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Shaping, adapting and reserving the right to play

Responding to uncertainty in high quality cassava flour value chains in Nigeria

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Abstract

Purpose – The purpose of this paper is to explain why the high quality cassava flour (HQCF) value chain in Nigeria has not performed as well as expected. The specific objectives are to: analyse important sources of uncertainty influencing HQCF value chains; explore stakeholders' strategies to respond to uncertainty; and highlight the implications of different adaptation strategies for equity and the environment in the development of the value chain.

Design/methodology/approach – The authors used a conceptual framework based on complex adaptive systems to analyse the slow development of the value chain for HQCF in Nigeria, with a specific focus on how key stakeholders have adapted to uncertainty. The paper is based on information from secondary sources and grey literature. In particular, the authors have drawn heavily on project documents of the Cassava: Adding Value for Africa project (2008 to present), which is funded by the Bill & Melinda Gates Foundation, and on the authors' experience with this project.

Findings – Policy changes; demand and supply of HQCF; availability and price of cassava roots; supply and cost of energy are major sources of uncertainty in the chain. Researchers and government have shaped the chain through technology development and policy initiatives. Farmers adapted by selling cassava to rival chains, while processors adapted by switching to rival cassava products, reducing energy costs and vertical integration. However, with uncertainties in HQCF supply, the milling industry has reserved the right to play. Vertical integration offers millers a potential solution to uncertainty in HQCF supply, but raises questions about social and environmental outcomes in the chain.

Research limitations/implications – The use of the framework of complex adaptive systems helped to explain the development of the HQCF value chain in Nigeria. The authors identified sources of uncertainty that have been pivotal in restricting value chain development, including changes in policy environment, the demand for and supply of HQCF, the availability and price of cassava roots, and the availability and cost of energy for flour processing. Value chain actors have responded to these uncertainties in different ways. Analysing these responses in terms of adaptation provides useful insights into why the value chain for HQCF in Nigeria has been so slow to develop.

Social implications – Recent developments suggest that the most effective strategy for the milling industry to reduce uncertainty in the HQCF value chain is through vertical integration, producing their own cassava roots and flour. This raises concerns about equity. Until now, it has been assumed that the development of the value chain for HQCF can combine both growth and equity objectives. The validity of this assumption now seems to be open to question. The extent to which these developments of HQCF value

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chains can combine economic growth, equity and environmental objectives, as set out in the sustainable development goals, is an open question.

Originality/value – The originality lies in the analysis of the development of HQCF value chains in Nigeria through the lens of complex adaptive systems, with a particular focus on uncertainty and adaptation. In order to explore adaptation, the authors employ Courtney *et al.*'s (1997) conceptualization of business strategy under conditions of uncertainty. They argue that organisations can assume three strategic postures in response to uncertainty and three types of actions to implement that strategy. This combination of frameworks provides a fresh means of understanding the importance of uncertainty and different actors' strategies in the development of value chains in a developing country context.

Keywords Uncertainty, Nigeria, Adaptation, Smallholder farmers, High quality cassava flour, Inclusive value chains, Processors

Paper type Research paper

1. Introduction

Developing smallholder-inclusive, sustainable agricultural value chains is a priority for many development actors aiming to meet a variety of social, economic, and environmental objectives under the sustainable development goals[1]. However, value chain development involves uncertainty, not least because it entails decision-making by a wide range of stakeholders and requires functioning linkages between them. In successful value chains, actors find ways to adapt to uncertainty. In other cases, the uncertainties may be so great that adaptation is possible for some actors, but not for all. If these happen to be key actors in the chain, then this failure to adapt to uncertainty may threaten the development of the entire value chain. Since value chain performance depends on the performance of each individual actor in the chain together with effective and mutually beneficial linkages or relationships between them, it is essential that each actor develops effective strategies to manage uncertainty in order for the chain to function.

In this paper we explore the uncertainties in the value chains for High Quality Cassava Flour (HQCF) in Nigeria, and the different ways that stakeholders have responded to these uncertainties. Cassava is a climate-resilient crop that is widely grown by smallholders. Nigeria is the world's largest cassava producer, producing over 50 million tonnes of roots in 2014 (FAOSTAT). Processed cassava can help meet the expanding demand for more and different types of agri-food products in Africa. This suggests that there is significant potential to develop cassava-based value chains in which smallholders participate and benefit. In particular, HQCF has multiple food and industrial uses and represents an opportunity for smallholder farmers and processors in raw material supply and manufacture (Westby, 2002). The potential economic benefits include economic import substitution – in 2015-2016, Nigeria imported 4.4 million tonnes of wheat (United States Department of Agriculture/Foreign Agriculture Service (USDA-FAS), 2016) at an average annual cost of US$1.39 billion between 2010 and 2013; employment creation, with the growth of the transport and processing industries; and greater income for smallholder cassava growers. Finally, because cassava is gluten-free there are potential health benefits for some consumers (Falade and Akingbala, 2008).

Since the 1980s there have been a series of attempts to promote HQCF in Nigeria. However, the development of this value chain has not so far met expectations. Several explanations have been offered (Ohimain, 2014). One important reason for this failure to meet expectations has been uncertainty (Lamboll *et al.*, 2015). However, there has been no systematic attempt to assess the various sources of uncertainty and the role of different value chain actors in both causing these uncertainties and responding to them.

This paper analyses the development of HQCF value chains in Nigeria through the lens of complex adaptive systems. A conceptual framework for the application of complex systems thinking to smallholder value is the subject of a separate article in this

special issue (Orr *et al.*, 2018). This framework identified seven common properties, all of which are relevant for the analysis of smallholder value chains. In the case of HQCF, for example, besides time (the paper covers a period of 34 years between 1982 and 2016), the common properties of sudden changes (the 10 per cent cassava flour inclusion policy in 1982 and a ban on wheat imports in 1987) and interacting agents (particularly the relationships between growers and processors, and between processors and policy makers) play a significant role. In this paper, however, we focus on just two of the seven common properties of complex adaptive systems, namely uncertainty and adaptation. This choice was made both on grounds of practicality (space does not allow us to analyse the contribution of all seven common properties) and because we believe they are the two common properties with the greatest impact on the HQCF value chain.

We argue that uncertainty is central to the uneven performance of the HQCF value chain, because it discouraged business actors from investing in the growth of the value chain. Uncertainty differs from risk. Whereas with risk the probabilities of a given outcome are, or can be known, uncertainty refers to a situation where outcomes are indeterminate and the odds of a given outcome cannot be known in advance. In these conditions, business actors are much less willing to invest. Second, the business actors in the value chain (growers, HQCF processors, and bakeries) have not devised a viable strategy to adapt to uncertainty and so capture the opportunity presented by HQCF. Business actors have pursued individual adaptive strategies, responding to uncertainty in different ways. Collectively, these diverse strategies have not been sufficient to reduce uncertainty to the point where it allows the development of the chain. In short, it is the failure to adapt to uncertainty has been a key reason for the slow development of the value chain.

To explore these different responses to uncertainty, we employ Courtney *et al.*'s (1997) conceptualization of business strategy under conditions of uncertainty. They argue that organisations can assume three strategic postures in response to uncertainty, and three types of actions can be used to implement that strategy. A posture defines the intent of a strategy relative to the current and future state of an industry. The three strategic postures are shaping, adapting and reserving the right to play. Shapers aim to drive their industries towards a new structure of their own devising. In contrast, adapters take the current industry structure and its future evolution as givens and react to the opportunities the market offers. The third strategic posture, reserving the right to play, is a particular form of adaptation. It involves making immediate incremental investments putting a company in a privileged position – through, e.g. superior information, cost structures, or relations between customers and suppliers – that allows the company to wait until the environment becomes less uncertain before formulating a strategy.

In terms of the actions required to fulfil these strategic intentions, three types of moves are especially relevant to implementing strategy under conditions of uncertainty. The first is "big bets" – large commitments, such as major capital investments, that will produce large payoffs in some scenarios and large losses in others. Shaping strategies usually involve big bets, while the other two strategies, adapting and reserving the right to play, do not. The second type of move, "options", are designed to secure the big payoffs of the best-case scenarios, while minimising losses in the worst-case ones; for example, conducting trials before the full-scale introduction of a new product, entering into limited joint ventures to minimise the risk of breaking into new markets, and licensing an alternative technology in case it proves to be superior to the technology currently used. Enterprises reserving the right to play rely heavily on options, though shapers use them as well, either to shape an emerging but uncertain market as an early mover, or to hedge big bets. Third, "no-regrets" moves are moves that will pay off no matter what happens. Managers often focus on obvious no-regrets moves such as reducing costs, gathering competitive intelligence,

or building skills. However, even in highly uncertain environments, strategic decisions such as investing in capacity and entering certain markets can be no-regrets moves.

Many factors have contributed to the slow development of HQCF value chains in Nigeria (Ohimain, 2014). In this paper we argue that one of the major reasons lies with the adaptive strategy followed by grain millers, who have reserved the right to play. Their decision not to invest in the value chain reflects the high levels of uncertainty surrounding this investment, including uncertainties over government policy, as well as the availability and quality of HQCF, in contrast to the ready availability of wheat imports. In these circumstances, reserving the right to play is a rational strategic response to uncertainty, and one that has so far proved difficult to change. However, this does not rule out the future development of the value chain provided that these uncertainties can be addressed. Indeed, recent developments suggest that this strategy is changing.

