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Governance of Emerging Biomass-Based Value Webs in Africa: Case Studies from Ghana

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EXECUTIVE SUMMARY

Rising global demand for food as well as for feed and biomass-based raw materials such as fuel and fibre crops has increased pressure on the agricultural sector, especially in Sub-Saharan Africa. The expected trend of increased demand for more diverse biomass-based produce from agricultural land effectively transforms the agriculture sector from just a food-supplying to a biomass-supplying sector in the growing international bioeconomy. This transition is leading to the development of biomass-based value webs whereby there are complex systems of interlinked value chains in which food, fodder, fuels, and other raw materials are produced, processed, traded and consumed. Against this background, this thesis aims to evaluate the appropriate roles of the public, private and third (civil society) sectors in facilitating the transformation of the agricultural sector in the developing bioeconomy in Ghana. The study focuses on the emerging value webs of cassava (*Manihot esculenta*) and maize (*Zea mays*), which are the two most important staple crops in Ghana.

Along biomass-based value webs there are a number of pre- and postharvest production, institutional and governance challenges that need to be addressed. This thesis focuses on three current problem areas of biomass-based value webs. These problem areas are related to the governance and institutional dimensions of the utilisation of bioeconomy crops, the sustainability of contract farming arrangements and the efficacy of commercial seed supply. Thus, the thesis explores the governance of biomass-based value webs from a broader perspective, before focusing on two specific aspects. This approach is used to understand the complexity of emerging value webs while also highlighting the importance of specific institutional arrangements to the effective functioning of these value webs. The findings are presented in three empirical chapters of the cumulative thesis (Chapters 2 to 4).

Chapter 2 investigates the requisite policy and institutional environment needed to foster the development of competitive and sustainable biomass-based value webs. For this assessment, the case of cassava, a major staple crop with increasingly diverse utilisations in Ghana, is used for an empirical case study. Chapter 3 focuses specifically on the sustainability of contract farming arrangements for farmers and agribusiness firms as a key aspect of the institutional linkage between biomass production and processing in value webs. Contract farming arrangements for cassava in Ghana are investigated in the wake of its industrial uses. Chapter 4 probes the governance challenges of commercial seed supply, which is integral to increasing farm productivity and the critical mass of crop biomass in value webs. As maize is

the predominant crop in the commercial seed system and the most important cereal crop in Ghana, the commercial maize seed sector is used for an empirical case study. The thesis employed a combination of qualitative and quantitative methods of data collection for these three empirical studies. This entailed the use of participatory mapping tools, namely, Net-Map and Process Net-Map as well as semi-structured in-depth interviews with experts and key informants, focus group discussions, direct observation and a household survey.

The results from Chapter 2 show that despite the substantial opportunities for the utilisation of cassava biomass in Ghana, there are coordination problems between farmers, processors and industrial end-users. There is also the need for more support from the government in the form of local content policies. Chapter 3 finds that ad hoc or opportunistic investments that only address smallholders' marketing challenges are not sufficient to ensure mutually beneficial and sustainable contract farming schemes in fast developing domestic value chains. There is the need for direct firm investment supporting outgrower operations. Public-private partnerships may be the best avenue to sustainably providing ideal contract conditions. Chapter 4 reveals that the well-known constraints caused by the dominance of public sector institutions in seed supply have not been overcome by reform efforts that aimed to promote increased private sector participation. Therefore, there is still a lack of complementary investments by the public sector, the private sector and the yet underdeveloped third sector at the various stages of the seed supply system to ensure that farmers get better access to improved seed varieties. Overall, the findings of these three chapters shed light on the roles public, private and third sector actors are playing along biomass-based value webs of the emerging bioeconomy.

The thesis concludes that growth of the private and third sectors are critical to developing the bioeconomy. Gradual state withdrawal must coincide with the government creating an enabling environment in terms of a strong regulatory system and the adequate provision of public goods and services to propel private sector dynamism. Collective action among farmers must also be encouraged and strengthened through the promotion of farmer-based approaches. Accordingly, the driving force behind strategies for more efficient biomass production and utilisation in the emerging bioeconomy must come from private sector actors and community-based organisations in order to be sustainable.

ZUSAMMENFASSUNG

In Sub-Sahara-Afrika hat die steigende globale Nachfrage nach Nahrung, Futter, bio-basierten Rohmaterialien, Kraftstoff- und Faserpflanzen zu einem zunehmenden Druck auf den Agrar-Sektor geführt. Die erwartete, zunehmende Nachfrage nach diverseren bio-basierten Produkten von landwirtschaftlichem Land transformiert den Agrar-Sektor von einen Nahrung-bereitstellenden Bereich zu einem biomasse-bereitstellenden Bereich als Teil der wachsenden internationalen Bioökonomie.

Diese Verwandlung führt zu der Entwicklung von auf Biomasse-basierten Wertschöfpungsnetzwerken (*Value Webs*), komplexe Systeme von miteinander verbunden Wertschöpfungsketten (*Value Chains*) in denen Nahrung, Futter, Kraftstoffe und andere Rohmaterialien produziert, weiterverarbeitet, gehandelt und konsumiert werden. In diesem Zusammenhang, versucht diese Thesis zu evaluieren welche Rolle öffentliche und private Akteure sowie Akteure des dritten (zivilgesellschaftlichen) Sektors mit Blick auf die Unterstützung der Transformation des Agrar-Sektors in der sich entwickelnden Bioökonomie Ghanas spielen. Die Studie fokussiert sich auf entstehende Wertschöfpungsnetzwerke von Cassava (*Manihot esculenta*) und Mais (*Zea mays*), die beiden wichtigsten Grundnahrungsmitteln in Ghana.

Entlang von Biomasse-basierten Wertschöfpungsnetzwerke gibt es eine Reihe von Herausforderungen mit Blick auf Vor- und Nachernteproduktion sowie institutionellen und Governance, die adressiert werden müssen. Diese Thesis fokussiert sich auf drei aktuelle Problemfelder von biomasse-basierten Wertschöfpungsnetzwerke. Diese Problemfelder beziehen sich auf Governance und institutionelle Dimensionen der Nutzung von Bioökonomie-Pflanzen, auf die Nachhaltigkeit von Vertragslandwirtschaft und die Wirksamkeit von kommerziellen Saatgut-Angeboten. Damit erforscht diese Thesis die Governance von biomasse-basierten Wertschöfpungsnetzwerke aus einer weiteten Perspektive, bevor sie zwei spezifischer Aspekte betrachtet. Dieses Verfahren erlaubt es, die Komplexität von entstehenden Wertschöfpungsnetzwerken zu verstehen und gleichzeitig die Bedeutung von spezifischen institutionellen Arrangements mit Blick auf das effektive Funktionieren von diesen Wertschöfpungsnetzwerken zu unterstreichen.

Die Ergebnisse werden also drei, empirische Kapitel einer kumulativen Thesis präsentiert (Kapitel 2 bis 4).

Kapitel 2 erforscht die notwendige politische und institutionelle Landschaft, um die Entwicklung von konkurrenzfähigen, nachhaltigen biomasse-basierten Wertschöpfungsnetzwerken zu fördern. Dazu wird eine empirische Fallstudie verwendet, die sich auf Cassava bezieht, eine bedeutende Hauptnahrungspflanze mit zunehmend diverser Nutzung in Ghana. Kapitel 3 fokussiert sich speziell auf die Nachhaltigkeit von Arrangements der Vertragslandwirtschaft für Landwirte und Agro-Business Unternehmen als Schlüsselaspekt der institutionellen Verknüpfung von Biomasse-Produktion und Weiterverarbeitung in Wertschöpfungsnetzwerken. Arrangements der Vertragslandwirtschaft für Cassava in Ghana werden mit Blick auf die industrielle Nutzung von Cassava analysiert. Kapitel 4 widmet sich den Governance Herausforderungen von kommerziellen Saatgut-Systemen. Diese sind integral für eine steigende Farm-Produktivität und die kritische Masse von Pflanzenbiomasse in Wertschöpfungsnetzwerken. Da Mais die dominierende Pflanze in kommerziellen Saatgut-Systemen ist und die wichtigste Getreidepflanze in Ghana, wird der kommerzielle Mais Saatgutsektor als Grundlage für die empirische Fallstudie verwendet. Die Thesis nutzt eine Kombination von verschiedenen qualitativen und quantitativen Methoden der Datenerhebung für alle drei empirischen Studien. Das beinhaltet die Nutzung von partizipativen Forschungsmethoden, namentlich, Net-Maps und Prozess Net-Maps sowie semi-strukturierte Tiefeninterviews mit Experten und Schlüssel-Informanten, Fokusgruppendiskussionen, Direktbeobachtungen und eine Haushaltsbefragung.

Die Ergebnisse aus Kapitel 2 zeigen, dass es, trotz hohen Potenzialen zur Nutzung von Cassava-Biomasse in Ghana, Koordinationsprobleme zwischen Landwirten, Prozessoren und Industrie-Endkunden gibt. Es gibt einen Bedarf nach mehr Unterstützung durch die Regierung in Form von Politkmaßnahmen, welche Anforderungen nach einem lokalen Anteil entsprechen (*local content policies*). Kapitel 3 findet, dass ad hoc oder opportunistische Investitionen, die lediglich kleinbäuerliche Vermarktungsherausforderungen adressieren, nicht ausreichen, um gegenseitig vorteilhafte und nachhaltige Vertragslandwirtschafts-Modelle in sich schnell entwickelnden lokalen Wertschöpfungsketten zu fördern. Direkte Firmeninvestitionen müssen Vertragsanbau-Modelle (*Outgrower Schemes*) unterstützen. Öffentlich-private Partnerschaften sind wohl die beste Option, um nachhaltig ideale Vertragsbedingungen sicherzustellen. Kapitel 4 zeigte, dass wohlbekannte Hindernisse, aufgrund der Dominanz von Institutionen aus dem öffentlichen Bereich im Saatgut-Bereich, durch Reformanstrengungen, die den privaten Bereich einschließen sollen, nicht überkommen werden konnten. Damit gibt es immer noch fehlende, komplementäre private

und öffentliche Investitionen sowie Investitionen des bislang kaum entwickelten dritten Sektors an mehreren Stellen des Saatgut-Angebotssystem, die sicherstellen könnten, dass Landwirte besseren Zugang zu verbessertem Saatgut bekämen. Zusammenfassend beleuchten die Ergebnisse der drei Kapitel die Rolle von öffentlichen und privaten Akteuren und sowie von Akteuren des dritten (zivilgesellschaftlichen) Sektors für biomasse-basierte Wertschöfpungsnetzwerken einer entstehenden Bioökonomie.

Die Thesis beschließt damit, dass privater und zivilgesellschaftlicher Sektor entscheidend für die Entwicklung der Bioökonomie sind. Ein gradueller Rückzug des Staates muss mit Maßnehmen korrelieren, mit denen der Staat ein befähigendes Umfeld mit Blick, auf starke regulatorische Systeme und der adäquaten Bereitstellung von öffentlichen Gütern und Dienstleistungen, schafft, das hilft, um Dynamiken des Privatsektors anzustoßen. Kollektive Aktionen zwischen Landwirten müssen ebenso gefördert und gestärkt werden. Die treibende Kraft hinter Strategien zur effizienteren Biomasse-Produktion und Nutzung in einer entstehenden Bioökonomie, müssen Akteure des privaten Bereichs und gemeinschaftsbasierte Organisationen seien, damit diese Strategien nachhaltig sind.

LIST OF ACRONYMS AND ABBREVIATIONS

AEA	Agricultural Extension Agent
AU	African Union
BMGF	Bill and Melinda Gates Foundation
CF	Contract Farming
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organisation of the United Nations
FASDEP	Food and Agriculture Sector Development Policy
FBO	Farmer-Based Organisation
GGBL	Guinness Ghana Breweries Limited
GGDP	Ghana Grains Development Project
GLDB	Grains and Legumes Development Board
GRATIS	Ghana Regional Appropriate Technology Industrial Service
GSID	Ghana Seed Inspection Division
HQCF	High Quality Cassava Flour
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
MoFA	Ministry of Food and Agriculture
NARI	National Agricultural Research Institute
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organisation
NVRRC	National Variety Release and Registration Committee

OPV	Open Pollinated Variety
PPB	Participatory Plant Breeding
PPRSD	Plant Protection and Regulatory Services Directorate
PSI	Presidential Special Initiative
QPM	Quality Protein Maize
RELC	Research and Extension Linkage Committee
RTIMP	Root and Tuber Improvement and Marketing Programme
SARI	Savannah Agricultural Research Institute
SG	Sasakawa Global
VIF	Variance Inflation Factor
WAAPP	West African Agricultural Productivity Program

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1. INTRODUCTION

This thesis explores the policy and institutional environment needed to foster the development of biomass-based value webs in Ghana in the emerging bioeconomy. Biomass-based value webs are complex systems of interconnected agricultural value chains in which food, feed, fuels and other biomass-based raw materials are produced, processed, traded and consumed (Virchow et al., 2016). The study investigates the governance and institutional challenges related to the development of the emerging value webs of two major staple crops in Ghana, namely cassava (*Manihot esculenta*) and maize (*Zea mays*). In this introduction, the background and research topics are presented together with the objectives of the thesis. This is followed by the conceptual framework and methodology that guided the empirical research. The study context is also described.

