obasonjo era which ended in mid-2007 a strong government push for 10% inclusion of HQCF in bread flour coupled with the development of small-scale flash drying units (capable of producing 1-2 tons of flour per day) in Nigeria led to the establishment of an extensive SME based HQCF industry. In 2007 there were 157 SME HQCF factories in operation but this dropped off rapidly with the change of government in 2008 and by 2013 only 27 factories were still operational. Research by C:AVA showed that none of the flash dryers used by the SME's were cost effective and 123 of the 157 factories were equipped with a very poor quality system with an operating efficiency of just 11% (as compared to 50% internationally). The costs of drying with diesel were US\$374/ton making the SME HQCF factories non-viable (production costs had risen to US\$721/ton as compared to a maximum price for HQCF of between US\$533-US\$645 dependent on market).

Under the C:AVA project, an UK engineering team from NRI has worked closely with a Nigerian engineer and fabricator (Nobex Ltd) to develop two solutions to the efficiency problem for the SME HQCF industry. One solution has been to develop a new 6 cyclone flash dryer with an operating efficiency of 50%. The Nobex 6 cyclone flash dryer increases output from 2 to 3 tons per day and reduces drying costs using kerosene down to US\$30/ton of HQCF (as compared to US\$318/ton for the old single cyclone models). The new Nobex 6 cyclone flash dryer has been purchased by three of the SME's at a cost of US\$45,000 per unit. However, this price has proved too costly for the majority of the 27 surviving companies. This resulted in the need for an alternative and cheaper solution. Initially the C:AVA team worked to upgrade the efficiency of the old single cyclone flash dryers but the improvements were not sufficient to be economically viable. Starting in mid-2012 we focused attention on the development of a new and highly efficient heat exchanger capable of using solid fuel wastes such as palm kernel shells, cashew shells, wood chips or even maize husks as a fuel source.

The new heat exchanger has been supplied to ten of the surviving SME's (at a cost of US\$7,000 per unit) so far with most choosing to use either cashew shell or palm kernel shells. Using palm kernel shells drying costs have been reduced to US\$50/ton but with cashew shells drying costs range from US\$8 to US\$14/ton due to the low cost of cashew shell waste which has no alternative use. Work on an upgrade fuelled with wood chips from a local saw-mill is still on-going and cost data was not available at the time of writing (end July 2013). The success of the first ten upgrades has resulted in requests from 15 more SME HQCF companies for installation of a Nobex solid fuel heat exchanger upgrade.

### **Developmental and environmental case**

A look at figure 1 shows that one of the advantages of the SME HQCF operators is their geographical distribution with the 27 operational units covering 10 different states. In every case the SME companies rely 100% on smallholder farmers for their raw material supplies and also generate local employment in rural areas including casual jobs for 10-30 women per day working as root peelers. If these factories worked at capacity they could produce nearly 13,000 tons of HQCF per annum with a requirement for 51,000 tons of fresh cassava roots. This would support the livelihoods of at least 4,250 smallholder farmers. However, outputs have been restricted by an inappropriate approach to marketing of the HQCF and lack of demand from the bakery sector until quite recently.

The C:AVA team discovered that the HQCF SME's were focusing on attempting to supply large volumes of product to the large flour mills in Lagos. This market had the most potential in terms of volume but prices were too low to compensate for the high transport costs from the more distant HQCF factories. In addition there was little real interest from most of the mills to purchase HQCF sales were not regular or reliable. In March 2013 an analysis of an SME in Ekiti State showed that his maximum margin on HQCF sold to mills in Lagos (12 hours drive away) was US\$26/ton. Given that raw material supply accounts for 65% of production costs for SME HQCF in Nigeria he was extremely vulnerable to root price sensitivities). The lack of demand for HQCF from bakers was explained by the lack of price differential between wheat flour and HQCF. In March 2012, Wheat flour cost US\$520 per ton and HQCF US\$516 offering little incentive for bakers. However, during 2012 and 2013 prices of wheat flour have risen sharply with predictions for the medium-term being for a continued upward trend. As of July 2013, the price for hard wheat flour in Lagos had risen to US\$839/ton and in Ekiti the price for wheat flour had reached US\$929/ton. In contrast HQCF prices had only risen to US\$581 in the urban market (large-scale production) and US\$645 in the rural markets (supplied by SME HQCF processors).