The general objective of this paper is to explain why the HQCF value chain in Nigeria has not performed as well as expected. The specific objectives are to: analyse important sources of uncertainty influencing HQCF value chains; explore stakeholders' strategies to respond to uncertainty; and highlight the implications of different adaptation strategies for equity and the environment in the development of the value chain.

Following this introduction, the next section outlines the structure of the HQCF value chain. Section 3 analyses key sources of uncertainty associated with the chain, while Section 4 considers some of the strategies used by value chains stakeholders to respond to uncertainty. We conclude by considering the implications that different approaches to adaptation and strengthening adaptive capacity have for social and environmental outcomes.

The paper is based on information from secondary sources and grey literature. In particular, we have drawn heavily on project documents of the Cassava: Adding Value for Africa project (2008 to present), which is funded by the Bill & Melinda Gates Foundation, and on our experience with this project. While some aspects of the value chain for HQCF in Nigeria, such as the composition of products from cassava flour (Olayimika *et al.*, 2015; Maziya-Dixon *et al.*, 2017) and its acceptance by consumers (Eriksson *et al.*, 2014; Komlaga *et al.*, 2012; Adepoju and Oyewole, 2013), have been widely studied, few publications have attempted to survey the value chain as a whole and explore the reasons for its poor performance (Ohimain, 2014). This paper uses the lens of complex adaptive systems to try and fill this gap.

2. The HQCF value chain in Nigeria

Although cassava is important for subsistence, it is also a very important cash crop. Significant quantities of cassava and processed products (e.g. *fufu*[2] and *gari*[3]) are sold into traditional food markets. In south-west Nigeria, a recent survey found that 20 per cent of harvested fresh cassava roots were used by growers for home consumption, while 52 per cent were sold for processing into *gari*, and 27 per cent into *fufu* (Naziri *et al.*, 2014). Another survey in the same region highlighted the gendered aspects of cassava sales. Typically, women and men have separate cassava fields, with cassava production by women primarily processed for household consumption with any surplus being sold in the local markets, while men produce cassava primarily for sale (Forsythe *et al.*, 2016). Men will mainly sell cassava as fresh roots, while women sell both cassava roots and processed cassava products, mainly *gari*.

A range of industrial cassava products for different markets are in various stages of development in Nigeria. These include HQCF, starch, sugar-syrups, ethanol (industrial, cooking), livestock feed, fish feed and brewing beer (Sanni *et al.*, 2009; Graffham *et al.*, 2013). At present, however, the share of cassava roots entering these markets is extremely small, amounting to no more than an estimated 1-2 per cent of total cassava production (Dahlberg Global Development Advisors, 2015).

HQCF is prepared from peeled and grated cassava that has been de-watered, dried to 10-12 per cent moisture content, then milled and screened to give a fine flour capable of passing through a 0.25 mm sieve. HQCF typically contains $>$ 90 per cent starch. HQCF is so named to distinguish it from the many traditional cassava flours which are typically off-white in colour, have a fermented smell and taste, and are coarsely ground. These traditional flours are not suited for use in bakery products or manufacture of paperboard adhesive (Graffham *et al.*, 2013).

Actors in a value chain fall into one of two categories: operators or support service providers. Value chain operators include farmers, small and medium enterprises (SMEs), industrial processors, exporters, wholesalers and retailers. What they have in common is that they become owners of (raw, unprocessed, or finished) product at one stage in the value chain. By contrast, value chain supports do not own the product, but provide support services to value chain operators (Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), 2007). In this paper we focus on the major operators in the HQCF value chain rather than on support service providers. An outline of the HQCF value chain alongside other cassava value chains in south west Nigeria is shown in Figure 1.

Farmers

More than 90 per cent of production takes place on smallholder farms that typically cultivate 0.5 ha of cassava, often intercropped with crops such as maize and legumes (United Nations Industrial Development Organisation (UNIDO)/Federal Government of Nigeria (FGN), 2006). Production is concentrated in South and South Central Nigeria, although production on a small scale also takes place in the Northern region of the country. Cassava is grown by an estimated 30 million farmers (Abdoulaye *et al.*, 2014). Labour is typically a much more important limiting factor than land. Many farming households and enterprises hire labour which is expensive and a major cost of production (68 per cent of production costs according to Adeyemo *et al.*, 2010). A small number of medium to large scale farmers/enterprises have begun to grow cassava as a monocrop, with varying degrees of mechanisation. Environmental impacts, often neglected in the drive towards mechanisation, are a concern.. These could be minimised by the use of sustainable

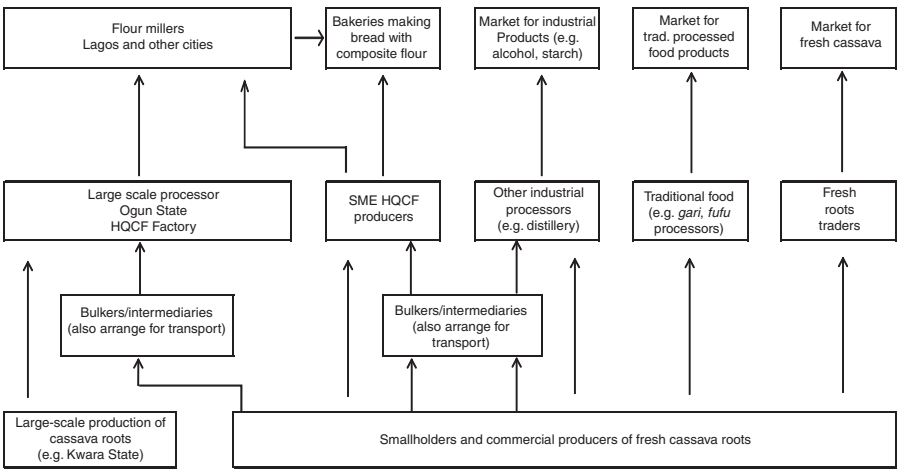


Figure 1.
HQCF and other cassava value chains in South West Nigeria

Source: Based on an internal report by Kleih *et. al.* (2014)

agricultural practices (Food and Agriculture Organisation (FAO), 2013). Good practices to manage environmental impacts of cassava include the expanded use of intercropping (including with trees and bushes) and the incorporation of crop residues into soils after harvest to maintain soil fertility (Howeler, 2002).

Community-level processors

At the community level, there are two main types of processing enterprises. Private businesses, also called village processing units (VPUs), with processing equipment such as a grater, press and milling machine provide services to processors of *gari*, *fufu*, etc. In addition, community processing groups buy fresh roots and process them into various products for sale. VPUs are usually owned by men but may have a linked *gari* or *fufu* processing unit mostly owned or managed by women (Lamboll *et al.*, 2008). In general, men handle the root processing after the initial peeling, which is usually done by women and children, while the women handle the processing into the final products (Butterworth *et al.*, 2008). Attempts to introduce processing of intermediate products (sun dried cassava grits or wet cassava cake) or HQCF itself at community level have generally not been very successful. Community-level processors view *fufu* and *gari* as more profitable than HQCF, particularly if they can sell directly to consumers and the market for these products is not saturated. For actors higher up the value chain, the processing of HQCF at community level has led to concerns about aggregation and quality.

Intermediate processors

There are approximately 180 SMEs in Nigeria equipped for cassava processing (Sanni, 2012), of which about 153 operate drying equipment known as flash dryers (Marchant *et al.*, 2015). However, most HQCF is produced by one large factory using imported equipment and benefiting from economies of scale and more efficient processing techniques. This factory has the capacity to process 30,000 tonnes of HQCF per annum, but typically processes significantly less than this. The SMEs use locally fabricated equipment with a capacity of 1-2 tonnes of HQCF per day (Graffham *et al.*, 2013).

Most SMEs producing HQCF were set up during the Obasanjo regime (1999-2007) in response to the President's Special Initiative, including the policy for 10 per cent inclusion of HQCF in bread flour. However, between 2008 and 2009 the majority went out of business because they used inefficient locally fabricated equipment which made them uncompetitive, and because demand for HQCF had fallen. By 2010-2011, it was estimated that only 23 SMEs were still operational, and by 2012 this number had fallen to between 6 and 10, although 4-5 new SMEs with more efficient equipment were under construction in South Western Nigeria. Dahlberg Global Development Advisors (2015) reported that only ten SMEs were known to be operational. According to a survey in 2016, SMEs cited their most severe challenges as lack of access to markets, the poor price offered by end-users, lack of access to working capital, lack of transport, the high cost of transporting cassava roots from farm to factory, and high production costs (Abayomi and Adegoke, 2016).

Researchers believe it is unrealistic to expect all SME factories to return to operation but estimate that if 50 SMEs resumed operations with upgraded equipment, they would have the capacity to produce about 25,000 tonnes of HQCF per annum (Graffham *et al.*, 2013). If, in the medium term, capacity increased to 75,000 tonnes per annum this would deliver only 15 per cent of the theoretical demand of 500,000 tonnes of HQCF (see below), but investors remain cautious due to problems with obtaining reliable supplies of cassava roots at competitive prices, unresolved technical problems with using HQCF in bakery products and in the case of SME operations, ongoing issues over highly inefficient processing equipment that make profitable operation difficult (Graffham *et al.*, 2013). Production of

HQCF by SME factories operating in 2011-2012 amounted to just 4,500 tonnes (Graffham, *et al.*, 2013). Information from the CAVA II project in 2016 indicates that there has been recent investment in flash dryers with 64 reportedly operational to some degree.