1.1 The emerging bioeconomy

The contribution of agriculture to food security, employment and wealth creation in Sub-Saharan Africa make the sector critical to both economic and social development on the continent (Diao et al., 2007). However, agricultural productivity in Sub-Saharan Africa continues to lag considerably behind that of other continents, as well as the region's own potential. The annual increase of productivity in food production in Africa is less than the estimated 1.7 per cent needed to feed Africa's rapidly growing population (Global Harvest Initiative, 2016). Additionally, increasing global demand for crop biomass not only for food, but also for non-food uses has also risen markedly in the past decade (Timilsina et al., 2012). This is putting pressure on Africa's agricultural sector to transition from just a food-supplying to a biomass-supplying sector in the growing international bio-based economy (bioeconomy).

Given African countries' endowment of natural resources, there is a high potential to produce plant biomass (Krausmann et al., 2008). This transition therefore presents a unique opportunity to stimulate economic development (Abass, 2014). Ostensibly, non-food biomass production competes with food production for land and other resources (Deininger, 2011). This can also lead to higher food prices (Rosegrant et al., 2013). Non-food biomass uses are mainly classified as biomass utilisation for feed, fuel and industrial raw materials. Evidence from several Asian countries however demonstrates that many crops can be used interchangeably for both food and non-food purposes in response to shifting demands

(e.g. see Waramit, 2012; Lam et al., 2009). Furthermore, the non-food uses of crop biomass can help generate income that improves access to food (Lynd & Woods, 2011). Agricultural systems that focus on the production, processing and utilisation of the entire biomass of locally adapted crops for both food and non-food uses can thus offer pathways to a number of economic benefits. These include food security; income and employment, particularly in rural areas; a reduction in a country's non-food import bill; export earnings; and environmental sustainability (Poulton et al., 2006). Consequently, an increasing number of countries, including a few African countries, have started adopting bioeconomy-related strategies and policies (see BÖR, 2015).

The concept of a bioeconomy essentially encompasses the knowledge-based system of producing and transforming biomass resources into economically competitive products in new, sustainable and eco-efficient ways so as to capture an increasing share of added value across all economic sectors (Global Bioeconomy Summit, 2015; OECD, 2008). The concept captures both the 'biotechnology innovation perspective' which stresses the importance of biotechnology for sustainable development, and the 'resources substitution perspective' which emphasises the use of crops as renewable industrial feedstock (EU, 2007). One of the main justifications for the resource substitution perspective was the concept of 'peak oil' which posits that oil extraction will eventually reach its peak and begin to decline thereafter, while oil prices continue to rise (Bardi, 2009). Rising oil prices increases the comparative advantage of using biomass as a source of energy or material use. This perception was reaffirmed by the oil price crisis of 2007/08. However, the ensuing use of food crops for biofuels also contributed to spikes in food prices (Heady & Fan, 2008). These developments highlighted two important implications for the bioeconomy. First, the potential tension between ensuring food security and the use of crop biomass as a source of energy in the bioeconomy became an important topic in the public policy debate (see Enciso et al., 2016; Koizumi, 2015). Second, there has been increased attention on the need to improve the productivity of biomass production and to develop viable options for producing and using biomass that do not comprise food security. Such options include second generation technologies and the use of by-products and waste products in place of fossil-based resources (see Dimitriadis & Bezergianni, 2017; Gupta & Verma, 2015).

The cascading effect of utilising and reutilising biomass effectively interlinks existing agricultural value chains in complex systems of closed material cycles, forming value webs. These 'biomass-based value webs' are therefore an integral aspect of the emerging

bioeconomy (Virchow et al., 2014). The value web concept was developed by Virchow et al (2016) as an extension to Porter's (1985) classical linear value chain concept to capture the multiple pathways and uses of biomass in the bioeconomy. However, as Scheiterle et al. (2017) point out, the term 'value web' has already been applied in the business literature, although in a different sense. In this literature, the concept was used to analyse the collaboration between enterprises in a range of industries including internet service provisioning and e-commerce (e.g. see Cartwright & Richard, 2000; Andrews & Hahn, 1998). In terms of the bioeconomy, the concept integrates social, economic and environmental perspectives and is therefore an effectively means of pinpointing the potential for sustainable productivity increases across the whole value web of defined local, national or international systems (Virchow et al., 2014).

1.2 Rationale of the thesis

Along emerging biomass-based value webs there are a number of pre- and postharvest production, institutional and governance challenges that need to be addressed. This study is part a of a larger collaborative research project across Ethiopia, Ghana and Nigeria known as "BiomassWeb- Improving food security in Africa through increased system productivity of biomass-based value webs." The project aims to improve food security in Sub-Saharan Africa through harnessing productivity and efficiency gains in the entire biomass producing, processing and trading system of locally adapted crops. This is to be achieved by focusing on increased integration of all value web components as well as the cascading utilisation of crop biomass (ZEF & FSC, 2013).

Within the context of the BiomassWeb project, this thesis is motivated by the need to explore the prevailing governance and institutional challenges of emerging biomass-based value webs in Ghana. Thus, it focuses on three current problem areas of biomass-based value webs. These problem areas are related to the governance and institutional dimensions of the utilisation of bioeconomy crops, the sustainability of contract farming arrangements and the efficacy of commercial seed supply. The pertinence of this enquiry lies in the critical role of the policy and institutional environment of the agricultural sector in ensuring food security while also meeting new biomass demands to promote economic development. Comprehensive studies on the governance of the bioeconomy, particularly in Africa, are still scarce. In the context of Ghana, there is a dearth of empirical studies analysing the transformation of the agricultural sector in the emerging bioeconomy. Thus, the thesis seeks

to explore the governance of emerging biomass-based value webs from a broader perspective, before focusing on two specific aspects. This approach is used to understand the complexity of emerging value webs while also highlighting the importance of specific institutional arrangements to the effective functioning of these value webs.

First, the study investigates the requisite policy and institutional environment needed to foster the development of competitive and sustainable biomass-based value webs. For this assessment, the case of cassava, a major staple crop with increasingly diverse utilisations in Ghana, is used for an empirical case study. Second, the thesis focuses specifically on the sustainability of contract farming arrangements for farmers and agribusiness firms as a key aspect of the institutional linkage between biomass production and processing in value webs. Contract farming arrangements for cassava in Ghana are investigated in the wake of its industrial uses. Third, the study probes the governance challenges of commercial seed supply, which is integral to increasing farm productivity and the critical mass of crop biomass in value webs. As maize is the predominant crop in the commercial seed system and the most important cereal crop in Ghana, the commercial maize seed sector is used for an empirical case study. Holistically, this thesis aims to evaluate the appropriate roles of the public, private and third (civil society) sectors in facilitating the transition of the agricultural sector from a food-supplying to a biomass-supplying and processing sector in the emerging bioeconomy.

1.3 Problem background

The emerging bioeconomy in Africa does not necessarily guarantee that smallholders and the informal economy will effectively be linked with the formal economy. Adequate policies, governance structures and institutional arrangements are essential for fostering this process (Dufey et al., 2007). The transition from a food-supplying to a biomass-supplying agricultural sector will require millions of small-scale farmers to adopt new technologies, agronomic practices as well as engage in new institutional arrangements with other agricultural actors within a conducive regulatory and policy environment (World Bank, 2007). Three critical aspects of the governance and institutional challenges of this transition are highlighted below.

The need for diversified biomass utilisation

In spite of the increasingly efficient and diversified utilisation of biomass generated from agricultural production in the international bioeconomy, biomass-rich African countries tend to only focus on the primary production of biomass (Börner et al., 2017). The cascading use

and crucial value addition of biomass occurs in high-income biomass-dependent countries that reap most of the benefits of novel high-value bio-based products (Erb et al., 2009; Charles et al., 2007). Widely grown bioeconomy crops like oil palm, maize and cassava are therefore currently underutilised in Africa. Many recent studies related to the development of Africa's emerging bioeconomy tend to focus more on the needed agronomic or technological innovations of biomass production and utilisation (see eg. Adekunle et al., 2016; Batidzirai et al., 2016; Tui et al., 2015). However, a sustainable bioeconomy development strategy is not confined to these types of innovations alone but equally requires a conducive policy and institutional environment. This is currently lacking in most African countries and yet, has received less attention in the literature.

Improving marketing arrangements

The link between biomass production and processing also requires efficient market systems to satisfy the increasingly differentiated demand for biomass products in the emerging bioeconomy. This is resulting in modernised procurement systems such as contract farming by agribusiness firms, even for agricultural commodities that have traditionally been dominated by spot market exchanges between small-scale farmers and traders (Reardon & Barrett, 2000). Some empirical studies on contract farming have found that small-scale farmers actively participate in these schemes and have improved farm productivity as well as higher income as a result (Barrett et al., 2012; Bellemare, 2012). Conversely, other studies have reported evidence of smallholder exclusion, high default rates, delayed payments and a lack of compensation for crop losses in contract farming schemes (Simmons et al., 2005; Key & Runsten, 1999). These divergent findings underscore the importance of contract design to the performance and impacts of contact farming schemes. Despite the win-win potential of contract farming, there is a paucity of studies, particularly in the African context, examining which institutional arrangements and contract conditions are sustainable for both farmers and agribusiness firms in such schemes.

Improving input supply systems

The development of effective supply systems for agricultural inputs such as high quality improved seed is essential for increasing agricultural productivity and biomass production in Africa (World Bank, 2007). However, the commercial seed sector in Africa has been very slow to develop. Only a few countries such as Kenya and Mozambique provide evidence of successful commercial seed sector development (World Bank, 2016). A major cause of the

sector's poor performance has been the weak capacity of the public sector organisations that monopolise seed supply (Tripp & Rohrbach, 2001). Recent efforts by many African governments to liberalise their seed sectors, particularly for cereal crops, has generally resulted in increased private sector participation. Nonetheless, deficiencies persist in the institutional linkages between the various stages of seed production, from breeding to commercial seed delivery (Langyintuo et al., 2010). Consequently, most small-scale farmers in Africa still obtain their seed from informal sources such as farmer-saved seed, seed exchanges among farmers and purchases from local seed markets (McGuire & Sperling, 2016; Louwaars & De Boef, 2012). Most empirical studies have focused on the socio-economic and agro-ecological factors that influence farmers' decisions to adopt improved seed varieties (Khonje et al., 2015; De Groote et al., 2013; Ragasa et al., 2013; Lunduka et al., 2012; Langyintuo & Mungoma, 2008). There is however a dearth of in-depth studies that investigate the governance challenges of seed supply systems.

Overcoming these governance and institutional challenges of emerging biomass-based value webs by addressing the identified knowledge gaps is critical to fostering the development of Africa's bioeconomy. This would enable African countries to ensure food security for smallholder farmers as well as fully exploit the potential to produce high-value biomass products for domestic, regional and international markets.

1.4 Objectives of the thesis

The overall objective of the study is to analyse the current governance and institutional challenges of emerging biomass-based value webs in Ghana, and derive strategies for needed policy and institutional reforms. The thesis focuses on cassava and maize which are the two most important staple crops in Ghana. Accordingly, the thesis has three specific objectives:

1) To assess the policy and institutional environment needed to foster the development of a competitive and sustainable cassava value web.
2) To examine which contract conditions are sustainable for both farmers and agribusiness firms in cassava contract farming.
3) To analyse the governance challenges of the commercial maize seed supply system.

Each objective constitutes a separate empirical chapter of the thesis.

1.5 Research Questions

The three broad research objectives of the thesis each have specific research questions.

The objective of assessing the policy and institutional environment needed to foster the development of a competitive and sustainable cassava value web is realised by addressing the following research questions:

a. Who are the stakeholders in the emerging cassava value web?
b. Which institutional arrangements exist between the different groups of stakeholders in the value web?
c. What are the challenges and opportunities of utilising cassava biomass for both food and non-food uses?

For realising the objective of examining which contract conditions are sustainable for both farmers and agribusiness firms in cassava contract farming, the research questions are as follows:

a. What are the prevailing models of contract farming for cassava in the wake of its industrial uses?
b. Which contract design features influence smallholders' participation in contract farming?
c. What are contracting firms' motivations for scheme design features?

The research questions for the objective of analysing the governance challenges of the commercial maize seed supply system are as follows:

a. Are there enough productive maize varieties currently available in the seed system?
b. What are the institutional factors accounting for the low dissemination of improved maize varieties?
c. What is the extent of collaboration between the public sector and private sector in commercial seed supply under the new seed law?

1.6 Conceptual Framework

The conceptual framework displayed in Figure 1.1 presents a guide for analysing the governance of biomass-based value webs in the emerging bioeconomy. The lower domain of the framework illustrates the cascading utilisation of crop biomass in a complex system of

interlinked agricultural value chains across the various stages of input supply, biomass production, biomass trading and processing, and finally consumption. This forms the biomass value web. The upper domain of the framework depicts the governance system which encompasses the institutions, processes and actors that are relevant for the development of a biomass value web. The framework distinguishes between different types of international, public, private and civil society actors that play a role in the governance system.