Using this price differential C:AVA has been facilitating the development of rural bakery markets for the HQCF SME's with training for the rural bakers on the use of HQCF in bakery products. This approach has proved successful for bakers in rural areas. In June 2013 an analysis was made of one of costs and margins of a rural baker in Ekiti State who is using 10% HQCF in his breads. Using HQCF at this level (which does not require bakery improver) the baker made a saving on flour costs of US\$18.39 per day on an output of 950 ~800g loaves per day. This is a substantial improvement in margins for a rural baker and this is helping to drive expansion of the rural bakery market for HQCF.

Based on current demand the 27 SME's have the potential to support the livelihoods of 3,250 smallholder farmers and create employment for 1,040 workers. The salary income for the workers averages US\$1,059 per annum. The net income of the farmers from cassava roots sales is US\$473.

SME production of HQCF has relatively little impact on the environment mainly due to the limited amount of water used and effluent generated by the process. A typical 2 ton per day HQCF factory will generate just 3,250 litres of liquid effluent/day having a quite low biological and chemical oxygen demand. This level of output does not justify the need for an effluent treatment in a rural area having a single factory. This would not be the case if a large number of factories were clustered in a single location but this is not the case in Nigeria where many of the factories are >100km apart. This is in contrast to small-scale starch factories of similar scale that produce 70-80,000 litres per day of effluent making effluent treatment essential for this type of plant (not seen in Nigeria).

### **Business case**

For the Nigerian investment model standardised figures were used that gave a production cost for HQCF of US\$554 and a profit of US\$91 per ton for HQCF where the root cost was US\$65/ton of roots, fuel costs for drying were US\$53 per ton of HQCF and the price for HQCF was US\$645. The sensitivity analysis shows that even if root costs rise to US\$75 per ton the margin on HQCF will still be US\$51/ton. This is certainly encouraging as it indicates that with proper support the Nigerian SME HQCF industry has a future. In reality actual data from SME's in Nigeria shows that the picture is more complex but even more encouraging. The C:AVA flash dryer upgrade programme has impacted heavily on energy costs for drying. The figures used in the investment model reflect an earlier stage in the upgrade work. In practice with a Nobex 6 cyclone flash dryer running on kerosene (in Nigeria) fuel costs for drying have been reduced to US\$30 per ton. Using palm kernel shells the drying costs for an old single cyclone flash dryer have been reduced to US\$50/ton (from US\$318/ton using kerosene or black oil). Cashew shell waste has given the best results of all reducing fuel costs down to US\$8-US\$14 per ton. In the case of cashew shells the cost is really a reflection of the costs of transporting the shells to the factory as this type of waste has no other use and is available in very large volumes. Overall production costs are much lower than US\$554. In the case of an SME using a Nobex 6 flash dryer running on kerosene production costs per ton of HQCF were US\$433.89, with a single cyclone flash dryer upgraded to run on palm kernel shells the costs were US\$443.89/ton and with cashew shells this reduced to US\$417.82 per ton of HQCF.

Profits from sales of HQCF were not only influenced by price of cassava roots and cost of energy for drying. Transport costs were also highly significant. A financial analysis of the activities of an HQCF SME in Ekiti State showed that sales to big mills in Lagos (12 hours drive away) yielded a profit of just US\$26/ton far lower than the US\$91 predicted in our investment model. This was due to the very high cost of transport over such a long distance and relatively low price (US\$533/ton) offered by the mill which offset the benefits gained from reduced energy costs. However, with C:AVA help this SME developed connections with a number of small rural bakeries mainly within 1 hours drive from the factory. Lower transport costs coupled with a much better price (US\$645) increased the margin per ton for HQCF to an attractive US\$147 per ton of HQCF.

### **Entry point for C:AVA2**

As with all of the sub-sectors, C:AVA has a role to play in supporting improvements to smallholder root supply especially in terms of improved yields on farm and better management of the procurement system. In addition there is still scope for further improvements to processing efficiency and support for development of rural bakeries close to the SME processors. In order to expand the market for HQCF further, C:AVA2 will also support introduction of innovative bakery improvers into the rural bakery sector to enable much higher percentages of HQCF to be used in bread.