End users

HQCF has been viewed primarily as a partial substitute[4] for wheat flour in the milling and baking industries. In 2015-2016, Nigeria imported an estimated 4.4 million tonnes of wheat (USDA FAS, 2016), equivalent to 3.3 million tonnes of wheat flour. Replacing wheat flour with HQCF, at an inclusion rate of 10 per cent, would correspond to 330,000 tonnes of HQCF. In addition, starch-based paperboard adhesives have been identified as a potential end-user market. If all the current constraints to uptake could be resolved, the theoretical demand for HQCF for use in bakery products (bread, biscuits, snacks) and paperboard industries could be as much as 500,000 tonnes per annum (equivalent to 2 million tonnes of fresh cassava roots) (Graffham *et al.*, 2013).

Three of the largest wheat milling companies in Nigeria – Flour Mills of Nigeria (FMN), Honeywell Flour Mills (HFM) and Dangote Flour Mills (DFM) – account for around 75 per cent of total milling revenues. FMN is the largest and most diversified player in the sector, built around food, agro-allied and support services. FMN's capacity utilisation was estimated at about 70 per cent, compared to other companies in the industry where average capacity utilisation is 50 per cent or less. In 2014, FMN was the major supplier of wheat flour in five out of six regions in Nigeria. DFM's market share is concentrated in two of the three Northern regions, while HFM is the lead supplier in the South East region and has a significant presence in all regional markets. While FMN has the largest market share by revenue, HFM is the most profitable (KPMG, 2016). Olam is a global commodity trader, which through its ownership of the BUA group and Crown Flour Mills (CFM) has the second largest milling capacity in the country. CFM primarily produces flour as an input for the group's packaged foods subsidiaries. BUA group produce pasta and Olam has acquired Titanium Holding Company, the parent company of OK Foods, which in 2014 had a 20 per cent share of the Nigerian biscuit market. Economies of scale in flour milling have fed into the development of a highly flexible bakery industry (Andrae and Beckman, 1985). A wide range of enterprises, from simple mud-oven bakers to fully automatic, electric bakeries, coexist and compete in the same market. The bakers have formed strong pressure groups which are important actors in attempts to establish HQCF inclusion in bread flour.

Although the number of companies in the milling industry is small, intense competition and rising costs in the industry, due to exchange rate challenges, have eroded profit margins (Table I). Capacity utilisation averages only 50 per cent (KPMG, 2016). In response to stiff competition and the ease with which distributors can switch brands, the major mills have forward-integrated into the manufacture of other flour-based foods, such as baked goods, bread and biscuits (KPMG, 2016). Pressure on profit margins has also increased the incentive for millers to use HQCF. Of the total 13,000 tonnes of HQCF produced in 2014, flour mills purchased 9,000 tonnes, with the remainder going to biscuit and snack companies and other small-scale end users (Dahlberg Global Development Advisors, 2015).

Table I.
Capacity, market share and net profit margins for major flour millers in Nigeria, 2014-2015

Indicator	Flour mills Nigeria	Olam	Dangote flour mills	Honeywell flour mills
Current installed capacity (tonnes/day)	8,000	6,140	4,800	2,610
Market share by capacity (%)	32	24	19	10
Net profit margin (%)	1.1	na	−39.0	2.3

Note: Olam comprises BUA and Crown Flour Mills
Source: KPMG (2016)

Several problems surrounding the level of inclusion of HQCF in bread flour have been consistently identified (Kleih *et al.*, 2008; Dahlberg Global Development Advisors, 2015; Ohimain, 2014; Graffham and Linton, 2016). In particular, millers have complained about the availability of HQCF and, together with bakers, have commented that the quality of bread suffered with the inclusion of HQCF. Consequently, HQCF is almost never blended into regular bread flour (Dahlberg Global Development Advisors, 2015). However, both FMN and HFM have launched new "multipurpose flour" products that incorporate 10 per cent HQCF (Dahlberg Global Development Advisors, 2015). These are marketed for use in general baking – for bread, cakes, biscuits, pastries and other confectioneries.

3. Sources of uncertainty

In this section we explore four major sources of uncertainty in the HQCF value chain, namely:

(1) frequent changes in the policy environment;

(2) demand for and availability of HQCF;

(3) availability and prices of cassava roots; and

(4) the supply and cost of energy.

The policy environment

Government policy has created two major sources of uncertainty that have directly affected the value chain for HQCF. First, uncertainty over how far policies favouring the use of HQCF will be enforced. Second, uncertainty over whether changes in government will result in these policies being continued or abandoned.

Table II summarises changes in the policy environment for HQCF since the 1980s. In 1982, for the first time, the government led by President Shagari stipulated that bread flour should include 10 per cent HQCF. However, with regime change in 1983 this stipulation was abandoned. In 1984 a foreign exchange crisis led to import restrictions on many imported commodities, but the budget provided exceptional relief for imports of wheat. This was "in agreement with the general policy over the last decade and a half to keep duties low and import restrictions generally non-prohibitive to maintain low prices and supplies flowing" (Andrae and Beckman, 1985). However, the next government, led by President Babangida, imposed a complete ban on wheat imports between 1987 and 1991. This reflected attempts to develop the domestic wheat industry during a period when Nigeria's currency depreciated dramatically against the USD. In 2002, President Obasanjo's Cassava Presidential Initiative re-introduced the stipulation that bread flour should include 10 per cent HQCF, together with a range of other initiatives to promote the HQCF industry. However, the Yar'Adua Government (2007 – 2010) halved the inclusion rate to just 5 per cent. In 2010, the government of President Goodluck Jonathan launched an Agricultural Transformation Agenda to reduce food imports by increasing production of key crops, including cassava. This led in 2012 to the re-introduction of a 10 per cent inclusion of HQCF in bread flour, scheduled to rise to 40 per cent by 2015. In fact, it reached only 20 per cent. In 2015, a further change of government revised the inclusion rate for HQCF back to 10 per cent (FMARD https://fmard.gov.ng/about/fmard-policies/).

In some cases, these changes in policy have had a pronounced effect. For example, in the mid-1980s the Nigerian Government invested in measures to disseminate the Tropical Manihot Species (TMS) varieties of cassava that had been released in 1977. This led to a significant increase in cassava production and a dramatic fall in prices (Nweke, 2004). Similarly, the Presidential Initiative on Cassava in 2002 led to the establishment of

Regime	Policies	Outcomes
President Shehu Shagari in 1982	10% cassava inclusion policy first introduced. Discontinued after regime change in 1983	
Ibrahim Babangida (1985-1993)	Ban on wheat importation (1987) for 4 years to encourage domestic production of wheat	Dramatic increase in cassava production and fall in consumer prices
President Obasanjo (1999-2007)	Presidential Initiative on Cassava of July 2002. Geared towards the expansion of the production of cassava to meet domestic demand and also make cassava a foreign exchange earner through exports. Introduced compulsory 10% inclusion of HQCF in wheat flour	Private sector set up over 500 micro-processing centres and 100 SMEs for manufacturing of cassava products. Significant investments in new factories for manufacture of glucose syrup, starch and HQCF Before 2002, there were only 2 flash dryers in Nigeria, but now over 160
President Umaru Musa Yar'Adua (2007-2010)	The Presidential Initiative of 2002 changed from 10% to 5% cassava inclusion in composite wheat flour	
President Goodluck Jonathan (2010-2015)	Agriculture Transformation Agenda (ATA) aimed to reduce food imports by increasing production of five key crops, including cassava Inclusion rate for cassava flour fixed at 10% in 2012, rising steadily to reach 40% by 2015 Policy provided for a changeover period of 18 months for flour millers and bakers to switch to composite flour Waivers on the importation of bread improvers, cassava processing and flour milling equipment 12% tax reduction on cassava flour utilisation for millers Provision of free starter packs of composite flours and bread improvers for 100 kg of bread for small-scale bakers Provision of 100 kg fertilizer at 50% discount and 15 bundles of improved cassava varieties free to smallholders Additional 65% duty on wheat flour imports to the initial 35% duty (total duty 100%) and 15% duty on the initial duty of 5% on wheat grain (total duty 20%) Creation of cassava bread development fund funded from importation of wheat, to be used for training, research, development and demonstration Training of about 400,000 master bakers Provision of loans to cassava processors for equipment. Ban on the importation of cassava flour	Upward trend in cassava root production Influence on HQCF appears quite limited. Although two of the major flour mills introduced a new 10% HQCF "composite flour" product, mainstream/traditional flour contains very little or no HQCF
President Muhammadu Buhari (2015-present)	10% cassava flour substitution for bread flour Under the Agriculture Promotion Policy for 2016 – 2020 the GON partnering the private sector to refresh the ATA APP proposes to build on the successes of ATA by closing domestic demand and supply gaps for crops and livestock, while exporting at quality standards required for international markets APP aims to improve selected value chains, including rice, wheat, maize but apparently not cassava FMARD will prioritise for export markets the production of a range of crops including cassava (starch, chips and ethanol)	Too early to assess

Table II.
Policies affecting the HQCF value chain in Nigeria, 1982-2016, by policy regime

Sources: Based on Adeloye (2012) was cited in Ohimain (2014), Sanni (2011), Ohimain (2014) and Federal Ministry of Agriculture and Rural Development (2016)

over 500 micro-processing centres and 100 SMEs manufacturing cassava products. Before 2002 there were only two flash dryers in Nigeria, but by 2014, there were reported to be over 160 (Ohimain, 2014). New factories were built to manufacture HQCF, glucose syrup and starch. In other cases, however, the effects of government policy were limited. The Cassava Transformation Agenda (part of the broader Agricultural Transformation Agenda) aimed to encourage commercially oriented cassava farmers linked to businesses that could drive reliable demand for cassava. Yet although two major flour mills introduced a new 10 per cent HQCF "composite flour" product, traditional bread flour still contains very little or no HQCF (Dahlberg Global Development Advisors, 2015).