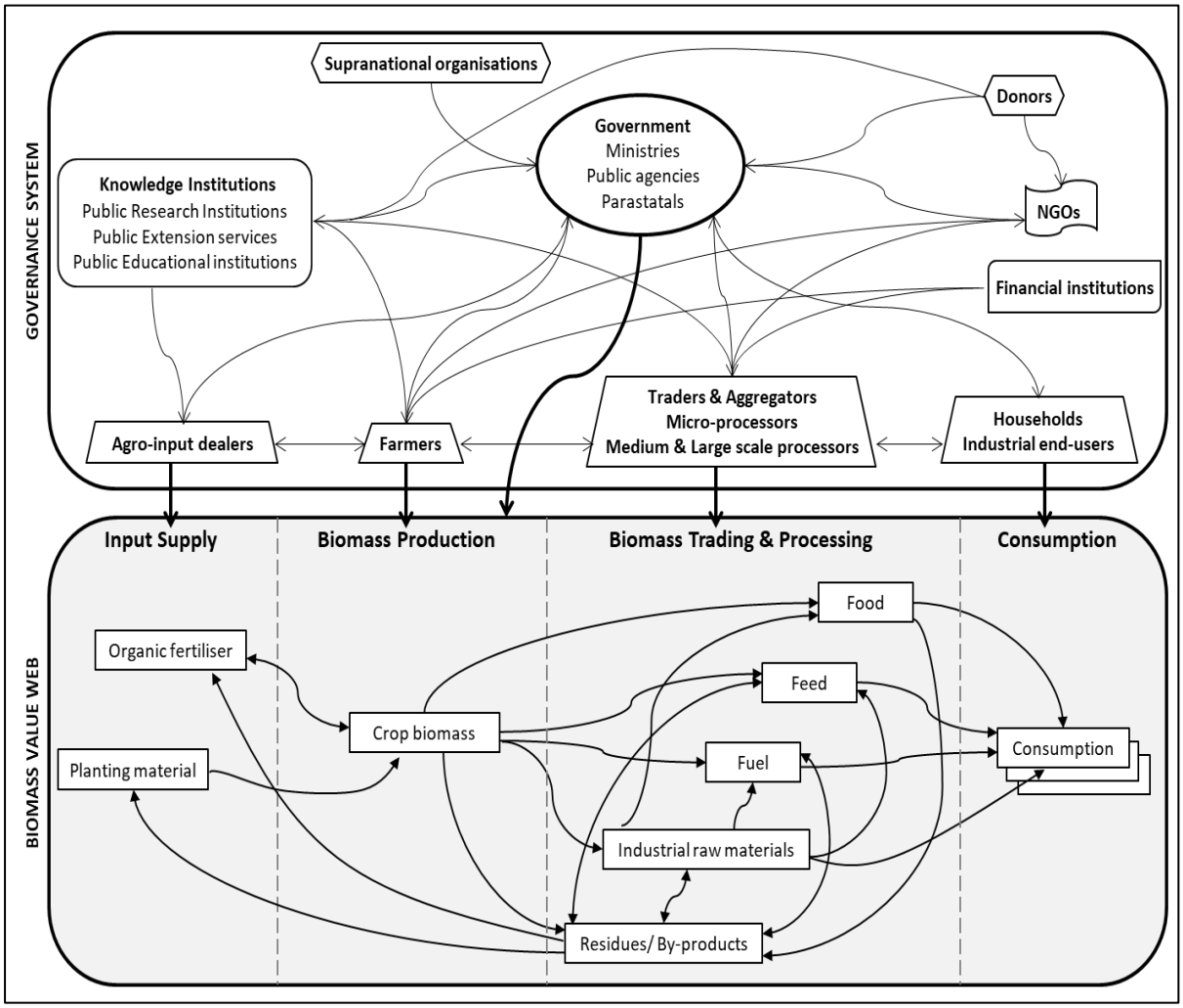

Figure 1.1: Conceptual framework of the governance of biomass value webs

Supranational organisations and donors are international actors that are depicted separately in view of their respective roles in influencing policy formulation and funding various research and development activities. The government, comprising ministries, public agencies and parastatals, plays a critical role in fostering the development of the biomass value web. This is done by the implementation of policy instruments, strategies and regulation targeted at

developing specific stages of the biomass value web or the system as a whole. The government can also become an economic actor that participates in activities at the various stages of the biomass value web, particularly through state parastatals. Knowledge institutions such as research institutions, extension services and educational institutions are typically public sector organisations. However, they are categorised separately on account of the specific role they play in fostering innovation and strengthening the knowledge-base of the system. Private sector actors such as agro-input dealers, farmers, processors, traders, industrial end-users and households are the main economic actors at the various stages of the value web. Financial institutions also provide support to some private sector actors to carry out their activities. There is therefore the direct provision of products and services between these actors along the value web. Civil society organisations, also known as non-governmental organisations (NGOs), play an important role in complementing and supporting the activities of public and private sector actors through advocacy and capacity building.

The development and functioning of the biomass value web depends on the various interactions among the different actors in the governance system. These interactions include policy processes, regulation, funding, knowledge transfer, exchange of goods and services as well as lobbying.

1.7 Methodology

The thesis employed a combination of qualitative and quantitative methods of data collection. This entailed the use of Net-Map, Process Net-Map, semi-structured in-depth interviews with experts and key informants, focus group discussions, direct observation as well as a household survey.

For the first objective of assessing the policy and institutional environment needed to foster the development of a competitive and sustainable cassava value web, the case of cassava in Ghana is used for an empirical case study. Case studies are considered as an effective means of comprehensively capturing the complexities of phenomena (Yin, 2009). A three-step approach was used to collect data for the study. In the first step, the cassava value web was visually mapped out with purposively sampled experts. These respondents were selected based on their extensive experience and knowledge of Ghana's cassava value web. The visualisation of the value web involved identifying all the existing products and cascading uses of cassava biomass in Ghana as well as potential future derivatives from the crop

biomass. This information was cross-checked from the existing literature and through direct observation (e.g., of various processing activities). The map produced was also used as the initial means of identifying the actors in the cassava value web. In the second step, the Net-Map tool was applied. Net-Map is a participatory social network mapping tool based on the visualisation of networks within multi-stakeholder systems by respondents (Schiffer, 2007). The tool was used to identify all the actors in the cassava value web and to assess how they are linked. Guided by the mapping exercise in the first step, the Net-Map exercise was carried out with purposively sampled respondents who had an in-depth understanding of how the entire cassava value web operates. The final step involved in-depth interviews with selected experts from all the identified stakeholder categories from the Net-Map exercise using purposive sampling. These respondents were selected on the basis of having a high level of experience and expertise in carrying out specific functions in the cassava value web. Additional in-depth interviews were conducted using chain-referral sampling to ensure exhaustive expert information. The respondents included donors, public research institutions, government agencies, processors, farmers and other stakeholders across the country. Each interview was semi-structured and open-ended with the aim of best capturing the respondent's expert opinion on the challenges and opportunities of a cassava based bioeconomy. Member checks in the interview process involved paraphrasing or restating responses from respondents for clarification where necessary (see Guba & Lincoln, 1989). All the interviews of the study were audio-recorded with the expressed permission of the respondents. The three-step research design was complemented with an extensive review and synthesis of relevant policy documents and project reports. The document review served as triangulation to validate the reliability of the findings.

A combination of qualitative and quantitative methods was used to analyse the data collected. The recorded in-depth interviews were inductively analysed using content analysis to identify recurring and unique themes (see Berg et al., 2004; Glaser & Strauss, 1967). The networks identified during the Net-Map exercises were analysed quantitatively using social network analysis.

For the second objective of examining which contract conditions are sustainable for both farmers and agribusiness firms in cassava contract farming, a comparative case study approach of a public and private cassava outgrower scheme in Ghana was used. Data collection was done in three stages using a complementary combination of qualitative and quantitative methods. First, in-depth interviews were conducted with government officials,

management personnel and staff of the two selected processing companies, some of their off-takers as well as with ten purposively sampled outgrowers in each scheme who have supplied the companies from the inception of the schemes. This was to fully understand how the schemes operate and how they may have evolved overtime. Secondly, two focus group discussions were carried out for each scheme. The first set was done with ten purposively selected outgrowers (five males and five females) of each scheme identified from the companies' supply ledgers for the year under review, which was 2015. In both cases this was followed by focus group discussions with ten non-participating smallholder farmers from the same communities as the outgrowers. These focus groups also had the same gender profile of five males and five females each. This was to gain contextual insight into farmers' understanding and experiences in the schemes. Specifically, the groups were asked to elaborate on their evaluation of the output and input arrangements, quality standards and contract enforcement mechanisms of the schemes. In the final stage, a pre-tested questionnaire designed on the basis of the first two stages of data collection was administered to a total of 315 famers using a multistage sampling process. For the state-led outgrower scheme, the supply ledger for 2015 was used to identify the four highest supplying communities. Proportional random sampling based on supply was used to select 100 outgrowers from these communities to participate in the survey. Fifty (50) non-participating cassava growing farmers were similarly sampled from these communities from lists provided by community leaders. Subsequently, for the privately-run outgrower scheme, the supply ledger for 2015 revealed 65 active outgrowers all of whom were selected for the survey. These outgrowers were distributed across five communities. Twenty (20) non-participating farmers growing cassava were randomly sampled from each of these communities from lists provided by community heads. The questionnaire collected a wide range of information on respondents' socio-economic characteristics as well as their experiences and perceptions of the contractual details of the schemes. The interviewers overtly presented themselves as researchers with no affiliation to either agribusiness firm. Neither firm was involved in the selection process of the respondents.

A probit model was used to estimate the factors that influence a given farmer's decision to participate in the outgrower scheme in each case. The regressors included socio-economic characteristics such as gender, education, farming experience, farm size and off-farm employment. Additionally, the importance of the contract design features to farmers'

participation decision was included in the models as dummy variables. This approach was used to validate the qualitative information collected on farmer perceptions.

For the third objective of analysing the governance challenges of the commercial maize seed supply system, Ghana's commercial maize seed sector is used for an empirical case study. The study employed a two-step data collection procedure. In the first step, the participatory mapping technique based on in-depth interviews and visualisation known as Process Net-Map was conducted with an array of purposively sampled experts in the seed supply system. The respondents were selected based on their extensive experience and understanding of how the entire commercial maize seed system operates. Process Net-Map is a variant of the Net-Map method that was developed to identify governance challenges in processes of policy-making and implementation (see Raabe et al., 2012). In this study, the tool was used to gain detailed insights into the process of commercial maize seed supply in Ghana. At the same time, the tool made it possible to identify the relevant stakeholders. Guided by the Process Net-Maps, the second step involved in-depth interviews with selected experts from all identified stakeholder categories using purposive sampling. These respondents were selected based on their high level of experience carrying out specific activities in the seed system. Additional in-depth interviews were conducted using snowball sampling to ensure exhaustive expert information. The respondents included agricultural researchers, public officials and regulators, donors, seed producers (individual seed growers), local private seed companies, input dealers, extension agents, maize farmers and other stakeholders throughout the country. Direct observation of seed supply activities, such as maize seed processing, certification, storage and sale was also conducted. Each interview involved a series of open-ended questions and follow-up questions to best capture the respondent's expert opinion on the governance challenges in the commercial maize seed system and his views on how these challenges may be overcome. The two-step research design was complemented with an extensive review and synthesis of relevant policy and legal documents as well as project reports. The document review served as triangulation to validate the findings. All the interviews, including those from the Process Net-Map exercises, were audio-recorded with the expressed permission of the respondents to enable an effective content analysis.

1.8 Study context: Crop production in Ghana

As one of the three countries of the BiomassWeb project, Ghana was chosen for the study because of its high potential for biomass production and its relatively large investments in

agribusiness (Duku et al., 2011; OECD, 2008). Similar to many other African countries, agriculture is the mainstay of the Ghanaian economy and employs over 50 per cent of the labour force. It accounted for an average of 32 per cent of GDP between 2000 and 2014 (MoFA, 2015a). The crops sub-sector constitutes the largest activity in the economy. Cocoa is Ghana's most important cash crop as it is the country's largest export earner. The most widely grown food crops include cassava, maize, yam, rice, cowpea and plantain (MoFA, 2015b). These crops are typically grown on small landholdings of less than two hectares with infrequent use of inputs and basic agronomic practices. Approximately 90 per cent of farmers in Ghana are smallholders (MoFA, 2015a).

On the policy front, the second phase of the Food and Agriculture Sector Development Policy (FASDEP II), which was implemented in 2007, serves as the sector-wide policy for the agricultural sector. The objectives of the policy include; food security and emergency preparedness; improved growth in incomes; increased competitiveness and enhanced integration into domestic and international markets; sustainable management of land and environment; science and technology applied in food and agriculture development; and improved institutional coordination (MoFA, 2007: 22). FASDEP II emphasises commercialisation of the agricultural sector as the principal means by which these set objectives will be achieved.

1.8.1 The Cassava sub-sector

Cassava (*Manihot esculenta*) is the most important root crop in Ghana in terms of quantity produced. It is grown in eight out of the ten regions of Ghana (Angelucci, 2013). Cassava accounts for approximately 50 per cent of all roots and tubers production in the country and is second only to maize in terms of area planted (MoFA, 2015a). The crop has the advantage of being able to produce economic yields even under marginal production conditions. This has made it a preferred crop among small scale resource poor farmers (Polson & Spencer, 1991). Ghana has been the third largest producer of cassava in Africa over the last decade behind Nigeria and DR Congo (FAOSTAT, 2017). As shown in Figure 1.2, national annual production of cassava steadily rose between 2000 and 2014.

Fresh cassava roots and traditionally processed food products are widely sold in domestic markets. Cassava leaves and tuber peels are mainly used as supplementary animal feed in Ghana. However, cassava leaves are also consumed by some segments of the population (Opoku-Nkoom et al., 2013). The stem of the crop is used as planting material

(Hillocks, 2002). There has also been increased recognition of cassava's potential as a bioeconomy crop (Koyama et al., 2015). Derivatives like high quality cassava flour (HQCF) have gained traction in some industries (Abass et al., 2011). Bakeries and institutions such as secondary schools and hotels have been using HQCF as a compliment to wheat flour for baking bread and other bakery products (Kleih et al., 2013). Plywood companies are similarly using industrial grade cassava flour, which is of lower quality than food-grade HQCF, as a glue extender in place of wheat flour (Koyama et al., 2015). Cassava is also being used to brew beer for the domestic market (MoFA, 2015b).