## **Aquaculture feed**

### **Introduction**

Aquaculture is one of the fastest growing agro-industries in Nigeria with a 10 fold growth over the last decade and predictions of continued growth of 10-12% per annum. Nigeria's aquaculture industry has become the largest in sub-Saharan Africa accounting for 25% of fish consumed in Nigeria. Production is mainly of catfish (80% of production) followed by tilapia, the supply system is dominated by some 50,000 small-scale farms and a smaller number of medium-scale farms with most farms being located in South Western and North Central regions of Nigeria. As production increases demand for pelleted aquaculture feeds has also grown. There are currently 10 aquaculture feed mills/importers with factories in Lagos, Ibadan, Ilorin and Jos. The market is dominated by imported floating pellets (23,000 tons in 2012) but 4 of the feed mills produced and sold 4,000 tons of sinking pellets in 2012. One of these mills relies on cassava as a carbohydrate source. The other 3 mills use maize but said that they would switch to cassava if they could produce floating pellets. Cassava is the carbohydrate ingredient of choice in South East Asia as it has better binding properties, digestibility and aeration when passed through a combination extrusion and pelletising system. The only feed mill currently using cassava (Ideal Feed Mill) is located in Kwara State in North Central Nigeria. This mill uses unpeeled sun-dried cassava chips as a raw material for sinking pellets but production is restricted by the limited demand for this type of pellet.

### **Developmental & environmental case**

The aquaculture feed market is of interest from a developmental perspective as it creates an opportunity for much smaller and resource poor farmers to sell into a higher value market. In addition the aquaculture feed mills source 100% of their raw material supplies from smallholders. The majority of the farmers involved in this market have just 0.5ha of cassava (about half the minimum seen in HQCF supply chains). These farmers have the option to either sell their roots in the fresh state or to make an added value product by chipping and sun-drying. As the roots are not peeled and artificial drying is not used production is much cheaper and margins higher. At farm level chipping is typically done manually but it could be done using either a manually operated rotary chipper (\$600 per chipper) or a motorised chipper (\$2,000 per chipper). Given a price of \$65 a ton the typical smallholder in North Central region should make ~\$237/ton per year if they sell fresh roots to the aquaculture feed mill. If they produce chips the profit from a single farms production (2.96 tons of chips/yr) will be ~\$800 delivered to the millgate. At the moment the single mill using cassava could benefit 1,000 farmers but this would

increase if the mill is able to produce floating pellets. If all of the current imported floating pellets were replaced by locally produced feed some 12,400 smallholder farmers would benefit directly.

The environmental case for unpeeled sun-dried cassava chips is likely to be neutral as almost no water is used in processing, there are virtually no liquid or solid waste outputs and no fuel is used for drying. If a motorised chipper is used it will consume only 1 litre of fuel per ton of chips produced.

### **Business case**

The business case for production of dry chips for aquaculture feed centres mainly around cost of cassava roots (which account for 52% production costs) and access to cost effective extrusion technologies. The first aspect is taken care of by a sensitivity analysis for production costs. In North Central Nigeria cassava root prices normally range between US\$65 and US\$75 per ton. Given that the factory is buying cassava chips at US\$581/ton if cassava costs US\$65 per ton the margin on the chips will be US\$271, this falls to US\$246/ton if the price for cassava rises to US\$75/ton. The margin can also be affected by a drop in the price of the obvious competing ingredient maize. At the lowest point the price for chips could be US\$481 thus reducing the margins by US\$100 per ton. Given these figures production of cassava chips for aquaculture feed appears to be attractive under most conditions. However during the last 12 months unusual conditions caused an abrupt rise in the price of cassava roots peaking at US\$129 per ton and remaining at this level for a period of ~4 months. At this price the margins for chips would range from US\$9 to US\$109 dependent on the selling price of the chips. However, it is quite encouraging to note that even under extreme circumstances the margin on the chips would still be positive.

The key point that is preventing development of this opportunity is a lack of access to small-scale fish feed extruders in Nigeria. Nigeria has several companies producing pelletisers for animal feeds (poultry & aquaculture) with one of the best known being located in Ibadan in Oyo State. However, none of these companies is familiar with extrusion technology and neither are their potential customers as aquaculture and fish feeds are such a recent development in Nigeria. However, this is not the case in South East Asia where extrusion units suitable for production of cassava-based fish feed pellets are readily available. A Chinese made system capable of producing 200kg/hr of pellets would cost around \$2,000 a larger unit producing 1 ton per hour would cost ~US\$5,000.