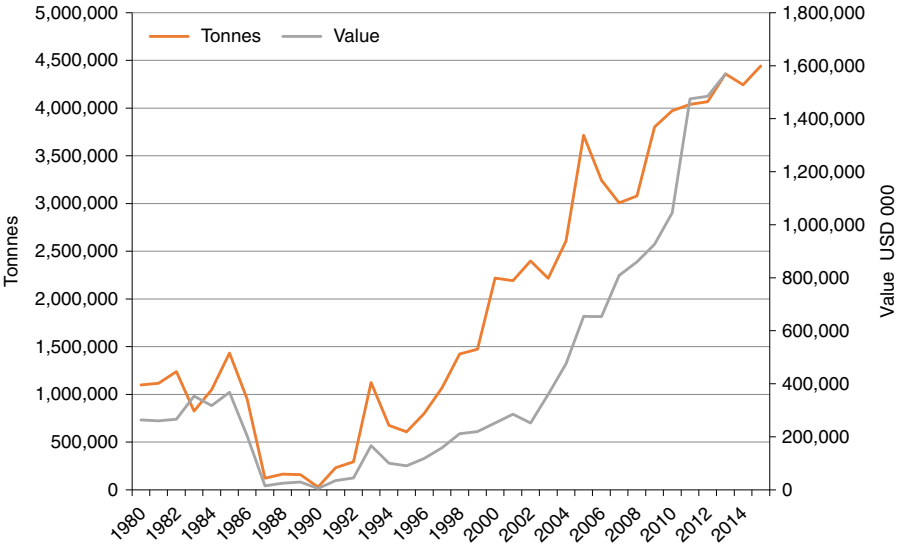
Advocates of cassava flour have argued that stipulations of minimum thresholds for inclusion must be backed up by legislation that will ensure continuity with changes in government. In 2012 the government of Goodluck Jonathan introduced a bill seeking to make it mandatory for the inclusion of cassava in the production of all flour products in Nigeria. However, the bill was rejected by the House of Representatives. Opposition to the bill was led from within the ruling party, which argued against the bill on health grounds, claiming that "30 to 40 per cent of Nigerians are diabetic and it will be unfair to compel them to eat cassava products since most diabetic patients are barred from consuming foods such as cassava"[5]. They advised the government to find alternative ways of enhancing the export of cassava (Channels Television, 2012). Consequently, although the Buhari government appears to have maintained the 10 per cent inclusion of HQCF in bread flour, the Agricultural Promotion Policy (2016-2020) no longer prioritises cassava for the domestic market, but instead aims to improve cassava value chains (starch, chips and ethanol) for the export market.

Had the government enforced the stipulation of 10 per cent inclusion of HQCF in bread flour, therefore, the prospects for the development of the value chain for HQCF were bright. The growing popularity of wheat products could have increased the demand for cassava, stimulating market-led innovation throughout the value chain. This can be represented as a missed opportunity. However, this scenario assumes that the supply of HQCF was competitive with wheat imports in terms of availability, price and quality.

Demand for and availability of HQCF

The main potential market demand for HQCF is as a substitute for wheat. In stark contrast to the value chain for HQCF, the value chain for wheat products has boomed. The value chain for wheat flour – which is primarily consumed as bread – is supplied almost entirely by imports of wheat grain. Following the end of the import ban in 1991, there has been a surge in wheat imports (Figure 2). In 2015, imports reached 4.4 million tonnes, three times the level reached prior to the import ban in 1985. Wheat imports per capita have increased from 2.3 kg/capita in 1987 at the time of the wheat import ban to 26.4 kg/capita in 2005. As elsewhere in SSA, the key demand drivers include population growth, rising incomes, urbanisation, and the growing participation of women in the labour force. Another important demand driver in Nigeria has been the declining price of wheat relative to other staples such as maize and rice (Mason *et al.*, 2012). Wheat imports are forecast to continue to rise, with wheat consumption in Nigeria rising faster than the global average until 2020 (KPMG, 2016).

For end users to have sufficient incentive to include HQCF in bread flour, the price of HQCF needs to be significantly lower than the price of wheat flour, in order to cover the costs involved in switching and the fact that, in the case of bread, only a relatively small percentage can be substituted without affecting the properties of the final product. This means, for example, that if an enterprise moves to a 20 per cent replacement rate, that enterprise is not comparing wheat flour with HQCF flour, but rather wheat flour with a 80 per cent wheat – 20 per cent HQCF blended flour.



Source: FAOSTAT and USDA-FAS (2016)

Figure 2.
Volume and value of wheat imports, Nigeria, 1980-2014

Although there is no long-term price series available for HQCF, between 2004 and 2014 prices at the factory gate were fixed through an agreement involving processors and millers at Naira 80,000 per tonne, raised to Naira 150,000 per tonne in 2015. Comparing these prices with the mean price of wheat flour shows that HQCF has a definite price advantage (Table III). With an inclusion rate of 100 per cent, the price advantage ranged from around Naira 1,000 to almost 3,000 per 50 kg bag. With an HQCF inclusion rate of 20 per cent, however, the price advantage of the wheat/HQCF blend over pure wheat flour drops to between Naira 200 – 550 per 50 kg bag. This gives a price advantage of below 10 per cent, which suggests while HQCF is competitive with wheat flour, the margin of advantage is relatively small.

In consumer acceptance tests, the acceptability of bread with HQCF decreases as the percentage of HQCF increases. Bread with up to 20 per cent HQCF inclusion does not significantly differ from bread made with 100 per cent wheat flour (Eddy *et al.*, 2007). Although, consumers may be unable to distinguish between bread made with 20 per cent

Year	US$/Naira exchange rate	Wheat flour					Price advantage for HQCF		HQCF price advantage at 20% inclusion (%)
		Golden penny	Superfine	Dangote	Mean	HQCF	100%	20%	
2009	149	5,100	5,090	4,940	5,043	4,000	1,043	209	4
2010	150	5,450	5,440	4,950	5,280	4,000	1,280	256	5
2011	154	5,950	6,060	5,850	5,953	4,000	1,953	391	7
2012	157	6,900	6,900	6,550	6,783	4,000	2,783	557	8
2013	157	6,900	6,900	6,400	6,733	4,000	2,733	547	8
2014	159	6,900	6,900	6,400	6,733	4,000	2,733	547	8
2015	255	9,100	9,100	8,500	8,900	7,500	1,400	280	3

Source: For wheat flour, KPMG (2016)

Table III.
Average wholesale price of wheat flour and HQCF, 2004-2015 (Naira/50 kg bag)

HQCF and that made from pure wheat flour, they may be reluctant to buy bread clearly labelled as HQCF, even when it is cheaper (Box 1). Consumers view the higher price of bread made from pure wheat flour as a premium for quality, and are prepared to pay extra for this perceived indicator of quality. HQCF may be profitable in theory, but unprofitable in practice if consumers refuse to buy HQCF bread without price discounts or if it remains unsold because it is perceived to be an inferior product.

One key area of uncertainty is the inconsistent supply of HQCF in large volumes of appropriate quality. Processors face challenges aggregating and transporting cassava roots to factories through a value chain originating from many smallholders, as well as with meeting quality standards. Millers face similar problems. The big mills are wary of buying small volumes of HQCF from large numbers of SME suppliers with the associated risk of variable quality and possible damage to their brand reputation (United Nations Industrial Development Organisation (UNIDO)/Federal Government of Nigeria (FGN), 2006; Graffham *et al.*, 2013; Ohimain, 2014).

Availability and prices of cassava roots

Cassava production in Nigeria shows an uneven trend, with a period of rapid growth followed by relative stagnation (Figure 3). Between 1983 and 1993, total production of cassava roots trebled, attributed to the introduction of high-yielding TMS cassava varieties (Nweke, 2004). This partially coincided with the period of a wheat import ban, 1987 to 1991. Production levelled off from the early 1990s to the early 2000s. This slowdown is attributed to labour bottlenecks in harvesting, suggesting that the adoption of labour-saving technology was now the critical challenge for 'cassava transformation' in Nigeria. However, from 2002 to 2014 annual cassava root production increased, but with some marked periods of scarcity and glut (Dahlberg Global Development Advisors, 2015).