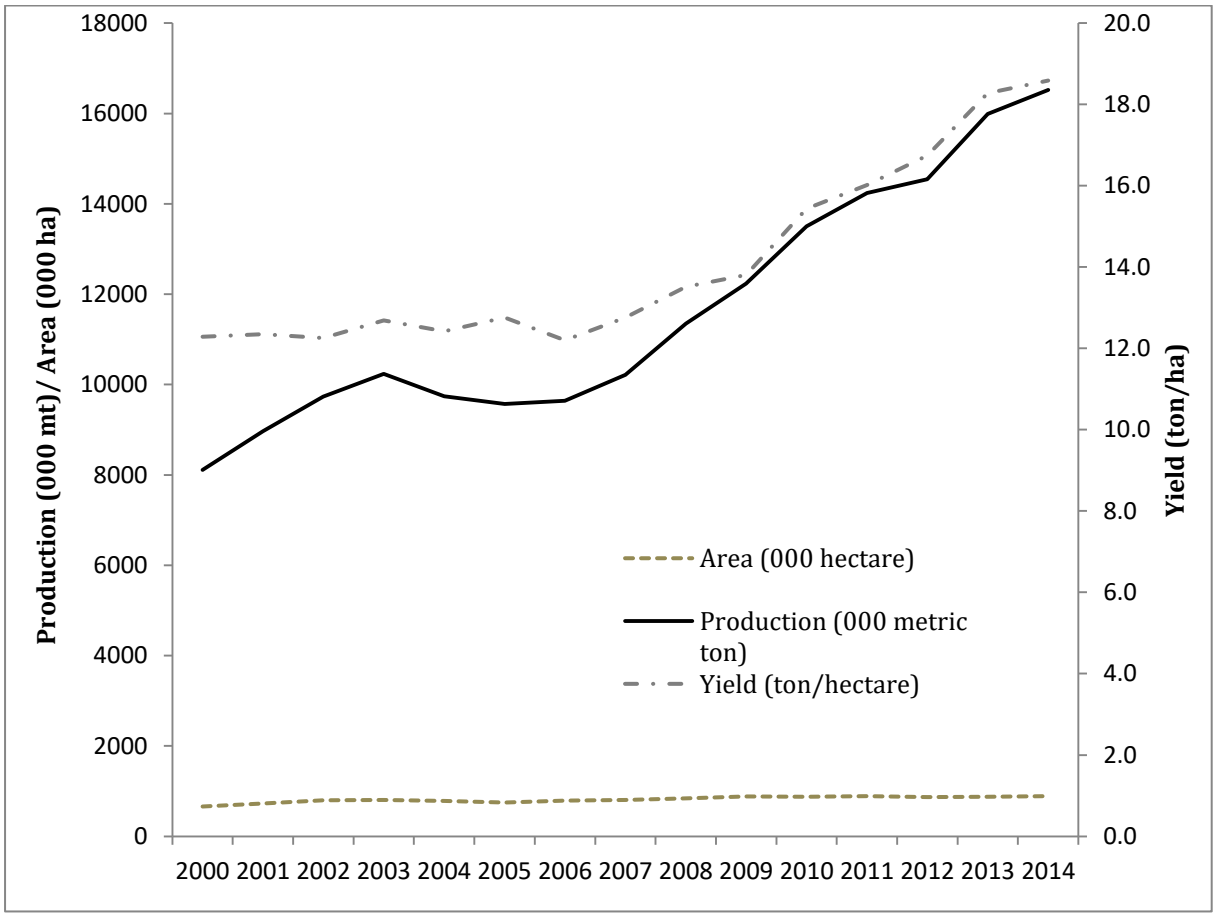

Figure 1.2: Cassava production, cropped area and annual yield, 2000-2014

Source: MoFA (2014; 2015a)

1.8.2 The Maize sub-sector

Maize (*Zea mays*) is Ghana's most important cereal crop and is grown by the vast majority of rural households in all agro-ecological zones in the country (Angelucci, 2012). It accounts for about 55 per cent of total grain production (MoFA, 2015a). Ghana is one of the major maize

producers in Sub-Saharan Africa. Yet, the national annual average yield between 2000 and 2014 was only 1.7 metric tons per hectare (Figure 1.3). Based on on-station and on-farm trials, achievable yields could be between 5 and 8 metric tons per hectare (Ragasa et al., 2013). This represents a significant yield gap in maize production in Ghana.

The majority of maize grain produced in Ghana is of the white variety and is used mainly for human consumption. It is mostly consumed directly by the farming households. The remaining production is traded domestically for traditional foods, processed food products and as a substitute or compliment to sorghum in the brewery industry (Andam et al., 2015; WABS, 2008). Some maize grain is also recycled, exchanged or sold as seed in local markets (MoFA, 2015c). The grain of yellow maize varieties are predominately used as animal feed in the poultry industry (Andam et al., 2017). Most of this maize is imported (Angelucci, 2012). The rest of maize biomass, namely the stalk, leaves, husks and cobs, are typically left on the farm after harvesting or burnt (Duku et al., 2011).

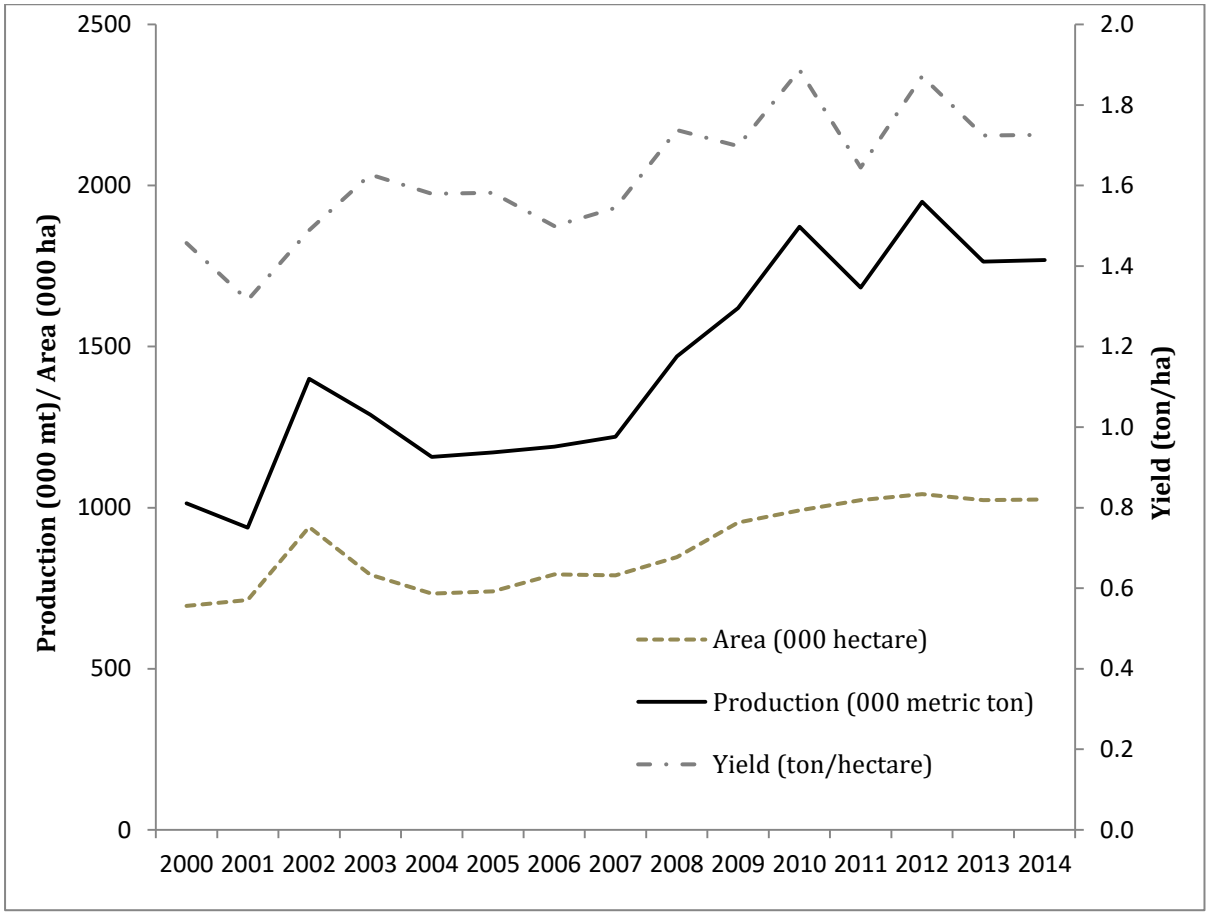

Figure 1.3: Maize production, cropped area and annual yield, 2000-2014

Source: MoFA (2014; 2015a)

1.9 Thesis layout

The thesis is made up of five chapters. Following this introductory chapter, Chapter 2 presents an in-depth case study of the challenges and opportunities of developing a competitive and sustainable cassava value web in Ghana in the emerging bioeconomy. Chapter 3 examines the contract conditions of a public and private cassava outgrower scheme in Ghana to investigate which contract farming arrangements are equitable and sustainable for both farmers and agribusiness firms. Chapter 4 presents an empirical case study of the governance challenges of commercial maize seed supply in Ghana following reform efforts in the seed sector. The final chapter of the thesis, Chapter 5, collates the insights from the previous three chapters in the form of a general discussion that is guided by the theoretical framework presented above. The key results of the thesis are discussed against the background of the existing literature. The limitations of the study are also presented. The chapter ends with the overall conclusions of the study as well as recommendations for policy and institutional reforms based on the findings.

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2. IS AFRICA READY TO DEVELOP A COMPETITIVE BIOECONOMY? THE CASE OF THE CASSAVA VALUE WEB IN GHANA

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Abstract

The increasing global demand for diverse biomass-based products such as food, feed and fuel can transform African agriculture from a food-supplying to a biomass-supplying and processing sector in the growing international bioeconomy. This study addresses the requisite policy and institutional environment needed to foster the development of a competitive and sustainable bioeconomy in Africa. The paper uses the case of cassava in Ghana for an empirical case study. The novel concept of biomass-based value webs, that is, interlinked agricultural value chains, is combined with Porter's Diamond model to analyse the extent to which Ghana is positioned to develop a competitive cassava value web. Empirical data collection involved mapping the physical biomass flows, applying the 'Net-Map' tool to identify all the actors in the emerging value web and their linkages, as well as in-depth interviews with the identified actors. The study finds that despite the huge opportunities for cassava biomass in Ghana, there are coordination problems between farmers, processors and industrial end-users. This has hindered the potential for increased cassava production, processing and utilisation. There is also generally a lack of private sector initiatives in the development of new cassava based products. Accordingly, industrial end-users tend to depend on imported alternatives. Unsuccessful government initiatives and the absence of legislation such as a composite flour policy or a biofuel blend policy have also been major contributing factors to the unrealised industrial potential of cassava in Ghana. The findings therefore suggest that competitive cassava utilisation in the emerging bioeconomy hinges on stronger institutional linkages between value web actors and government support mainly in the form of local content policies that encourage the use of cassava based products.

Keywords: Bioeconomy; Value web; Diamond Model; Cassava; Africa; Ghana

2.1 Introduction

The primacy of food security in crop production in Sub-Saharan Africa cannot be denied. However, there is also increasing global demand for other biomass-based products such as feed, fuel and fibre (Timilsina et al., 2012). This trend can transform African agriculture from a food-supplying to a biomass-supplying and processing sector in the growing international bio-based economy (bioeconomy) (Virchow et al., 2016). Biomass-rich African countries, most of which are agrarian-dominated economies, are gradually beginning to recognise the economic potential and sustainability of such a transition. Development of a bioeconomy in Africa can promote economic growth by diversifying the markets for agricultural commodities whiles also reducing dependence on imports of oil and intermediate inputs. This would generate employment and income, particularly in rural areas. The demand-pull would also stimulate increased agricultural productivity thereby ensuring food security (Abass, 2014). Countries like Malawi, Tanzania, Ethiopia and Ghana have started engaging in some bioeconomic activities based on various feedstock crops (see Acheampong & Campion, 2014; De Groote, 2013; Jumbe et al., 2009). However, the existing institutional framework in African countries often does not enable the optimal and sustainable exploitation of these emerging and potential opportunities.

This paper addresses the requisite policy and institutional environment needed to foster the development of a competitive and sustainable bioeconomy in Africa. Currently, many studies related to the development of the emerging bioeconomy in Africa tend to focus more on the needed agronomic or technological innovations (see eg. Adekunle et al., 2016; Batidzirai et al., 2016; Tui et al., 2015). However, a sustainable bioeconomy development strategy is not confined to these types of innovations alone but equally requires a conducive policy environment and broad-based institutional innovations.

The augmented diversity of activities in the evolving bioeconomy strengthens the interlinkages between the production, processing, utilisation and trading of both food and non-food biomass. This includes the cascading use of biomass as well as the use of by-products. This leads to complex systems of merged or interlinked biomass value chains (Virchow et al., 2014). For instance, sugarcane biomass in Brazil is used for a wide range of bio-based products, including food (sugar and related products), bioenergy (ethanol, bioelectricity), bio-based bulk materials (bio-plastic) as well as bio-based high value products (e.g. flavours and fragrances) (Scheiterle et al., 2018). Hence in such a system, the

conventional product-focused linear value chain approach is not sufficient to analyse the complex pathways of biomass flows. To better understand the development of the bioeconomy, there is therefore the need to utilise new tools and concepts.