### **Entry point for C:AVA2**

As with all the sub-sectors C:AVA2 could assist in developing more reliable smallholder inclusive supplies of fresh roots or sun-dried chips working with the feed mill, farmers and community leaders to develop the best procurement strategies. At farm level we would work with farmers and their advisers to introduce better practices to improve yields and returns on the available area of production.

However, the key area of intervention would be in the area of small-scale extrusion technology as this is vital for realisation of this opportunity. We would recommend working with the feed millers and local engineering firms to look at potential to manufacture suitable systems in Nigeria. In the early stages it

might be worthwhile to import one or two units from South East Asia to demonstrate the potential of this technology and increase the local knowledge base on the principles of simple extrusion systems.

## Ethanol for home-cooking

### Introduction

Cassava roots are a rich source of starch than can be readily and relatively cheaply converted into ethyl alcohol by community based micro-distilleries producing 500-5000 litres of ethanol per day. Ethanol can be used as fuel source for cooking and has the advantage over other fuels such as firewood and kerosene that it can be produced locally from sustainable sources and burns much more cleanly thus improving consumer health and reducing contributions to climate change. 95% ethyl alcohol intended for fuel use could be used illegally as a source of cheap liquor. However, this can be prevented by ensuring that the micro-distilleries denature the alcohol at source by adding non-toxic compounds such as denatonium or bitrex that give the alcohol a very bitter taste and induce vomiting if consumed. Based on research conducted as part of the market and investment studies we believe that the developmental and environmental cases are extremely strong, the business case is reasonable and that we can demonstrate useful intervention points for the BMGF under C:AVA2.

### Developmental & environmental case

According to a recent study by the International Centre for Energy Environment and Development (ICEED) some 67% of Nigeria's population rely on firewood (and three stone hearths) as a source of fuel for cooking. Some 23% of Nigerians rely on kerosene for cooking but this is becoming very expensive (US\$0.90-US\$1.03/litre), difficult to obtain in many parts of Nigeria and is not a very clean or safe fuel for domestic use. Firewood for cooking is generally collected from non-sustainable sources contributing to an estimated 3% annual reduction in forest cover. There are some 30 million households with ~90 million women and children spending 2-3 hours every day collecting firewood. Each household is estimated to use 8kg of wood per day which is a staggering 240,000 tons of wood per day nationally for domestic cooking. The adverse health impacts from using wood and an open fire for cooking are serious. Low temperature burning of the wood releases a complex and toxic mix of volatile hydrocarbons and fine particles that enter the lungs and absorb into the bloodstream of those involved in domestic cooking. The World Health Organisation (WHO) has estimated that in 2012 ~95,000 Nigerian women died as a direct or indirect result of chronic smoke inhalation from wood fires. Furthermore ICEED has estimated that smoke from Nigerian cooking fires is contributing over 21 million tonnes of CO<sub>2</sub> equivalents to greenhouse gases every year. On this basis there is clearly a case for development of a cleaner more sustainable fuel source for domestic use that would have less impact on the environment and not impact so adversely on women's health.

In Nigeria, there are a number of initiatives and projects seeking to promote cleaner and safer cooking fuels. Some are focusing on promotion of cleaner high temperature wood & sawdust briquette stoves. However, four of the most promising initiatives are focused on alcohols such as ethanol and methanol as cooking fuels. Of these three one private sector initiative is simply a marketing operation seeking to sell ethanol stoves and ethanol gel imported from Korea. Another initiative involving a public/private sector

partnership seems to be making little progress towards installing a micro-distillery and hence offers no realistic entry point for C:AVA2 although this may change in future.

Of the remaining two initiatives one is purely private sector driven and involves a small-scale entrepreneur near Lagos who has built a pilot-scale distillery near Lagos capable of converting cassava peels purchased from local gari and lafun processors into 93% ethanol for sale to the home-cooking market. Purchase of enough cassava peels for one days operation of the micro-distillery would contribute US\$44.70 in additional income to the women's gari or lafun processing group. The pilot distillery is capable of converting 990kg meal prepared from cassava peels into 300 litres of ethanol per day. Using cassava peels is attractive partly as it utilises a waste product and also because the raw material cost of US\$0.15 per litre of ethanol compares favourably with fresh cassava roots that contribute US\$0.45 to raw material costs per litre of ethanol (given a cassava root price of US\$65/ton). It is estimated that the raw material supply covers 64% of the total cost of production of 1 litre of cassava-based ethanol. The owner of the pilot-plant is selling bio-ethanol to the largest of the clean stove projects in Nigeria. He is also in the process of developing a 500 litre per day micro-distillery for a community group near Benin City. The price for a 500 litre/day locally fabricated unit is \$33,000. This price compares favourably with the price for an HQCF flash dryer at \$45,000. However, his process requires refinement to improve efficiency and cost effectiveness. This initiative is at an early stage and would make only a small contribution to our beneficiary targets in its present form but does have potential which will be discussed further in the section on entry points for C:AVA2.