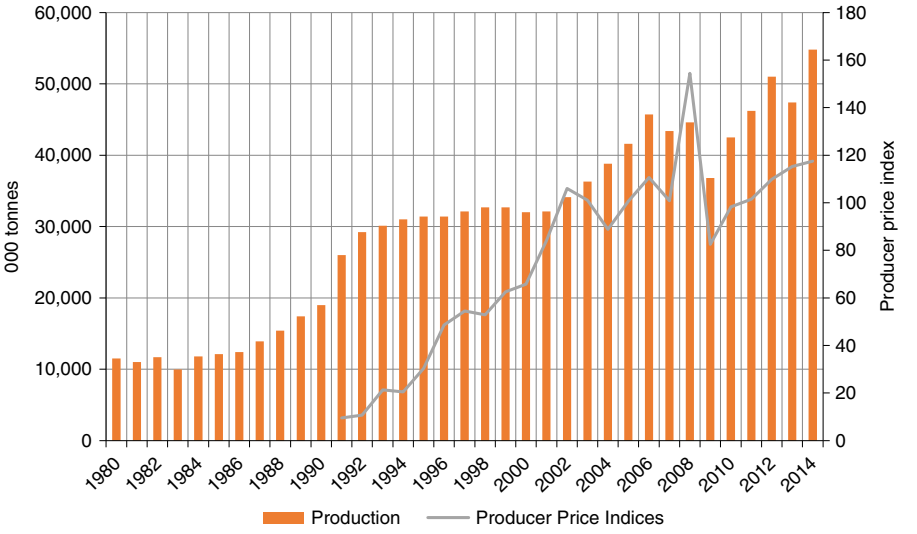
Although total cassava root production has increased, production per capita has shown a different pattern (Figure 4). There was a dramatic doubling of per capita cassava production between 1983 and 1993, which included the period of the wheat import ban, accompanied by falling prices to consumers. The subsequent period up to 2001 showed a fall in per capita production, and an increase in producer prices, leading to a rise in consumer prices relative to other staples (Nweke, 2004). Despite the rise in total root production since 2001, per capita

Box 1. Consumer responses to HQCF bread

A bakery working with the C:AVA project reported that the big motivation for making HQCF bread was the difference in price of wheat flour when compared to HQCF. A 50kg bag of wheat flour costs USD 39.3 whereas a 50 kg bag of HQCF costs USD 21.7). At an inclusion rate of 20% this represents a saving of USD 3.50 per 50 kg of flour. The owner reported that they bake 1,000 x 900gm loaves per day. The HQCF bread sells for a wholesale price of USD 0.83 per loaf and retails in her bakery shop for USD 1 per loaf. The labelling gave no indication of the presence of HQCF and it appeared that the bakery saw HQCF as an economic advantage for the bakery that must be kept hidden from the customer. The pricing structure for the bread matched that of conventional wheat flour loaves, indicating that savings on the cost of production were not being shared with the customer.

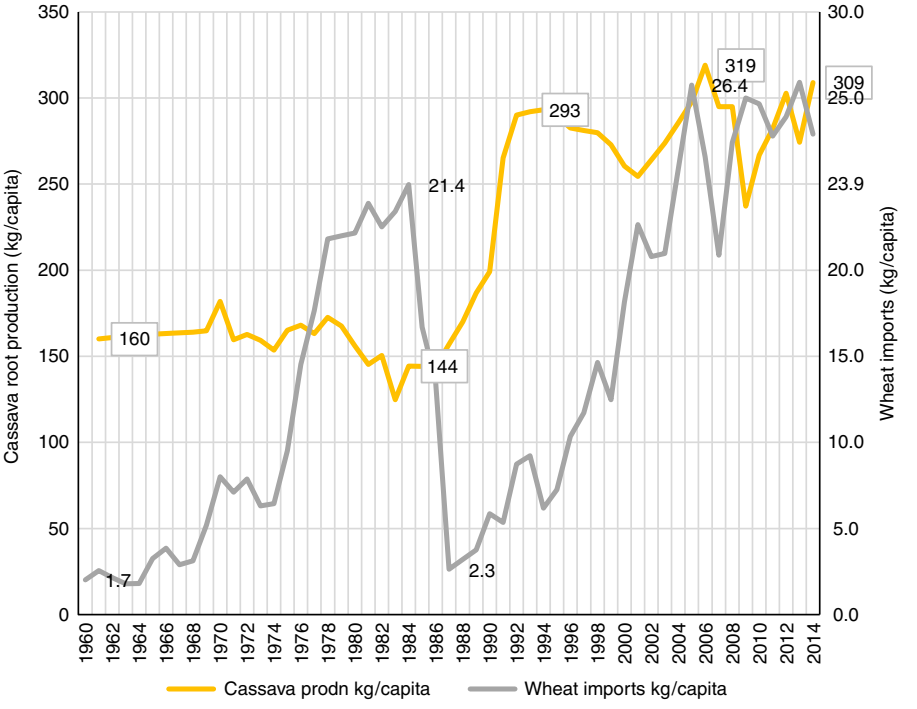
By contrast, a supermarket in Abuja was selling bread with an inclusion rate of 20% HQCF for USD 0.80 per 800g loaf and 100% wheat flour bread for USD 1 per 800g loaf. Packaging was almost identical, but the HQCF bread was clearly labelled as containing cassava and the shelf had large display signs advertising that HQCF cassava bread was on special offer. In the 30 minutes that the team talked with the store manager, there was a brisk trade in wheat bread but not a single loaf of HQCF bread was sold, despite a 20% discount.

Source: Graffham and Linton (2016)



Source: FAOSTAT

Figure 3.
Cassava production and price trends in Nigeria, 1980-2014



Source: FAOSTAT

Figure 4.
Cassava production and wheat imports per capita, Nigeria, 1960-2014

production has not shown a marked increase. Cassava root prices, although fluctuating, have generally shown an upward trend in the latter period. Wheat imports per capita, after recovery from the wheat import ban, returned to their prior levels by the early 2000s, but there has been no substantial further increase. To reduce levels of uncertainty there is a need for a further increase in cassava productivity such that it retains profitability for farmers, but becomes available at prices competitive for the HQCF industry.

Seasonality of supply is important in terms of both availability and price of roots to HQCF processors. In Nigeria, cassava is mainly harvested in the wet season, particularly in the major cassava producing areas of the south west. The primary reason for this is the difficulty of getting labour at the right price to uproot from dry soils. Another reason is the need to preserve planting materials for subsequent plantings (Dr Samson Adeola Odedina, Cassava Agronomist, 2014).

The supply and cost of energy

A fourth major source of uncertainty has been fluctuations in the supply and price of energy required for processing. This is an additional disincentive for entrepreneurs considering investment in the flash dryers that are required for the efficient manufacture of HQCF. High energy costs squeeze profit margins because HQCF processing is more energy intensive than wheat flour milling, which contributes to explaining the high failure rate of SMEs producing HQCF. Marchant *et al.* (2015) estimate the energy consumed in the processing of HQCF to be 3.2 to 14.3 MJ/kg, which compares to the Olaoye *et al.* (2014) estimate of 0.101 MJ/kg to mill wheat flour. Nigeria has an installed electricity generation capacity for supply to the national grid of 12,522 MW, but has an available capacity of only approximately 4,500 MW. At the end of January 2016, the demand for electricity in Nigeria was estimated to be 12,800 MW (Latham and Watkins Africa Practice, 2016). This mismatch between demand and supply results in frequent power outages. A recent survey of companies reported that for SSA as a whole, the average number of power outages was 8.3 per month. For Nigeria, the figure was 32.8, rising to 44.3 for large firms with 100 employees or more (Latham and Watkins Africa Practice, 2016).

As a result, HQCF processors supply their own energy using diesel-powered generators. This not only increases the cost of production but also the negative impact on the environment caused by using fossil fuels. Energy is required to generate heat and power the flash dryer. The cost of energy in HQCF processing depends on a number of factors, including the type and source of fuel and the efficiency of the drying process. Fuel costs for the flash drying process are the second highest component of costs in HQCF production. Based on use of fossil fuels, fuel represented 36 per cent of the total cost of producing HQCF in 2014, of which 33 per cent is for heating and 3 per cent for the generator (Marchant *et al.*, 2015). Foreign exchange scarcity and the removal of fuel subsidy in May 2016 also contributed to the increasing costs of domestic production. Diesel prices rose by 42 per cent between July 2015 and July 2016, following the removal of government subsidy in May 2016 (National Bureau of Statistics, 2016). This has tightened the profit margin on HQCF processing.

4. Responses to uncertainty

Shaping

On the supply side, the main shapers of the HQCF value chain have been the supporting services. These include the research organisations – the Federal Institute of Industrial Research, Oshodi (FIIRO) and the International Institute for Tropical Agriculture – that initially developed HQCF as a product.

On the supply side, research has also involved the design of processing equipment, particularly flash-dryers. To address the costs and uncertainty associated with flash drying,

processing enterprises have sought cheaper fuel sources such as waste oil and coal. Researchers modified existing flash dryers to achieve major gains in energy efficiency, and identified alternative fuel sources from waste products such as cashew nut and palm kernel shells. Energy consumption ranges from 14.2 MJ/kg of HQCF to an improved 2.9 MJ/kg of HQCF. An economic and carbon emission assessment of the heat exchangers with alternative fuel sources showed fuel cost reductions of 90 per cent (Marchant *et al.*, 2015). Nigeria's main manufacturer of flash dryers has produced at least 25 of these improved high efficiency, high throughput oil-fired units, and 15 SMEs have been retrofitted with waste fuel heat exchangers. Theoretically, the maximum output from these units is around 200 tonnes of HQCF per day, which is higher than that of largest HQCF factory in the country. However, some of the perceived problems with equipment in fact reflect both their challenging operating environment and inefficient management by SMEs. For example, actual operational efficiency is substantially reduced by short production runs and associated warm up times and wasted residual heat after drying (Marchant *et al.*, 2015). SMEs producing HQCF appear to have relatively low adaptive capacity. A recent survey of seven SMEs identified a low skill base of supervisory staff in HQCF factories, frequent change-overs, and weak management (Abayomi and Adegoke, 2016). The leading role played by public research in reducing fuel costs illustrates the limited capacity of SMEs to adapt to the uncertainties they face. While Nigeria can manufacture fuel-efficient flash dryers, R&D to adapt this equipment to changes in the economic environment continues to rely on public funds. Even with this support, SMEs processing HQCF in Nigeria have found it hard to survive.