Using the case of cassava (*Manihot esculenta*) in Ghana as an empirical example, the paper makes two contributions to the bioeconomy literature. First, the paper applies the novel 'biomass-based value web' concept to provide a more holistic analytical approach to understanding the linkages between several agricultural value chains and how they are governed (Virchow et al., 2016). This concept is combined with Porter's (1990) Diamond model of national competitive advantage to identify the policies and institutional factors that are relevant for developing an internationally competitive value web. Second, the study highlights the potential of cassava as an important crop in the emerging bioeconomy. Cassava is a perennial starchy crop that has the advantage of being able to grow under marginal production conditions (Pandey et al., 2000). The potential high yields of starch and total dry matter even under such conditions make cassava one of the most attractive bioeconomy crops with multiple usages (Abass et al., 2011; Jansson et al., 2009). Yet, it has received less attention in the literature than other bioeconomy crops like maize, oil palm and sugarcane (e.g. see Scheiterle et al., 2018; Umar et al., 2013; Goldemberg & Guardabassi, 2009).

In Ghana, cassava biomass is increasingly serving as a raw material for bio-based products such as starch, industrial flour, ethanol and feed formulations (see Poku et al., 2018). Ghana has been the sixth largest producer of cassava globally and the third largest in Africa over the last decade (FAOSTAT, 2017). Cassava is a major food crop in Ghana, as in other parts of Africa. Fresh cassava roots and traditionally processed products are widely sold in domestic markets. Cassava leaves are also consumed in some parts of the country. However, there has recently been increased recognition of the industrial potential of cassava biomass (Kleih et al., 2013). The country's annual food balance sheet consistently shows approximately 30% surplus in cassava production (MoFA, 2015a; MoFA, 2014). Most of this produce goes to waste (Naziri et al., 2014). This presents a viable starting point for establishing alternative value chains without affecting food security.

Three data collection methods were combined for the empirical application of the concepts of the biomass-based value web and the Diamond model: mapping the physical biomass flows, the relatively new participatory mapping tool known as Net-Map (Schiffer, 2007) and expert interviews. Social network analysis and content analysis are used to analyse the data. The

study finds that despite the huge opportunities for cassava biomass in Ghana, there are coordination problems between farmers, processors and industrial end-users. This has hindered the potential for increased cassava production, processing and utilisation.

The rest of the paper is organised as follows: Section 2.2 highlights the development of the cassava sub-sector in Ghana. Section 2.3 develops the conceptual framework used for the study. Section 2.4 describes the research methods. The empirical results are presented in Section 2.5 and subsequently discussed in Section 2.6. Section 2.7 concludes by summarising the study's main findings.

2.2 The cassava sub-sector in Ghana

Cassava is a major staple crop in Ghana that has seen a steady increase in annual production since the 1990s. Ghana is self-sufficient in cassava production and the crop is very important in terms of caloric intake and per capita consumption in the country (Angelucci, 2013). As shown in Table 2.1, Ghana was the sixth largest producer of cassava globally and the third largest in Sub-Saharan Africa between 2000 and 2014. However, Ghana was the fourth most productive producer over the period, behind Thailand, Indonesia and Vietnam where cassava is mainly grown as an industrial crop.

Table 2.1: Top cassava producers globally, 2000-2014

Country	Average Annual Production (1000 t)	Average Annual Yield (t/ha)
Nigeria	41,824	9.91
Brazil	24,208	13.91
Thailand	23,412	20.20
Indonesia	20,696	17.29
Democratic Republic of the Congo	15,027	8.10
Ghana	11,640	14.27
Angola	9,678	12.16
Vietnam	7,319	16.17

Source: FAOSTAT (2017)

The early 1980s marked a shift in the image of cassava in Ghana from a famine-reserve crop to a staple crop due to its food security benefits. This shift was facilitated by government investment in the dissemination of disease-resistant improved cassava varieties developed by the International Institute of Tropical Agriculture (IITA) to increase productivity (Nweke, 2004). More recently, the Food and Agriculture Sector Development Policy (FASDEP) developed in 2002 and revised in 2007 signalled continued commitment from the government to increase farm productivity in the sub-sector for food security. These efforts have been greatly supported by donor-funded programmes such as the Root and Tuber Improvement and Marketing Programme (RTIMP) and the West African Agricultural Productivity Program (WAAPP). As of 2010, twenty-one improved cassava varieties had been developed and released in Ghana (Alene et al., 2015). However in 2001, a Presidential Special Initiative (PSI) on industrial cassava starch production for export was also introduced. This was one of similar initiatives undertaken in other cassava producing countries in Africa, supported by the New Partnership for Africa's Development (NEPAD) Pan-African Cassava Initiative (see Anga, 2008). The initiative involved the establishment of the model government-owned starch processing factory, Ayensu Starch Company. This PSI was ultimately unsuccessful at tapping into foreign markets due to numerous operational challenges of the factory (Angelucci, 2013). Nonetheless, the PSI raised awareness of the commercial and industrial potential of cassava.

Approximately 50% of all harvested cassava roots are still consumed as freshly cooked tubers (FRI, 2012). However, there are an increasing number of small and medium scale enterprises that are now producing packaged forms of traditional foods like *gari* (granulated roasted cassava) for both the urban domestic and foreign markets (van Rheenen et al., 2012). The use of high quality cassava flour (HQCF), the development of which was spearheaded by IITA, has also gained traction in some industries (Abass et al., 2011). Bakeries and institutions such as secondary schools and hotels have been using HQCF as a compliment to wheat flour for baking bread and other bakery products (Kleih et al., 2013). Plywood companies are similarly using industrial grade cassava flour, which is of lower quality than food-grade HQCF, as a glue extender in place of wheat flour (Koyama et al., 2015). Cassava is also being used to produce beer for the domestic market (MoFA, 2015b).

Cassava leaves and tuber peels are mainly used as supplementary animal feed in Ghana. However, cassava leaves are also consumed by some segments of the population, most notably in Northern Ghana (Opoku-Nkoom et al., 2013). In the pig industry, concentrated in

the forest zone of the country, cassava roots are also increasingly being used in feeding rations in various forms such as dried chips and grits, flour and cooked roots (Kleih et al., 2013).

The diverse use of cassava biomass and the derived products and by-products have high potential utility in different end-user markets. The development of these new cassava value chains demonstrates the growing importance of cassava in Ghana to food security, employment and wealth creation.

2.3 Conceptual Framework

The conceptual framework of the study consists of two parts. First, the concept of biomass-based value webs is explained. Subsequently, the Diamond model is applied to guide the empirical investigation of the competitive advantage of Ghana's cassava value web.

2.3.1 The biomass-based value web concept

Biomass is a term used to describe organic matter that is derived from plants and animals. Agricultural crops and their residue are therefore a rich source of biomass. A bio-based economy or bioeconomy is a knowledge-based system of producing and transforming such biomass resources into economically competitive products in new, sustainable and eco-efficient ways so as to capture an increasing share of added value across all economic sectors (Global Bioeconomy Summit, 2015; OECD, 2008). These processes effectively strengthen the link between biomass production, utilisation and trading. Accordingly, 'biomass-based value webs' are complex systems of interlinked value chains in which food, feed, fuel and other biomass-based raw materials are produced, processed, traded and consumed (Virchow et al., 2016).

The value web concept was developed by Virchow et al (2016) as an extension to Porter's (1985) classical value chain concept to capture the multiple pathways and uses of biomass in the bioeconomy. The web perspective serves as a multidimensional framework that facilitates exploration of both the synergies and bottlenecks in and between interrelated value chains (Smith et al., 2000). This approach also importantly accounts for recycling processes and the cascading effects of biomass utilisation which not only merges value chains but also closes material cycles in a system of 'zero waste' biomass (Virchow et al., 2016). This emphasises the synergies between different biomass uses. Scheiterle et al. (2018) aptly used this approach to assess the multiple uses of sugarcane biomass in Brazil's bioeconomy. Similarly, the value

web concept is used in this study to analyse the physical flow of biomass as well as the actors involved in production, processing, trade and use of the biomass and the products and by-products that are derived from it.

The biomass-based value web concept therefore provides a holistic analytical approach to understanding the increasingly complex pathways of cassava biomass flows in Ghana and how this system is governed, whiles also highlighting the potential for innovation.

2.3.2 Applying the Diamond Model

In order to develop a sustainable and efficient biomass-based value web in the emerging bioeconomy, the production, processing and utilisation of biomass must be competitive. Therefore, Porter's (1990) Diamond model is applied to analyse the national competitiveness of the cassava value web in Ghana.

The Diamond Model defines four broad attributes that determine the competitive advantage of nations or industries. The framework allows for the assessment of why certain industries based in some countries are able to innovate faster than other industries as well as international competitors. As shown in Figure 2.1, the four interrelated determinants of competitive advantage proposed by the Diamond Model are factor conditions, demand conditions, firm structure and strategy, and related and supporting industries. The model also considers the role of the government in acting as a catalyst to improve a country's position in a globally competitive economic environment. The dynamics of national competitive advantage also effectively creates clusters of competitive industries that are linked by different types of interactions (Porter, 1990). The Diamond model has been appropriately used in analyzing the national competitiveness of different agricultural industries and value chains (see Sterns & Spreen, 2010; Neven & Dröge, 2001).

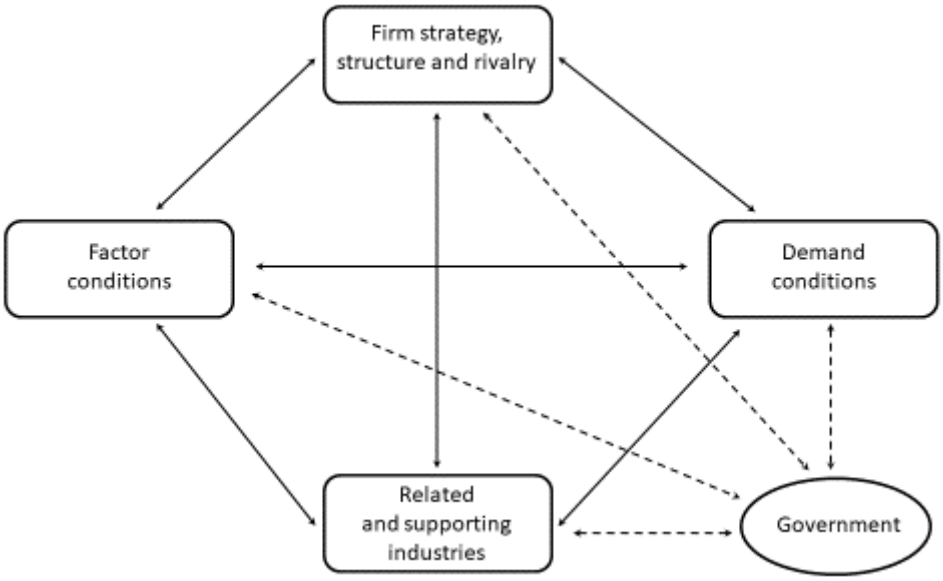

Figure 2.1: Porter's Diamond model of national competitive advantage

Source: Porter (1990)

In this paper, the Diamond Model is combined with the concept of biomass-based value webs to identify the linkages between all the actors involved in the value web and thereby analyse the competitive advantage of Ghana's cassava value web. The financial, knowledge and business interactions between the different stakeholders are therefore assessed. The analytical goal is to identify the extent to which Ghana is positioned to make use of new opportunities and develop a competitive cassava value web in the emerging bioeconomy.

2.4 Research Methods

This section presents the research design of the study followed by the data collection methods used for the study.

2.4.1 Research Design

A three-step approach was used to collect data for the study. In the first step, the cassava value web was visually mapped out with purposively sampled experts. These respondents were selected based on their extensive experience and knowledge of Ghana's cassava value web. The visualisation of the value web involved identifying all the existing products and cascading uses of cassava biomass in Ghana as well as potential future derivatives from the crop biomass. This information was cross-checked from the existing literature and through

direct observation (e.g., of various processing activities). The map produced was also used as the initial means of identifying the actors in the cassava value web.

In the second step, the Net-Map tool was applied. Net-Map is a participatory social network mapping tool based on the visualisation of networks within multi-stakeholder systems by respondents (Schiffer, 2007). The tool was used to identify all the actors in the cassava value web and to assess how they are linked. Guided by the mapping exercise in the first step, the Net-Map exercise was carried out with purposively sampled respondents who had an in-depth understanding of how the entire cassava value web operates. A detailed description of how this tool was applied is explained in Section 2.4.2.

The final step involved in-depth interviews with selected experts from all the identified stakeholder categories from the Net-Map exercise using purposive sampling. These respondents were selected on the basis of having a high level of experience and expertise in carrying out specific functions in the cassava value web. Additional in-depth interviews were conducted using chain-referral sampling to ensure exhaustive expert information. The respondents included donors, public research institutions, government agencies, processors, farmers and other stakeholders across the country. A total of 47 respondents were involved in the study (see Table 2.2). Each interview was semi-structured and open-ended with the aim of best capturing the respondent's expert opinion on the challenges and opportunities of a cassava based bioeconomy. Member checks in the interview process involved paraphrasing or restating responses from respondents for clarification where necessary (see Guba & Lincoln, 1989). The three-step research design was complemented with an extensive review and synthesis of relevant policy documents and project reports. The document review served as triangulation to validate the reliability of the findings.