The most advanced of the Nigerian biofuel initiatives is Project GAIA operational in the area around Benin City and also in Oyo State north of Ibadan. Project GAIA is a US funded organisation linked to the US based NGO the Global Alliance for Clean Cook Stoves. Project GAIA is operating in several African and Asian countries promoting sustainable production of bio-ethanol and affordable clean stove technologies. Project GAIA started in 2007-2008 with a pilot study in the Niger Delta aimed at assessing the potential and acceptability of conversion of flare gas from the petroleum industry into methanol as a cooking fuel. A pilot study with 150 households found that alcohol based cooking stoves were clean and cost effective cooking systems reducing toxic fume emissions by more than 80%. Using methanol as an alternative to kerosene reduced household expenditure on cooking fuels by 42%. Householders liked the stoves and were happy to purchase methanol fuel supplied as part of the project. The stoves for the project were supplied by the Swedish company Demetic AB the world leader in clean stove technology. Householders were willing to pay \$32 for an alcohol stove a significant purchase (comparable to investing in a mobile phone) given that many of the members of these households earn on average \$3.50/day. However, the methanol project was not taken forwards. This has been attributed to avoided methanol as a toxic substance but it is more likely that the technology for conversion of fuel gas to methanol was not economically viable.

In 2010, as an alternative to methanol, Project GAIA began looking at the potential for community based ethanol production from sustainable sources such as cassava roots. There are interesting precedents for this approach. In Brazil community owned micro-distilleries linked to clean stove technologies are quite common. Several companies produce micro-distillery systems but the market leader appears to USI

Industries who also have a patented low temperature saccharification system that is reputed to reduce energy costs of distillation by 50%. Similar technology has been introduced successfully into Mozambique by a South African owned company called Clean Star. The Clean Star distillery has a capacity of 10,000 litres of ethanol per day and is reported to be supporting the livelihoods of ~2,000 smallholders with potential for expansion to 7,500 smallholders as the plant builds toward delivering maximum output.

In Nigeria, Project GAIA are partnering with the National Biotechnology Development Agency (NABDA) part of the Federal Government of Nigeria to establish a cassava-based plant to produce 1,000 litres of ethanol per day in the small town of Obamoshu in Oyo State about 2 hours north of Ibadan. Project GAIA are supporting an investment in a US\$260,000 micro-distillery supplied by USI industries of Brazil. They have imported 1,500 Dometic AB stoves from Sweden that would retail at US\$45.16 per stove. As this is too expensive for poorer households, Project GAIA is encouraging local manufacture of a licenced copy of the Dometic AB stove. The Nigerian stoves will retail for US\$14.19. The Project manager was optimistic of commissioning of the plan during 2013 but it seems more likely that the Obamoshu plant will be operational in early 2014. To produce 1000 litres of ethanol per day the Obamoshu plant will require 7 tons of fresh cassava roots. This equates to ~2,600 tons of roots per annum. A plant of this type will require a minimum of 1,000 smallholder farmers to ensure a reliable supply of roots.