On the demand side, the main shaper has been the government of Nigeria, primarily through a range of policy interventions. As we have seen, these policies to shape the economic environment in favour of HQCF have had limited success. The USA lodged formal complaints against Nigeria in response to the ban on wheat imports, citing violation of the General Agreement on Tariffs and Trade. These complaints were settled through bilateral negotiation and consultation (Oyejide *et al.*, 2012). Similarly, the milling industry has largely ignored government stipulations to include 10 per cent HQCF in bread flour. During the implementation of the Agricultural Transformation Agenda in 2012, the Minister of Agriculture and Rural Development, Dr Akinwumi Adesina, accused the flour milling industry of being "bent on undermining the efforts of the Federal Government" to promote greater use of cassava flour in bread, with the government now "importing 18 quality cassava mills from China to […] break the monopoly of flour millers" (CTA Agritrade, undated). In fact, no mills were ever purchased. This illustrates the limits of government policy in the face of entrenched industrial interests.

Adapting

Most smallholder cassava growers in Nigeria sell at least some cassava, either as fresh roots or in the form of processed products. Demand for these traditional food products has grown with population and urbanisation. More recently, demand for traditional products such as *gari* has further increased due to purchases for food aid for internally displaced people in northern Nigeria. This has created significant competition for cassava roots in some locations, including areas where HQCF enterprises are located. Competition for cassava roots has driven up prices, further eroding profit margins for HQCF processors. Although sales volumes may be lower, *fufu* and *gari* are often more profitable than HQCF. Moreover, the uncertainty surrounding the value chain for HQCF has meant that the demand for cassava from HQCF processors has been irregular, and they have been unable to compete on price with processors of alternative cassava products. As a result, many cassava growers have experienced problems supplying or have been unwilling to supply the value chain for HQCF. The high cost of fresh roots is particularly a problem for processors without their

own farms. Despite this, growers complain of cassava being rejected at the factory-gate, not because of poor quality, but due to lack of demand. This in turn prompts growers to reduce production in the following season, perpetuating the cycle of over - and under-supply and uncertainty over availability. At the same time, factory managers complain of not being able to access sufficient cassava roots (Abayomi and Adegoke, 2016). Clearly, there is a need for better information to reduce uncertainty about supply and demand, particularly for farmers. The majority of sales are on the basis of spot markets rather than negotiated contractual arrangements, which increases the uncertainty.

The advent of the value chain for HQCF was expected to increase the demand for fresh roots, and lead to further expansion in the area planted to cassava. Following the cassava inclusion policy, farmers expanded their cassava production in expectation of increased market demand, but when demand was not forthcoming they reverted to former markets, principally traditional food product markets. Farmers have adapted to uncertainty in the value chain for HQCF by switching or reverting to alternative chains. This illustrates another property of complex adaptive systems – interactions between agents. In the HQCF value chain, uncertainty in the demand for cassava from processors has resulted in uncertainty over supply, as smallholders switch to alternative buyers which creates further uncertainty in the chain. Farmers' willingness and ability to supply roots at the prices offered are a major source of uncertainty for processors, while processors and their level of demand and prices offered are an important source of uncertainty for farmers.

SME processors entered the industry in response to a favourable policy environment. They assumed that the stipulation of 10 per cent inclusion of HQCF in bread flour would stimulate demand, and that (over time) HQCF could compete on price with wheat flour. Together with other forms of support, this induced SMEs to make "big bets" and invest in HQCF processing. As these assumptions unravelled, processors were forced to adapt in order to survive. Many have made no-regret moves to reduce their costs (e.g. switching sources of fuel) and diversified into more certain markets such as *gari* and instant *fufu*. Nigeria produced an estimated 4.2 million tonnes of *gari* in 2009 (Nnadozie *et al.*, 2015), compared to only 13,000 tonnes of HQCF. Another adaptive strategy has been vertical integration. Investing in their own farms cushions processors against the high elasticity of cassava supply and reduces the problem of unused capacity. The largest HQCF processing enterprise established by foreign investors in Ogun state bought cassava roots directly or indirectly from hundreds of farmers in at least six states. It has now invested in a very large scale farm.

An alternative adaptive strategy has been to cut transport costs by first processing cassava roots into wet cassava cake at village level before reaching the HQCF factory. One factory (with a capacity of 15,000 tonnes/year) relied on mobile processing units to obtain wet cake from rural locations for drying and milling at the main factory. However, this closed in 2013. Another strategy to reduce the ex-factory transport costs is to sell HQCF to local users such as smaller bakeries and food processors close to the factory gate. One SME successfully sells HQCF to a biscuit manufacturer in Sagamu, 3 km from the HQCF factory. This biscuit manufacturer uses 10 per cent HQCF in class "C" biscuits. As HQCF is cheaper than wheat flour in that location, and given the tight margins in class "C" biscuits, even 10 per cent inclusion of HQCF is attractive to this biscuit maker (Graffham *et al.*, 2013). Rural bakers could use HQCF at up to 20 per cent inclusion without serious adverse effects on loaf volume and colour, but bakers would have to make changes to their recipes and adopt different baking techniques to get the best results. Successful marketing of HQCF to the rural bakery sector would involve considerable promotion with demonstrations, training and recipe support to enable bakers to take advantage of the cheaper flour (Graffham *et al.*, 2013).

Collaboration and collective action by processors provides a further means of adapting to uncertainty. The National Cassava Processors and Marketers Association (NCAPMA) – formed in 2008 – by the then CEO of FIIRO, at the insistence of the former President Obasanjo – harmonised all the cassava processor associations under one umbrella, with the mission to industrialise Nigeria through Cassava Value Addition (http://ncapma.org/about/). According to NCAPMA's website, benefits to members include: better government recognition for cassava development, access to finance, better control of market forces giving advantages in price bargaining, regulation of quality control to minimise financial losses, opportunity to manage government funded processing centres in public/private partnership, and reducing production costs through economies of scale. However, it is not clear whether these benefits have actually been achieved.

Reserving the right to play

The actors with the greatest capacity for adaptation to uncertainty – the wheat milling companies – have largely stayed out of the HQCF value chain. They have reserved the right to play.

The wheat milling industry in Nigeria dates from the 1960s and is well-established (Andrae and Beckman, 1985). Millions of tonnes of wheat are injected into the Nigerian economy each year through the decisions of a small number of firms and individuals. Millers, traders and bakers have established an industry where the quantity and quality of the main commodity is relatively well controlled. This wheat business network has the capacity to handle bulk with speed and hence stakeholders have a strong interest in maintaining the status quo and the flow of imports.

The wheat milling industry has successfully adapted to uncertainties in the supply of wheat imports. It has coped with a declining and fluctuating exchange rate and a wheat ban from 1987-1991, which saw changes in officially recorded wheat imports per capita from 21.4 in 1986 to 2.3 in 1987 and rising to 26.4 in 2005. In 2016, depreciation of the Naira and high domestic food prices weakened consumers' purchasing power, preventing wheat millers from further raising wheat flour prices. Millers adapted by blending and adjusting their wheat milling formulas to achieve bread flour that was acceptable to bakers while maintaining favourable profit levels. The milling industry has also adapted to falling profitability by switching suppliers. Nigerian consumers prefer flour made from US Hard Red Winter wheat (USDA-FAS, 2016). However, US wheat is more expensive than that of competitors. Scarcity of foreign exchange and rising inflation resulted in supplies from the USA declining from over 90 per cent of total Nigerian wheat imports in 2012, to 33 per cent in 2016, while Russian supplies increased from less than 1 to 28 per cent.

The proven ability of the Nigerian wheat milling industry to adapt to changes in the world market for wheat means that they occupy a privileged position which has allowed them to reserve the right to play as long as incentives are limited and high levels of uncertainty remain in the value chain for HQCF. The consensus is that consistent supply of HQCF is the prime area of uncertainty for the milling industry. This helps explain why they have reserved the right to play and why after so many years HQCF is still not being incorporated into bread flour.

Some milling companies have begun to explore the options for securing a regular supply of flour. FMN recently (2012) acquired the largest HQCF processing enterprise established by foreign investors in Ogun state. This enterprise buys cassava roots directly or indirectly from hundreds of farmers in at least six states. This was followed by further backward integration with investments in the acquisition of land for large-scale, heavily mechanised farms in order to secure the supply of fresh cassava roots. To protect its existing brands, FMN incorporates HQCF into separately branded composite flours, or sells to food processing companies. Other wheat milling companies

are vertically integrating to produce food products using their own wheat flour, with potential scope for HQCF. Until now, the players with the greatest capacity to shape the industry have had insufficient incentives to take on this role. However, FMN's recent investments may signal a change of role that could shape the future of the HQCF value chain. This is happening as the milling industry in Nigeria faces fierce internal competition, low profit margins, and high levels of unused capacity (Table I). Faced with these market conditions, millers are finally prepared to make 'big bets' in the HQCF value chain, for example FMN have acquired the biggest HQCF factory in Nigeria and then further backward integrated by planting 1,000s of ha of cassava through large scale mechanisation. However, the business model which allows the wheat milling industry to adapt to uncertainties in the value chain for HQCF has implications for other business actors. Private investment in large factories and mechanised cassava root production will give economies of scale, reduce the high cost of manual labour through mechanisation, and ensure continuity and security of supply. However, this may tend to exclude both smallholders, particularly women (Forsythe *et al.*, 2016), who cannot consistently produce at the required volumes because of limited land, capital and SMEs. Large-scale mechanised monocrop cassava farming also brings with it environmental risks (Alufohai and Oyoboh, 2013; FAO, 2013; Reynolds *et al.*, 2015). There may be significant trade-offs between adapting to uncertainties through shifting towards large-scale, integrated supply chain management with relatively few actors, and achieving social inclusion of small-scale producers and processors, and minimising environmental impacts such as soil degradation and biodiversity loss.