2.4.2 Data Collection

Data collection was carried out between October 2015 and April 2017. The exercise of mapping out the physical flow of cassava biomass and its products was carried out with three respondents. These respondents represented government agencies, public research institutions and medium and large scale processors.

The Net-Map tool was applied with six respondents from different stakeholder categories in the cassava value web. The respondents included those from the initial mapping exercise. The application of Net-Map involved four steps: (1) The respondents were asked to identify all

the actors involved in the cassava value web and their respective roles. These actors were recorded on a large sheet of paper. (2) The respondents were asked to identify the fund flows, knowledge flows and business linkages between the different actors. One-sided arrows were used for linkages that were unidirectional while double-sided arrows were used for two-way linkages between actors. Different colors were used to distinguish the three types of linkages. Fund flows were defined as money or financing meted out for particular activities; knowledge flows were considered as linkages involving the transfer of information, technical know-how, training and capacity building; business linkages were defined as transactions involving the exchange of goods and services (service delivery). (3) After completion of the map, respondents were asked to review whether all the actors and linkages in the value web had been included. (4) Finally, follow-up questions were asked on the challenges and opportunities in the cassava value web. This included asking respondents to identify any additional actors who had not been considered in the Net-Map that could potentially play an important role in the development and production of cassava based bioeconomy products. The visualisation of the stakeholders of the value web in the form of the Net-Map in front of the respondent facilitated the identification of these challenges and opportunities.

The subsequent interviews mainly focused on the challenges and opportunities related to respondents' specific activities in the value web. The interviews also served as a means of validating the fund flows, knowledge flows and business linkages of the actors established from the Net-Map exercises. The Net-Map exercises and in-depth expert interviews were conducted in person on a one-on-one basis at the convenience of the respondents. All the interviews of the study were audio-recorded with the expressed permission of the respondents.

Table 2.2: Overview of expert interviews

Stakeholder Category	Number of Value Web maps	Number of Net-Maps	Number of Interviews (including Value Web maps & Net-Maps)
Development Partners/Donors			1
Government agencies	1	1	6
Public research institutions	1	2	8
Financial institutions			1
Industrial end-users			7
Supporting actors		1	5
Micro-processors			3
Medium & large scale processors	1	2	7
Farmers			6
Traders			3
Total	**3**	**6**	**47**

2.4.3 Data analysis

A combination of qualitative and quantitative methods was used to analyse the data collected. The recorded in-depth interviews were inductively analysed using content analysis to identify recurring and unique themes (see Berg et al., 2004; Glaser & Strauss, 1967).

The networks identified during the Net-Map exercises were analysed quantitatively using social network analysis. There were no contradictions in the information provided by the respondents in the Net-Map exercises. However, some of the Net-Maps varied in the level of detail in terms of the number of stakeholders and linkages. The lack of contradictions facilitated aggregation of the 6 Net-Maps. The UCINET software (Borgatti et al., 2002) was used to derive statistical measures of centrality (degree, closeness and betweenness) among the actors.

Degree centrality shows the number of links an actor has compared to other actors in a network (Borgatti, 2005). Therefore, an actor with a higher value has a larger number of interactions with other actors in a given network and is considered more influential. In the estimations of degree centrality, outgoing and incoming links from an actor are presented as (Out)Degree and (In)Degree respectively.

Closeness centrality measures the average number of links an actor needs to reach other actors in a network (Freeman, 1978). Thus, actors who were unconnected were not included in this calculation. A higher value depicts the more central or interlinked an actor is in a network and the closer that actor is to all other actors. In the estimations of closeness centrality, outgoing and incoming links from an actor are presented as (Out)Closeness and (In)Closeness respectively.

Betweenness centrality quantifies the number of times an actor acts as an intermediary along the shortest path between two other actors in a network. A higher value indicates a higher frequency of an actor's role as an intermediary between two other actors (Borgatti, 2005).

2.5 Results

This section begins by presenting the graphical representation of biomass flows in the cassava value web. Afterwards, the empirical findings of the social network analysis and the challenges and opportunities of developing a competitive cassava value web are presented.

2.5.1 The cassava value web

The map of the cassava value web illustrated in Figure 2.2 identifies all the cascading uses of cassava biomass in Ghana. The map also considers the most realistic potential uses of the crop biomass as envisaged by industry experts.

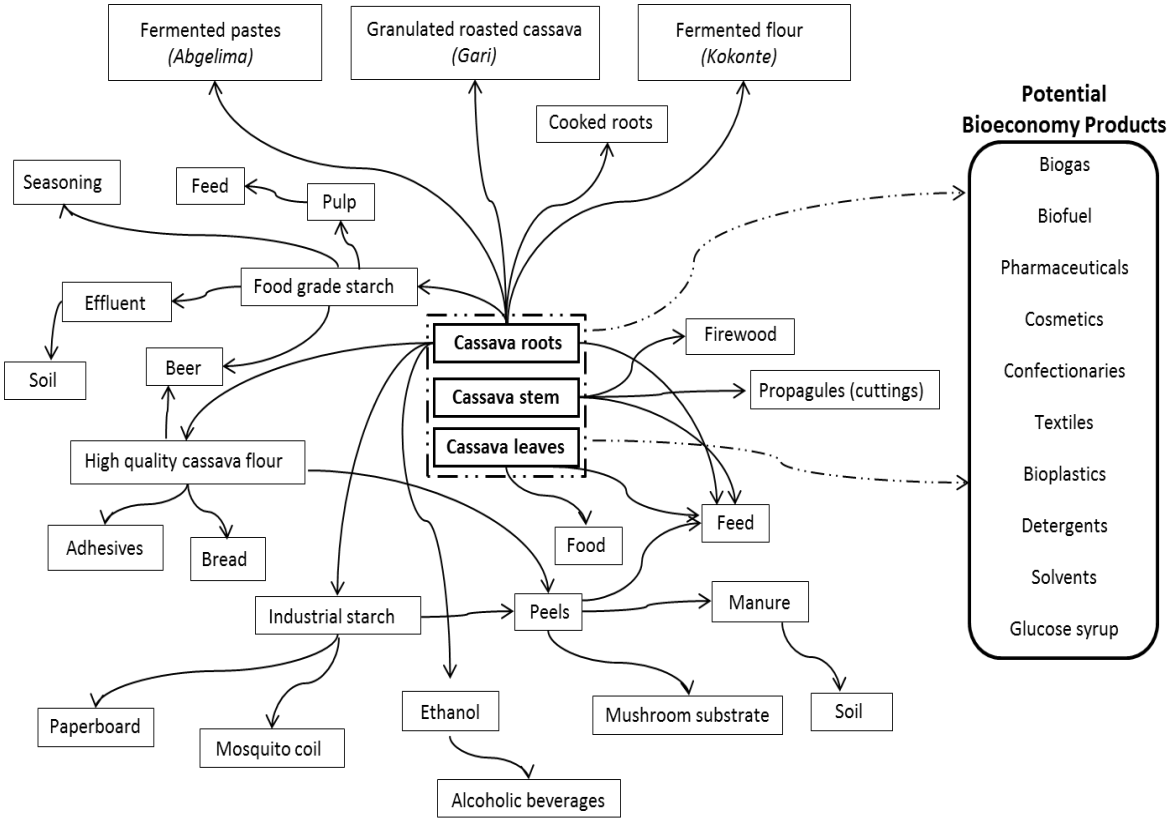

Figure 2.2: Biomass flows in the cassava value web

2.5.2 Actors and their roles in the cassava value web

The results from the Net-Map exercises revealed that the World Bank, the International Institute of Tropical Agriculture (IITA), the Food and Agriculture Organisation of the United Nations (FAO), the Bill and Melinda Gates Foundation (BMGF) and the International Fund for Agricultural Development (IFAD) are the main funding institutions of projects and programmes in the value web.

Smallholder farmers serve as the main source of cassava biomass. However more recently, there are a few commercial cassava producers in Ghana. Micro-processors specialise in processing cassava into traditional foods. Medium and large scale processors on the other hand are involved in processing both food and industrial products. Traders are the main outlet for the sale of fresh cassava roots and processed traditional foods. Most micro-processors are also traders.

The Ministry of Food and Agriculture (MoFA) is the primary government agency responsible for the growth and development of the cassava sub-sector in Ghana. The Ghana Regional

Appropriate Technology Industrial Service (GRATIS) is also a public institution that designs and manufactures cassava production and processing equipment.

Public research institutions are the driving force of innovation in the value web. The Crop Research Institute (CRI) and the Savannah Agricultural Research Institute (SARI) are mandated to breed improved cassava varieties suitable for the different agro-ecologies. The Institute of Industrial Research is responsible for scientific and technological research into industrial equipment and processes. The Soil Research Institute focuses on the utilisation and management of the soil resources of Ghana for increased and sustainable cassava production. The Food Research Institute is responsible for market oriented research of cassava's various food uses. All of these institutions fall under the umbrella of the Council for Scientific and Industrial Research (CSIR). The public universities collaborate and complement the output of these public research institutions. For instance, 3 improved cassava varieties have been bred by public universities.

The main financial institutions involved in the cassava value web are commercial banks and microfinance institutions which offer short and medium term financing to farmers and processors. The Outgrower and Value Chain Fund on the other hand is a German funded programme for outgrower schemes that offers long term financing. EximBank is a public development bank that funds enterprises in the export business.

There are a number of end-users that are increasingly utilising and selling cassava based products. They include bakeries, piggeries, plywood manufactures, packaging companies and breweries. Finally, there are other supporting actors such as input suppliers that mainly sell herbicides to cassava producers; aggregators buy fresh roots from numerous dispersed smallholders and sell in bulk to medium and large scale processors; fabricators are private entities that compete with GRATIS in designing and manufacturing cassava processing equipment; the industrial cassava stakeholders' platform is a platform of actors in the value web that aims to link farmers and processors to industrial end-users and advocates for favourable government policies to support industrialising cassava in Ghana.

The 29 institutions identified in the cassava value web can be grouped into 7 clusters as shown in Table 2.3.

Table 2.3: Clusters of actors in the cassava value web

Clusters	Institutions
Development Partners/ Donors	World Bank IITA FAO BMGF IFAD
Cassava sub-sector	Farmers Micro-processors Medium & large scale processors Traders
Government agencies	Ministry of Food & Agriculture GRATIS
Public research institutions	CRI/ SARI Institute of Industrial Research Food Research Institute Soil Research Institute Universities
Financial institutions	Outgrower & Value Chain Fund EximBank Banks & microfinance institutions
Industrial end-users	Bakeries Piggeries Supermarkets Breweries/ Distilleries Plywood manufacturers Packaging companies
Supporting actors	Stakeholders' platform Fabricators Input suppliers Aggregators

2.5.3 Institutional linkages in the cassava value web

The results of the social network analysis display the institutional linkages between the actors in the cassava value web in terms of the fund flows, knowledge flows and business linkages.

2.5.3.1 Fund flows

Figure 2.3 shows the network of fund flows in the cassava value web. It is evident that the network is highly dependent on donor funds. MoFA serves as the focal institution that directly receives and disperses most donor funds to other actors in the value web. Therefore, MoFA controls most of the funds in the network. Public research institutions such as the Food Research Institute and CRI/SARI are the only other actors that receive direct funding from development partners. However, these institutions also receive funds from MoFA.

Apart from MoFA, banks and microfinance institutions as well as medium and large scale processors are the only two other actors who play an intermediary role in the funding network. Interestingly, farmers do not receive any direct funding from banks and microfinance institutions in the network. They rather depend on medium and large scale processors and MoFA. These findings are also indicated by the centrality measures (see Appendix 2.1).