#### **Livelihood, health and environmental benefits**

Using available data it is reasonable to assume that the 1,000 litre day at Obamoshu will supply 1,333 families with clean cooking fuel and contribute to the livelihoods of 1,000 smallholder farmers. Studies carried out by the University of Chicago on a range of clean cook stoves demonstrated that the Dometic AB type stove reduced toxic cooking emissions by ~95% when compared to a traditional three stone health and firewood. This is an important finding from the perspective of consumer health. If the root price is assumed to be US\$65/ton each farmer will benefit by US\$194 per annum. By switching from kerosene to ethanol each family should make a saving of US\$144 per annum (at current prices see business case). In theory firewood consumption would be reduced from the current 750m<sup>3</sup> per annum (for the 1,333 families) to zero. However, the Brazilian based micro-distillery has a wood fired boiler that will consume 548m<sup>3</sup> of wood per annum. The wood fired boiler reduces much of the environmental benefit of the plant but this could be readily addressed and a solution will be suggested under entry points for C:AVA2. It is also important to take account of the potential negative environmental impacts of the micro-distillery. A 1,000 litre/day plant will produce just 91 tons of solid pulp per year which can readily be used for animal feed. However, for each litre of ethanol the plant will discharge 13 litres of vinasse an environmentally unfriendly liquid effluent. Over the course of a year vinasse production will be 4.75 million litres. In our discussions with the project staff it was unclear as to how they plan to deal with the serious issue of the vinasse. However, solutions do exist and C:AVA2 could help ensure that positive impacts of the plant at Obamoshu are not spoilt by a lack of provision for effluent treatment.

## Business case

The starting point for the business case for micro-distilleries in Nigeria must be the cost and availability of the competing fuel sources. As mentioned earlier the majority of Nigerians rely on firewood or kerosene as fuel sources, only 2% use charcoal. LPG is only 1% and electricity is used by just 0.3% of the population for cooking. The majority of firewood is collected and technically is “free” but respondents to an ICEED survey mentioned having to spend 2-3 hours every day collecting wood. In May 2013 kerosene was retailing in Obamoshu for US\$1.03/litre. Previous studies by Project GAIA in the Niger Delta found that kerosene stoves used an average of 30 litres of kerosene per month giving a monthly cost for kerosene of US\$31. Users have complained of high prices, reduced availability and problems with adulteration. In contrast the Demetic AB alcohol stove used only 26 litres of alcohol per month.

Pure (99%) ethanol is imported and sold at US\$2 per litre, but rough alcohol (>60% ethanol) is available locally at US\$0.97 per litre. A user of a Demetic AB stove fuelled with rough ethanol said they used 0.5 litres of ethanol per day giving a monthly operating cost for ethanol stove of US\$14.40 which compares very favourably with US\$31 for kerosene.

Figures from a detailed financial analysis of the investment in a Brazilian designed micro-distillery at Obamoshu indicate that with an assumed root cost of US\$90/ton the production cost for 95% ethanol will be US\$0.67/litre. Based on the kerosene price the Obamoshu micro-distillery intends to market denatured 95% ethanol for home-cooking at US\$0.84 per litre to households in the local community (thus transport costs will not be a major factor). At this price the distillery will make a margin of US\$0.17 per litre of ethanol sold. Project GAIA reported that consumption of 0.5 litres per day was rather low they prefer to use 0.75 litres per day for the ethanol stove. Using this figure the ethanol stoves will cost US\$19 per month to operate which is a saving US\$12 per month when compared to kerosene. For firewood users the need to collect wood has been removed and studies from University of Chicago have proved that the ethanol stove is more efficient than firewood and does not need to be tended to keep it going. At Obamoshu stove owners will bring their fuel containers (part of the stove) to the outlet for filling. Ethanol will be denatured with bitrex or denatonium to prevent abuse and also to avoid excise duty. In practice root prices will normally be closer to US\$65/ton. Under these circumstances production costs will reduce to US\$0.5 per litre giving a much improved margin of US\$0.34/litre.

It might be asked as to how the Obamoshu distillery will be able to produce 95% ethanol so much more cheaply than local distillers producing rough alcohol. This is explained by the efficiency of the technology used. Large-scale distilleries are typically the most cost efficient, small artisanal stills are highly energy inefficient. The success of the Brazilian designed micro-distilleries is based on process optimisation and elimination of the conventional jet cooking step of the saccharification process which typically accounts for 50% of total energy used.

It is clear that cassava-based ethanol for home-cooking is technically feasible and financially attractive in terms of margins and cost savings for domestic users. However, the question must be asked as to what the market potential will be and what the investment cost would be for a rural community. The

theoretical markets for ethanol as a home cooking fuel are vast, in terms of kerosene replacement the estimated market would be 750 million litres of ethanol per annum. Replacement of firewood is more difficult to estimate. However, if 30 million households use an average of 8kg of wood per day and this was replaced by 0.75 litres of ethanol per day the theoretical market would be a massive 67.5 billion litres per annum. However, these figures have little meaning in practice.