5. Conclusions

This paper used the framework of complex adaptive systems to help explain the development of the HQCF value chain in Nigeria. We identified several sources of uncertainty that have played a pivotal role in restricting the development of the value chain, including changes in the policy environment, the demand for and supply of HQCF, the availability and price of cassava roots, and the availability and cost of energy for flour processing. Value chain actors have responded to these uncertainties in different ways. Analysing these responses in terms of adaptation provides useful insights into why the value chain for HQCF in Nigeria has been so slow to develop.

Among the key factors which have influenced the performance of the value chain has, until recently, been the reluctance of the actors with the greatest adaptive capacity (the wheat milling companies) to engage in the HQCF industry – they reserved the right to play. Without their participation, the value chain for HQCF in Nigeria has lacked an essential player. In the absence of demand for HQCF from the milling industry, other actors in the value chain have had mixed fortunes. Smallholders have adapted to the lack of demand for HQCF by supplying cassava roots to rival value chains. Growing demand for a wide range of processed cassava products, namely *gari* and *fufu*, have kept prices for cassava roots high and benefitted growers. The main losers have been the HQCF processors, who have struggled to survive, their profit margins squeezed by stiff competition from buyers of cassava to make *fufu* and *gari*, high energy costs, high costs of aggregation and the lack of strong demand from the milling industry.

Consequently, there has been a high failure rate among HQCF processors – most of which are small, under-capitalised SMEs with limited management and technical skills. The players that have made the biggest bets in the HQCF value chain have also had the least capacity to adapt to uncertainty.

The main shapers of the value chain have been research organisations and the government. While research was able to develop technically suitable technology, its successful operation required favourable conditions for the development of the

value chain. Governments attempted to create this environment using strongly directive policies, but these were applied inconsistently and never enforced. Indeed, along with its over-reliance on oil revenues and failure to provide a sustainable and affordable energy supply, government policy itself became a major source of uncertainty in the value chain. However, government policy can only support the need for the value chain to be market-led. It cannot itself lead the market. Without demand from the wheat milling industry, and their active participation in the value chain, there were limits to what policy-makers could achieve.

Recent developments, particularly the trend towards vertical integration by wheat milling companies, suggest that the most effective strategy for the milling industry to reduce uncertainty in the HQCF value chain is to produce their own cassava roots and flour. This may enable the production of HQCF at lower cost (through mechanisation and reduction of aggregation costs) and with more secure and consistent supply. These principles are also observed in tendency to source larger volumes of roots from larger scale farmers rather than engage in aggregating supplies from many small producers. This raises concerns about equity. Until now, it has generally been assumed that the development of the value chain for HQCF can combine both growth and equity objectives, providing opportunities for smallholder farmers and small and medium scale processors. The validity of this assumption now seems to be open to question. Also to be considered are the potential long term environmental impacts of large scale mechanised, monocrop cassava production. The extent to which these developments of HQCF value chains can combine economic growth, equity and environmental objectives, as set out in the Sustainable Development Goals, is an open question.

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Notes

1. https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals
2. *Fufu* is a dough produced by crushing and then sieving roots which have been fermented in water for three days. The sieved mass is then left to settle for 24 hours, after which the liquid is poured off and the sediment is pressed overnight in a suitable bag to dewater it. The resulting wet paste "wet *fufu*" may then be sold in that form, or cooked and sold as a ready to eat product. A more recent development has been dry *fufu* powder.
3. *Gari* is made by peeling and grating roots and fermenting for three days before squeezing in a sack to de-water. The product is then sieved and roasted in a large iron pan or an earthen pot over a fire. After cooling the product may be sieved again and then this fermented gelatinised flour can be stored in bags for up to three months. When required, the *gari* is reconstituted in boiling water and stirred to produce a stiff porridge; it can also be mixed with cold water/milk or sugar and taken as a snack.

4. The low gluten content of HQCF means that dough made with high levels of this flour will not rise in the same way when made from 100 per cent wheat flour.
5. The Minister of Agriculture, Dr Akinwnumi Adesina, responded in defence of HQCF that in fact cassava is better than processed white wheat flour with a much lower Glycemic Index (an indicator of how much and quickly sugar is released from food eaten) of 59 than that of wheat at 71. Available at: http://odili.net/news/source/2012/may/27/20.html.

References

Abayomi, L. and Adegoke, A. (2016), "High quality cassava flour (HQCF) case study report", Increasing Performance of the Cassava Industry in West and Central Africa Region (IPCI) January-March, NRI report for IFAD, Chatham, available at: http://projects.nri.org/cassava-ipci/images/documents/CAVA-IFAD-HQCF-SME-Nigeria-case-study_final.pdf

Abdoulaye, T., Abass, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. and Ayedun, B. (2014), "Awareness and adoption of improved cassava varieties and processing technologies in Nigeria", *Journal of Development and Agricultural Economics*, Vol. 6 No. 2, pp. 67-75.

Adepoju, A.O. and Oyewole, O.O. (2013), "Household's perception and willingness to pay for bread with cassava flour inclusion in Osogbo metropolis, Ogun state, Nigeria", *Paper presented at the 4th International Conference of the African Association of Agricultural Economists*, *22-25 September*, *Hammamet*, p. 17.

Adeyemo, R., Oke, J.T.O. and Akinola, A.A. (2010), "Economic efficiency of small scale farmers in Ogun State, Nigeria", *Tropicultura*, Vol. 28 No. 2, pp. 84-88.

Alufohai, G.O. and Oyoboh, D.E. (2013), "Environmental impacts of commercial agriculture in Nigeria", *A Review. Paper presented at the 4th International Conference of the African Association of Agricultural Economists*, *22-25 September*, *Hammamet*.

Andrae, G. and Beckman, B. (1985), *The Wheat Trap: Bread and Underdevelopment in Nigeria*, Zed Press, London.

Butterworth, R., Abdulsalam-Saghir, P. and Martin, A. (2008), "Gender and diversity report – Nigeria. C:AVA Cassava adding value for Africa", p. 48, available at: http://cava.nri.org/images/publications/Nigeria_GDSituationalAnalysis.pdf (accessed 20 January 2017).

Channels Television (2012), "Lawmakers reject Jonathan's cassava bread", Channels television, 23 May, available at: www.channelstv.com/home/2012/05/23/lawmakers-reject-jonathans-cassava-bread/ (accessed 6 January 2017).

Courtney, H., Kirkland, J. and Viguerie, P. (1997), "Strategy under uncertainty Harvard business review", November-December, available at: https://hbr.org/1997/11/strategy-under-uncertainty (accessed 19 January 2017).

CTA Agritrade (undated), "Nigeria implements import duty reforms to promote cassava flour use", available at: http://agritrade.cta.int/en/layout/set/print/Agriculture/Commodities/Cereals/Nigeria-implements-import-duty-reforms-to-promote-cassava-flour-use (accessed 20 December 2016).

Dahlberg Global Development Advisors (2015), "Market opportunities for commercial cassava in Ghana, Mozambique, and Nigeria", available at: www.growafrica.com/resources/new-study-market-opportunities-commercial-cassava-grow-africa-secretariat-idh-and-dalberg (accessed 6 September 2017).

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) (2007), "ValueLinks manual: the methodology of value chain promotion", First edition, available at: www2.giz.de/wbf/4tDx9kw63gma/ValueLinks_Manual.pdf (accessed 20 January 2017).

Eddy, N.O., Udofia, P.G. and Eyo, D. (2007), "Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference", *African Journal of Biotechnology* , Vol. 6 No. 1, pp. 2415-2418.

Eriksson, E., Koch, K., Tortoe, C., Akonor, P.T. and Oduro-Yeboah, C. (2014), "Evaluation of the physical and sensory characteristics of bread produced from three varieties of Cassava and wheat composite flours", *Food and Public Health*, Vol. 4 No. 5, pp. 214-222, doi: 10.5923/j.fph.20140405.02.

Falade, K.O. and Akingbala, J.O. (2008), "Improved nutrition and national development through the utilization of cassava in baked foods in using food science and technology to improve nutrition and promote national development", in Robertson, G.L. and Lupien, J.R. (Eds), *International Union of Food Science and Technology*, Chapter 10, Ontario, CA, available at: www.iufost.org/publications/books/documents/Chapter10FaladeAkingbala.pdf (accessed 20 December 2016).

Federal Ministry of Agriculture and Rural Development (2016), "The agriculture promotion policy (2016 – 2020) building on the successes of the ATA, closing key gaps policy and strategy document. Policy and strategy document", Federal Ministry of Agriculture and Rural Development, Abuja, available at: http://fmard.gov.ng/wp-content/uploads/2016/03/2016-Nigeria-Agric-Sector-Policy-Roadmap_June-15-2016_Final.pdf (accessed 7 January 2017).

Food and Agriculture Organisation (FAO) (2013), "Save and grow: cassava a guide to sustainable production intensification", available at: www.fao.org/docrep/018/i3278e/i3278e00.htm (accessed 20 January 2017).

Forsythe, L., Posthumus, H. and Martin, A. (2016), "A crop of one's own? Women's experiences of cassava commercialization in Nigeria and Malawi", *Journal of Gender, Agriculture and Food Security*, Vol. 1 No. 2, pp. 110-128.