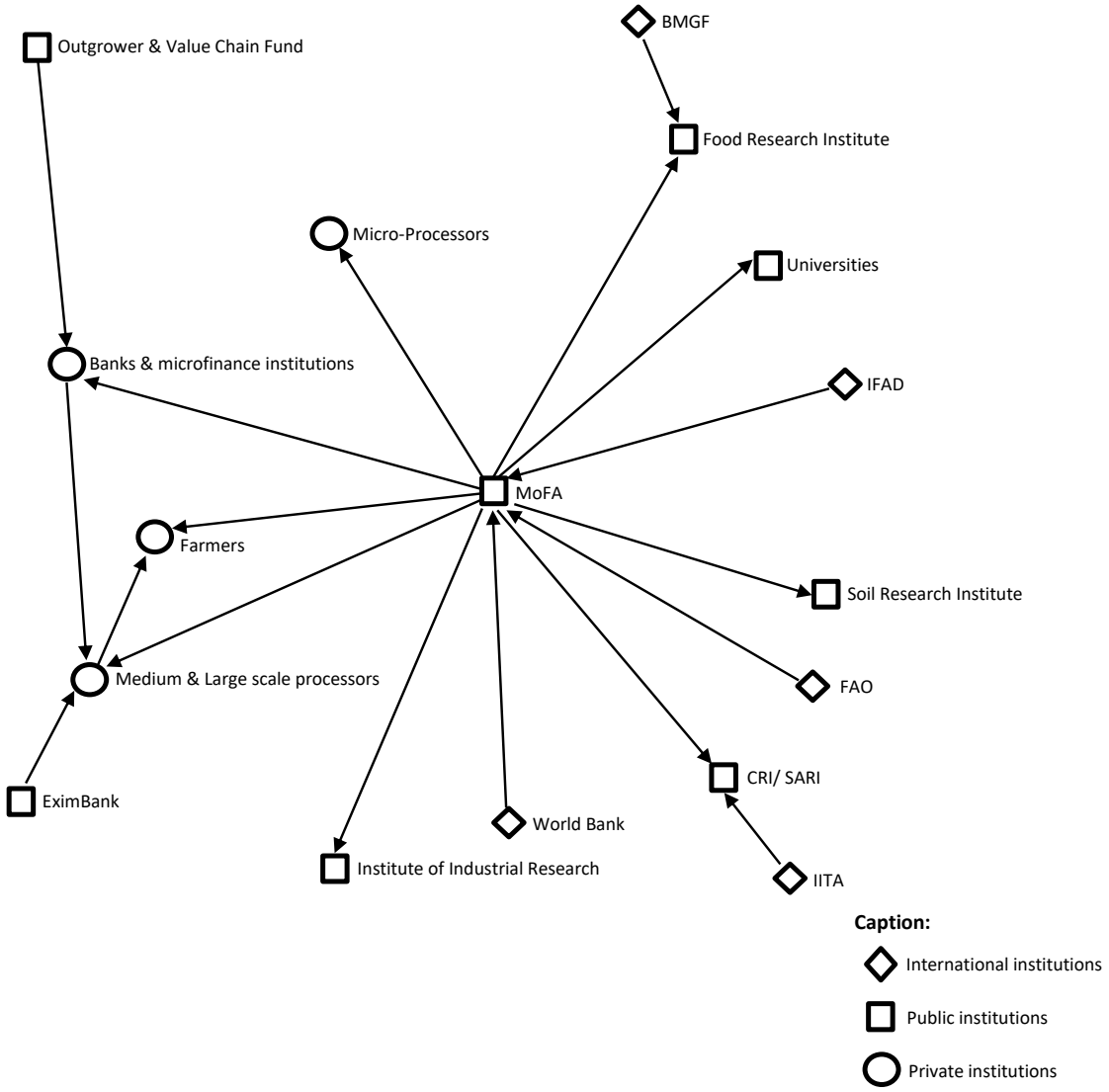

Figure 2.3: Network of Fund flows

2.5.3.2 Knowledge flows

Figure 2.4 shows that knowledge flows are significantly dispersed among public and private institutions in the value web. Most of the actors in the network both transfer and receive knowledge. It must however be noted that a number of actors including banks and microfinance institutions, traders and some industrial end-users are isolated in the network (see Appendix 2.2).

The Food Research Institute is the most connected actor in the network, followed by MoFA and the universities respectively. These public institutions serve as the main sources of new

knowledge for other public and private sector actors. Conversely, private sector actors such as bakeries, plywood manufacturers and packaging companies share the least amount of knowledge with other actors. Indeed, fabricators do not transfer any knowledge in the network. IITA is also the only international institution that transfers and receives knowledge in the network.

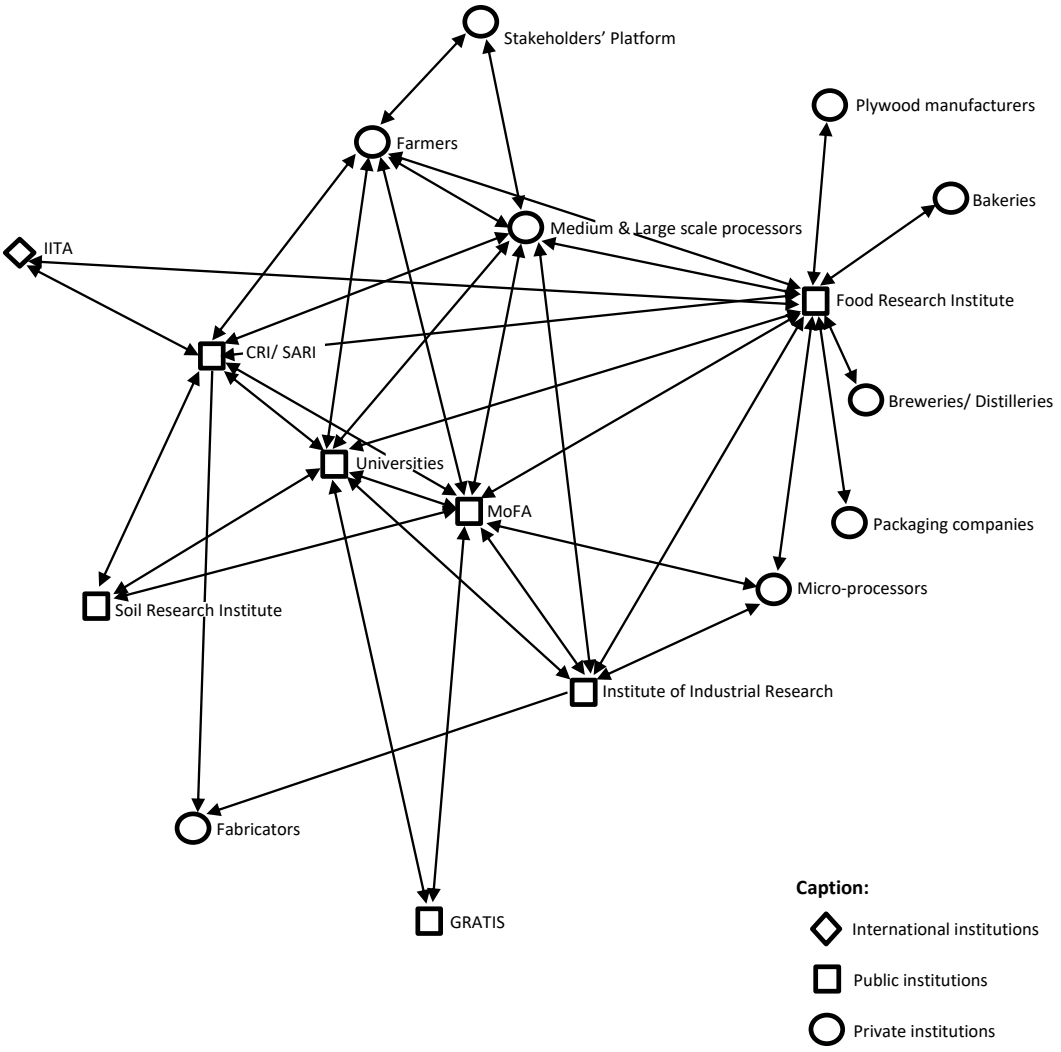

Figure 2.4: Network of Knowledge flows

2.5.3.3 Business linkages

The network for business linkages is dominated by private sector actors as expected (see Figure 2.5). Medium and large scale processors are the most influential actor in controlling the flow of business in the cassava value web. Accordingly, medium and large scale processors have the most number of business linkages in the network, followed by farmers and micro-processors. These actors have the easiest access to other actors in establishing business collaborations. For instance, all industrial end-users deal directly with medium and large scale processors in the network.

Conversely, the only public sector actor in the network, GRATIS, has little influence in controlling the flow of business in the network. The structure of the network is reflected in the centrality measures of the business linkages (see Appendix 2.3).

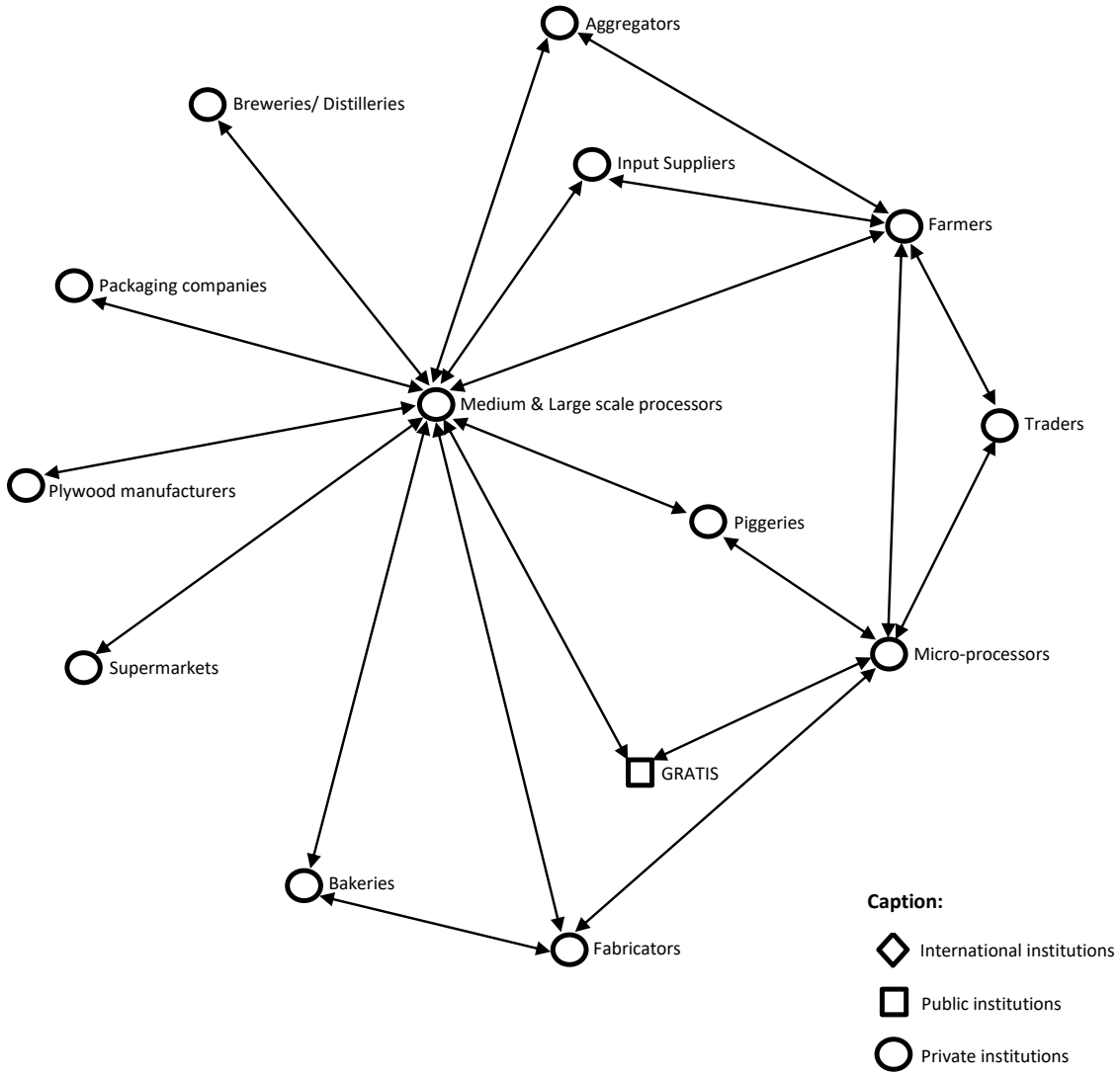

Figure 2.5: Network of Business linkages

2.5.4 Challenges and opportunities in the cassava value web

A summary of the main findings from the expert interviews on the challenges and opportunities in the cassava value web are presented in Table 2.4 using the Diamond model framework to categorise the themes.

2.5.4.1 Challenges

The expert interviews confirmed that a factor condition such as the predominance of subsistence-based smallholder cassava production in Ghana has meant minimal use of inputs and rudimentary agronomic practises in the cassava value web. This has contributed to relatively low yields. Respondents also pointed out the major challenge of poor road networks.

The interview information collected for this study as well as direct observation of various facilities suggests that in terms of demand conditions in the value web, processors tend to have inconsistent demand for cassava roots because they usually operate below installed capacity. According to interview information, this serves as a disincentive for farmers to increase yields or production volumes.

Respondents of the study observed that there is generally a lack of private sector initiatives in the development of new cassava based products in Ghana, with very few exceptions. Most processors and industrial end-users refrain from investing in the development of innovative ways of utilising the crop biomass.

Respondents emphasised that the public extension system, a supporting institution of the value web, is understaffed and under-resourced in its role of promoting new technologies among farmers.[1] This has contributed to low adoption rates of improved technologies among cassava farmers in Ghana. According to interview information, commercial banks and microfinance institutions also tend to be wary of agricultural investments given the high level of risk and unpredictability associated with such investments.

Respondents of the study pointed out that currently, Ghana does not have a cassava development policy. The government has however recognised cassava's economic potential by supporting several programs and projects as well as by way of the PSI on cassava starch introduced in 2001. Yet, these efforts have largely proved to be either unsustainable or

[1] The extension-farmer ratio in Ghana is currently 1:1,500 (MoFA, 2015b).

unsuccessful in most cases. Beyond that, interview information also emphasised the lack of legislation in the form of a composite flour policy or a biofuel blend policy that would mandate the use of cassava based products such as HQCF or bio-ethanol.

2.5.4.2 Opportunities

Respondents pointed out that most parts of Ghana have the climatic conditions conducive for growing cassava. However, there is still a lot of unutilised farm land available for large scale commercial investments. Nonetheless, despite widespread subsistence cultivation, there is commonly significant surplus produce of cassava which is wasted or remains unharvested because farmers are unable to find off-takers. Respondents noted that there is therefore a huge potential for the industrial use of cassava in Ghana without food security being adversely affected.

According to the information collected for this study, there is growing domestic demand for cassava based products such as processed food products and alcoholic beverages. There is also rising demand across other countries in the West African sub-region. Consequently, the pharmaceutical, textile and food and beverage industries, among others, are becoming increasingly aware of the industrial applications of cassava.

The expert interviews confirmed that medium and large scale processors have started employing outgrower and contract farming models to help secure a reliable supply of cassava roots from farmers in adequate volumes. Another strategy being employed by processors is the diversification of their production portfolios. According to interview information as well as direct observation, most processors hedge their risk of making losses by producing more than one cassava product.