If we look at the 1,000 litre per day micro-distillery at Obamoshu this has potential to supply 1,333 households with ~350,000 litres of ethanol per annum. The question must be asked as to the level of potential for replication of this initial plant. Using imported Brazilian technology this plant was originally estimated to have a total cost US\$180,000 to the point of commissioning. However, by mid-2013 these costs had been revised to US\$260,000. In addition this cost takes no account of the requirement to treat the large volume of vinasse produced. Detailed costing for a suitable treatment plant are not available but as a rough estimate ~US\$40,000 should be added making a total investment of US\$300,000 (as compared to US\$100-150,000 for an HQCF factory). Discussions with industry experts indicate that 1,000 litre/day may not be attractive enough for commercial investment (micro-distilleries worked in Brazil because of the ready availability of wastes from community level sugar cane operations). In Mozambique, for example Clean Star saw little potential for a plant of less than 5,000 litres per day and settled for 10,000 litres per day capacity with associated benefits in terms of economy of scale and operating efficiency.

Overall the figures for the investment at Obamoshu look encouraging and it seems likely that production could expand to 5,000 litres per day within the life of C:AVA2 with potential to contribute to the livelihoods of 5,000 smallholder farmers and deliver clean fuel to >6,500 households. However, it seems unlikely that rural communities will have the resources to invest in Brazilian micro-distilleries so scaling out of the project might be limited.

### **Entry points for C:AVA2**

The Project GAIA investment in Oyo State is backed by a reasonable business case and a very strong developmental and environmental case. The type and scale of benefits is attractive but there are concerns over the need to treat the liquid effluent produced, the fuel source for the distillery, the strategy for procurement of roots from smallholder farmers and the potential for scaling out. C:AVA2 could make a useful contribution in addressing all of these concerns and make a useful contribution towards enhancing the potential of this worthwhile initiative.

In the case of the Obamoshu investment we could work with Project GAIA to develop improved strategies for procurement of roots from smallholder farmers simply by including the Obamoshu distillery as part of our work with SME HQCF producers who have similar procurement issues. Given that Obamoshu is located in one of the largest cashew producing areas of Nigeria, we feel that we could use expertise developed under C:AVA to modify the wood fired boiler system to run on cashew shell waste. This would eliminate fire-wood and utilise a sustainable supply of solid wastes. In the same part of Nigeria we have already demonstrated that we can reduce energy costs for drying of HQCF using systems running on cashew shells.

The issue of liquid effluent (vinesse) is a serious issue that must be addressed, from our experience in other projects we believe that we could support development of a simple and cost-effective system for dealing with the vinesse relying on a micro-scale anaerobic digester (possibly combined with aerobic treatment). This type of technology would also be of interest for use by Nigeria's starch industries which currently lack suitable means of effluent treatment). The liquid output from the digester would be suitable for re-use (offering potential savings on water consumption), it may also be possible to harvest and utilise methane gas from the digester system but the financial feasibility and practicality of this for a small-scale operation would require further investment).

The issue of scaling out and scale-up of the outcomes of the Project GAIA investment will depend on private sector interest in investing in micro-distillery plants across Nigeria. For a greenfield site the initial investment would be \$300,000 including facilities for effluent treatment which is likely reduce interest. However, if one of the HQCF SME's was to diversify into ethanol production as an additional line of business the initial investment for a Brazilian based system could be reduced to ~US\$83,000 as much of required infrastructure and equipment would already be in place. In addition the SME would be able to use cassava peels to meet ~50% of their raw material requirement with the rest being provided by cassava roots.

It would also be possible for HQCF SME's to look at adopting an improved version of the Nigerian cassava-based distillery seen in operation close to Lagos. In its current form this distillery costs \$33,000 and converts 990kg of meal derived from cassava peels into 300 litres of ethanol. It would be straightforward to increase output to 500 litres per day at very little extra cost. Operating efficiency could be improved using a solid-fuel boiler system. Such a system is likely to cost ~US\$40,000 (similar to a new flash dryer) and would be able to rely entirely on cassava peels as a feedstock for production of 500 litres per day of ethanol. These are only possibilities but as a potential route for scaling out of the Project GAIA programme HQCF SME's seems to offer an attractive route that would merit further investigation (in collaboration with NICAPMA and its membership) and possible support under C:AVA2.