Graffham, A. and Linton, J. (2016), *Coordination Visit to Ghana & Nigeria to Update on Progress with C:AVA:2 and Modalities of Future Inputs by NRI*, Natural Resources Institute University of Greenwich, Chatham, September.

Graffham, A., Naziri, D., Sergeant, A., Sanni, L., Abayomi, L. and Siwoku, B. (2013), "Market opportunities for cassava in Nigeria", C:AVA report, NRI, Chatham, available at: https://agriknowledge.org/downloads/mk61rg97b

Howeler, R.H. (2002), "Cassava mineral nutrition and fertilization in Cassava: biology, production and utilization", in Hillocks, R.J., Thresh, J.M. and Bellotti, A. (Eds), Cassava Biology, Production and Utilization, CABI Publishing, Wallingford, pp. 115-147.

Kleih, U., Sanni, L., Dipeolu, A., Abass, A., Abdulsalam-Saghir, P., Butterworth, R. and Siwoku, B. (2008), *Value Chain Analysis for Nigeria. Submitted to Cassava: Adding Value for Africa (C:AVA)*, Natural Resources Institute, Chatham.

Komlaga, G.A., Glover-Amengor, M., Dziedzoave, N.T. and Hagan, L.L. (2012), "Consumer acceptability of wheat/cassava composite bread", *World Rural Observations*, Vol. 4 No. 2, pp. 78-81.

KPMG (2016), "Wheat-based consumer foods in Nigeria", available at: https://assets.kpmg.com/content/dam/kpmg/co/pdf/005-wheat-based-consumer-foods-in-nigeria.pdf (accessed 20 January 2017).

Lamboll, R., Ilona, P., Dipeolu, W., Abdulsalam-Saghir, P., Gibson, R., Sanni, L., Martin, A., Odedina, S. and Siwoku, B. (2008), *C:AVA Nigeria Situation Analysis: Scoping studies for C:AVA Objective 1*, Natural Resources Institute and Mimeo, Chatham, p. 78.

Lamboll, R., Nelson, V., Posthumus, H., Martin, A., Adebayo, K., Alacho, F., Dziedzoave, N., Mahende, G., Sandifolo, V., Sanni, L., Abayomi, L., Graffham, A., Hillocks, R. and Westby, A. (2015), "Practical lessons on scaling up smallholder-inclusive and sustainable cassava value chains in Africa", *Food Chain*, Vol. 5 Nos 1-2.

Latham and Watkins Africa Practice (2016), "Nigerian power sector: opportunities and challenges for investment in 2016", Latham and Watkins Client Alert White Paper No. 1930, available at: www.lw.com/thoughtLeadership/lw-nigerian-power-sector-opps-and-challenges

Marchant, A., Graffham, A., Sanni, L. and Adeoya, I. (2015), "Dramatic efficiency gains through improved heat exchangers: the case of cassava flash drying in Nigeria", *Food Chain*, Vol. 5 Nos 1/2, pp. 91-104.

Mason, N.S., Jayne, T.S. and Shiferaw, B. (2012), "Wheat consumption in Sub-Saharan Africa: trends, drivers, and policy implications", MSU International Development Working Paper No. 127 Published jointly with CIMMYT, available at: http://fsg.afre.msu.edu/papers/idwp127.pdf

Maziya-Dixon, B., Alamu, E.O., Popoola, I.O. and Yomeni, M. (2017), "Nutritional and sensory properties", *Snack Food Made From High-Quality Cassava Flour and Legume Blend Food Science and Nutrition*, Vol. 5, pp. 805-811.

National Bureau of Statistics (2016), "National Bureau of Statistics automotive gas oil (diesel) price watch", October, available at: www.nigerianstat.gov.ng/report/465 (accessed 20 January 2017).

Naziri, D., Quaye, W., Siwokul, B., Wanlapatit, S., Viet Phu, T. and Bennett, B. (2014), "Market opportunities for commercial cassava in Ghana, Mozambique, and Nigeria the diversity of postharvest losses in cassava value chains in selected developing countries", *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, Vol. 115 No. 2, pp. 111-123.

Nnadozie, A.K.O., Ume, S.I., Isiocha, S. and Njoku, I.A. (2015), "Nigerian Cassava potentials in national economic development", *Science Journal of Business and Management*, Vol. 3 Nos 5/1, pp. 47-49, doi: 10.11648/j.sjbm.s.2015030501.20.

Nweke, F. (2004), "New challenges in the cassava transformation in Nigeria and Ghana", EPTD Discussion Paper No. 118, International Food Policy Research Institute, Washington, DC, available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.58.2411&rep=rep1&type=pdf (accessed 6 September 2017).

Ohimain, E.I. (2014), "The prospects and challenges of composite flour for bread production in Nigeria Global", *Journal of Human Social Science*, Vol. 14 No. 3, pp. 32-42, (accessed 6 September 2017).

Olaoye, O.S., Adefajo, A.A. and Ekundayo, S.O. (2014), "Energy analysis of a wheat processing plant in Nigeria", *ARPN Journal of Engineering and Applied Science*, Vol. 9 No. 9, pp. 1586-1591.

Olayimika, O.M., Oose, M.O., Apantaku, O.S., Adebowale, A.A. and Ashimolowo, O.R. (2015), "Baker's willingness to utilize high quality Cassava flour (HQCF) for bread production: experience from Ogun state", *Nigeria International Journal of Applied Agricultural and Apicultural Research*, Vol. 11 Nos 1/2, pp. 146-155.

Orr, A., Donovan, J. and Stoian, D. (2018), "Smallholder value chains as complex adaptive systems: a conceptual framework", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 8 No. 1, pp. 14-33.

Oyejide, A., Ogunkola, A. and Bankole, A. (2012), "Prohibition as a trade policy instrument: the Nigerian experience", WTO case studies, available at: http://wtocenter.vn/wto/case-studies/import-prohibition-trade-policy-instrument-Nigerian-experience (accessed 5 January 2017).

Reynolds, T.W., Waddington, S.R., Anderson, C.L., Chew, A., True, Z. and Cullen, A. (2015), "Environmental impacts and constraints associated with the production of major food crops in Sub-Saharan Africa and South Asia", *Food Security*, Vol. 7 No. 4, pp. 795-822.

Sanni, L.O. (2011), "Process and product innovations in the cassava agro-industrial sectors in Africa: The stimulating effect of presidential initiatives", in da Silva, C.A. and Mhlanga, N. (Eds), *Innovative Policies and Institutions to Support Agro-Industries Development*, Food and Agriculture Organization of the United Nations, Rome, pp. 1-8.

Sanni, L. (2012), "Audit of SMEs in Nigeria", unpublished document for the Federal Government, FUNAAB.

Sanni, L.O., Onadipe, O.O., Ilona, P., Mussagy, M.D., Abass, A. and Dixon, A.G.O. (2009), *Successes and Challenges of Cassava Enterprises in West Africa: a Case study of Nigeria, Benin, and Sierra Leone*, International Institute of Tropical Agriculture, Ibadan, p. 19, available at: https://agriknowledge.org/downloads/m613mx61z (accessed 6 September 2017).

United Nations Industrial Development Organisation (UNIDO)/Federal Government of Nigeria (FGN) (2006), *Nigeria Cassava Master Plan (NCMP)*, United Nations Industrial Development Organization and Federal Government of Nigeria, Lagos.

United States Department of Agriculture/Foreign Agriculture Service (USDA-FAS) (2016), "Nigeria Grain and Feed update", available at: www.fas.usda.gov/data/nigeria-grain-and-feed-update-0 (accessed 11 September 2016).

Westby, A. (2002), "Cassava utilization, storage and small-scale processing", in Hillocks, R.J. and Bellotti, A. (Eds), *Cassava Biology, Production and Utilization*, CABI Publishing, Wallingford, pp. 281-300.

Further reading

Adebayo, K. (2005), "Traditional institutions and information uptake in the conduct of Cassava Fufu Market", in Porter, G. and Lyon, F. (Eds), *Investigations on Building A Food Marketing Policy Evidence Base In Nigeria*, Briefing Report No. CNTR 04 5785, November, Report funded by the UK Department for International Development, pp. 102-120.

Dipeolu, A.O., Adebayo, K., Ayinde, I.A., Oyewole, O.B., Sanni, L.O., Pearce, D.M., Wandschneider, T.S., White, J.L. and Westby (2001), Fufu marketing in South West Nigeria|| NRI Report No. 2626, Natural Resources Institute, Kent and University of Agriculture, Abeokuta, p. 45, available at: www.nri.org/research/rootcrops.A0898.doc

Graffham, A., Fabusoro, E., Lam, H. and Adegoke, A. (2015), "Mission Report for Visit to Ogun State Nigeria. Increasing performance of the Cassava industry in West and Central Africa region (IPCI)", 21st September – 1st October, Chatham, available at: http://projects.nri.org/cassava-ipci/reports-and-useful-information

International Fund for Agricultural Development (IFAD) and Food and Agriculture Organisation (FAO) (2005), "A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin", *Proceedings of the Validation Forum on the Global Cassava Development Strategy, Vol. 2, International Fund for Agricultural Development Food and Agriculture Organization of the United Nations*, *Rome*, p. 66, available at: ftp://ftp.fao.org/docrep/fao/009/a0154e/A0154E00.pdf.

Nweke, F.I., Spencer, D.S. and Lynam, J.K. (2002), *The Cassava Transformation: Africa's Best-Kept Secret*, Michigan State University Press, East Lansing, MI.

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