Respondents noted that public research institutions have been effective in supporting the growing cassava value web. CRI and SARI have bred twenty-four improved cassava varieties. The Food Research Institute has also been instrumental in the development and application of new products such as HQCF and industrial grade cassava flour in Ghana. Furthermore, respondents confirmed that local fabricators are becoming more proficient in manufacturing processing equipment.

Cassava has been earmarked as one of Ghana's food security crops in the government's sector-wide policy (FASDEP). Respondents observed that this has resulted in increased focus on research on improving cassava productivity. According to the expert interviews, another

notable initiative by the government has been an excise duty concession for local content beers announced in 2012.[2] This tax incentive policy has encouraged the introduction of two cassava beers in Ghana. Respondents also noted that Ghana has a draft National Biofuel Policy which aims to accelerate the development and use of second-generation biofuels (using the non-edible parts of food crops) when enacted.

[2] This is a tiered reduction in excise tax for beers that contain more than 30% of locally sourced content.

Table 2.4: Matrix of themes from expert interviews

Themes from Expert Interviews			Interview number							
			4	6	8	10	12	14	16	18
Challenges	**Factor conditions**	>90% subsistence-based smallholder cultivation								X
		Limited labour available for harvesting			X					
		Poor road networks								X
	Demand conditions	Inconsistent demand for cassava roots from processors						X		
		Reluctance of industrial end-users to use cassava products due to supply and quality concerns							X	
	Firm strategy, structure and rivalry	Lack of private initiatives in the development of new cassava based products				X				
		Dependence on imported inputs							X	
	Related and supporting industries	Weak public extension system to support farmers in adopting new technologies					X			
		High cost of credit and loan facilities from financial institutions								X
		Lack of continuous supply of electricity from the state		X						
	Government policies	Lack of a cassava development policy like for cocoa								X
		The unsustainability of projects and initiatives such as the PSI on cassava starch				X				
		Lack of a composite flour policy							X	
		Lack of a biofuel blend policy	X							
Opportunities	**Factor conditions**	Availability of land								X
		Good climatic conditions			X					
		Surplus cassava production in excess of subsistence needs				X				
	Demand conditions	Growing local and regional markets for cassava-based products					X			
		Latent demand for the industrial applications of cassava					X			
	Firm strategy, structure and rivalry	Outgrower/contract farming models for sourcing cassava								X
		Diversification in processing cassava based products				X				
		Recognition of the zero waste potential of cassava biomass			X					
	Related and supporting industries	Good research institutions involved in breeding and product development							X	
		Growing capacity in the manufacturing of processing equipment by local fabricators				X				
		Establishment of an industrial cassava stakeholders' platform		X						
	Government policies	Cassava a priority crop for food security (FASDEP)						X		
		Excise duty concession for local content beers		X						
		One-District-One-Factory Programme						X		
		Draft National Biofuel policy	X							

2.6 Discussion

This study aimed to identify the potential of Ghana's cassava value web in contributing to the emerging bioeconomy. From the application of the Diamond Model, it is evident that despite opportunities to develop a competitive value web, critical challenges remain. Deficiencies in the institutional linkages between actors and a less than conducive policy environment appear to be hampering innovation and development of the value web. The reasons are discussed in the following sub-sections.

2.6.1 Underdeveloped factor conditions

Cassava cultivation is dominated by small scale subsistence-based farmers in Ghana. At that scale, farmers make use of limited chemical and technical inputs in the production, harvesting and post-harvest handling of the crop. The findings of the study indicate that there are deficiencies in the institutional linkages (funding, knowledge and business interactions) within the cassava sub-sector. This leads farmers to believe that there is insufficient demand for their produce, even when demand exists among certain processors. A major contributing factor to this problem has been poor road infrastructure which causes inaccessibility and raises the logistical costs of processors acquiring and transporting cassava from widely dispersed smallholders. These conditions in turn serve as a disincentive for farmers to increase their planted area or adopt new technology and agronomic practices to increase their productivity. This is consistent with the findings of Acheampong et al. (2017) and Onumah et al. (2008) that marketing challenges contributed to the reluctance of smallholders in Ghana to increase their cassava production.

2.6.2 Deficient demand conditions

The study's findings indicate that medium and large scale processors are very often faced with the challenge of securing sufficient volumes of fresh cassava when demand arises. This is due to low farm productivity and lack of accessibility. Thus, most processors are forced to operate below installed capacity. Similarly, Kleih et al. (2013) found that since the Ayensu Starch factory was established in 2002 under the PSI, it has never operated at full capacity mainly due to insufficient supply of cassava roots. This affects the quantity of cassava products like starch or flour that are processed to meet the demand of end-users. As shown in the network of business linkages (Figure 2.5), medium and large scale processors are the main source of cassava products for various end-users. Inconsistent supply of these cassava

products has created reluctance among industrial end-users to replace their current inputs. Many processors are also unable to meet the quality standards of industrial end-users, leading to rejections. Thus, high rejection rates and low confidence in processors' ability to supply the required volumes has led to low demand for cassava products by industrial end-users. As a result, a vicious cycle is created because processors in turn do not have sufficient demand to consistently buy cassava from farmers.

2.6.3 Lack of innovative firm strategy, structure and rivalry

Potential end-users of cassava products such as the pharmaceutical and textile industries in Ghana appear to lack initiative in developing cassava products suitable for their production processes. Locally produced medical-grade starch and ethanol for instance could replace imports of these products for pharmaceutical companies. The results of the study indicate that this is a task that has been left to public research institutions which are solely dependent on donor funds as evidenced by the networks of knowledge and fund flows (Figures 2.3 and 2.4). The Food Research Institute, for example, has been instrumental in the development and application of HQCF, a major intermediate product, in Ghana (see Dziedzoave et al., 2006; Dziedzoave et al., 2003). In some industries, there is still a low level of awareness of the potential of cassava products to substitute imported goods. However in industries where there is awareness, most end-users are unwilling to commit resources to develop the needed supply chain in terms of ensuring that requirements of supply volumes, quality standards and competitive pricing are met. There might also be additional costs associated with switching inputs such as installing new equipment. Moreover, it must be noted that cassava products are not always cheap enough to warrant producers switching from imported alternatives. Koyama et al. (2015) found that biscuit companies in Ghana rely on wheat flour imports from Turkey which is cheaper than HQCF. Abass et al. (2011) reported a similar situation in Nigeria.

2.6.4 Inaccessible related and supporting industries

The primary crop breeding institutions in Ghana, CRI and SARI, as well as the public universities have been effective in developing improved cassava cultivars. However, uptake among farmers has remained relatively low. Alene et al. (2015) found that the area planted to improved cassava varieties in Ghana only increased from 25% in 1998 to 36% in 2009. The study found that the limited number of agricultural extension agents to promote these technologies has been a contributing factor to the low adoption rate. The poor coverage and low extension-farmer ratio have primarily been caused by staff attrition and a lack of

replacements and recruitments by MoFA. This is in line with a freeze on public sector hiring in an attempt to reduce the government wage bill.

Access to formal sources of financing for farmers and processors also remains a critical challenge in Ghana as confirmed by studies by Acheampong et al. (2017) and Essegbey (2009). Banks and microfinance institutions offer high interest rates of between 18-25% per year for loans and credit facilities, making them inaccessible to most enterprises. The network analysis confirms the weak interaction between financial institutions and the cassava sub-sector. For instance, Figure 2.3 shows that banks and microfinance institutions do not have direct interaction with farmers and micro-processors. Similarly, medium and large scale processors tend to struggle to compete with the price of imported goods due to these high costs of finance. Available value addition technologies are also underutilised by processors because of financial constraints. Furthermore, persistent challenges with state supplied electricity have compelled processors to invest in alternative sources of power generation like generators to stay in business. This has led to higher operating costs and a significant downturn in operations.

These institutional challenges have inhibited the role these supporting institutions are supposed to play in facilitating much needed investments in 'factor upgrading' in cassava production and processing in Ghana.

2.6.5 Missing government policies

Cassava does not have a specific sub-sectorial policy like cocoa (see Poku, 2017). This invariably means government support tends to focus on specific aspects of the sub-sector rather than taking a more holistic approach. The study confirms that government policies supporting the development of the cassava sub-sector in Ghana thus far have mainly focused on improving productivity and food security. There has been less emphasis on commercialisation and industrial development. This is evidenced by the study's finding of the lack of a direct institutional linkage between government agencies and industrial end-users (Figures 2.4 and 2.5). Koyama et al. (2015) point out that based on the success of Thailand and Vietnam, African countries must recognise the important role of government policies in stimulating demand and sustained market opportunities both locally and internationally for high value cassava products. Correspondingly, the study's findings indicate that unsuccessful initiatives such as the PSI on cassava starch and the absence of legislation such as a composite flour policy or a biofuel blend policy have been major contributing factors to the

unrealised industrial potential of cassava in Ghana thus far. In this regard, companies with strong political connections might also have entrenched interests in maintaining the status quo of a system fully dependent on certain imports.

Overall, the study's findings show that a conducive policy and institutional environment are critical to realising the untapped potential of cassava and developing a competitive value web in Ghana.

2.7 Conclusions

In this paper, the policy and institutional environment required for developing a competitive and sustainable bioeconomy in Africa were analysed using the novel concept of biomass-based value webs. Cassava in Ghana was used for an empirical case study. The analysis, which was based on a combination of social network analysis and content analysis of expert interviews, revealed the challenges and opportunities of developing a competitive cassava value web in Ghana.

The findings indicate that overcoming the challenges of low farm productivity, low utilisation of cassava biomass by processors and low demand by industrial end-users hinges on improved coordination between value web actors. Outgrower or contract farming models can serve as an effective means of strengthening these institutional linkages. Supporting institutions such as financial institutions and public extension services also have critical roles to play in strengthening fund flows, knowledge transfer and business linkages between actors. Furthermore, government policies that actively support the use of local content across industries would incentivise end-users to adopt cassava products and thus give processors the assurance of a ready market for their products. This will incentivise increased farm productivity.

The study concludes that there are important complementary roles that need to be played by a diverse set of institutions within an enabling environment in order to realise competitive biomass production and utilisation in Africa's emerging bioeconomy.

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3. MAKING CONTRACT FARMING ARRANGEMENTS WORK IN AFRICA'S BIOECONOMY: EVIDENCE FROM CASSAVA OUTGROWER SCHEMES IN GHANA

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Abstract

This paper uniquely focuses on rapidly-developing domestic value chains in Africa's emerging bioeconomy. It uses a comparative case study approach of a public and private cassava outgrower scheme in Ghana to investigate which contract farming arrangements are sustainable for both farmers and agribusiness firms. A complementary combination of qualitative and quantitative methods is employed to assess the sustainability of these institutional arrangements. The results indicate that ad hoc or opportunistic investments that only address smallholders' marketing challenges are not sufficient to ensure mutually beneficial and sustainable schemes. The results suggest that firms' capacity and commitment to design contracts with embedded support services for outgrowers is essential to smallholder participation and the long-term viability of these arrangements. Public-private partnerships in outgrower schemes can present a viable option that harnesses the strengths of both sectors and overcomes their institutional weaknesses.

Keywords: Contract farming; Contract design; Cassava; Bioeconomy; Ghana

3.1 Introduction

Rapid agro-industrialisation in sub-Saharan Africa is leading to the development of high-value supply chains for agro-food systems (Henson & Reardon, 2005). Additionally, there is increasing demand for feed and other biomass-based raw materials such as fuel and fibre crops in Africa's emerging bioeconomy (Timilsina et al., 2012). This has meant a transition towards modernised procurement systems even for agricultural commodities that have traditionally been dominated by spot market exchanges between small scale farmers and traders (Reardon & Barrett, 2000). Consequently, contract farming (CF)— the institutional arrangement wherein processors enter into formal or informal contractual agreements with farmers to produce and supply them with agricultural commodities— has increasingly been embraced by agribusiness firms in developing countries as an efficient approach for coordinating supply chain activities (Schipmann & Qaim, 2011; Barrett et al., 2012; Bellemare, 2012; Saenger et al., 2013).

CF, however, remains a highly contested institutional arrangement in terms of poverty alleviation and rural development. Empirical evidence from developing countries on smallholder participation in CF and its impact presents mixed results. Some studies have found that smallholders actively participate in CF schemes and earn higher income as a result. These farmers were found to have benefitted from better access to inputs and new technology leading to improved farm productivity (Warning & Key, 2002; Minten et al., 2009; Rao & Qaim, 2011; Barrett et al., 2012; Bellemare, 2012). Conversely, other studies have reported evidence of smallholder exclusion, high default rates and various forms of opportunistic behaviour by firms such as delayed payments and a lack of compensation for crop losses in CF schemes (Key & Runsten, 1999; Singh, 2002; Simmons et al., 2005). These divergent findings shed light on how essential contract design is to the performance and impacts of CF schemes. However, there is a paucity of studies, particularly in the African context, examining which institutional arrangements and contract conditions are sustainable for both farmers and agribusiness firms in these schemes. Addressing this knowledge gap is even more pertinent considering the increased competition for the procurement of multi-purpose crop biomass in rapidly developing domestic agricultural value chains. Such domestic value chains have previously been considered as less than suitable for CF arrangements (see TechnoServe & IFAD, 2011). Therefore, in the wake of numerous failed contract farming arrangements in Africa (Oya, 2012), this paper empirically investigates the role of contract design in facilitating sustainable contract farming arrangements between

farmers and agribusinesses, particularly for a staple crop. The study does not directly address the impacts of CF, but rather focuses on investigating which CF arrangements are sustainable for both farmers and agribusiness firms. Sustainability in this context refers to the long-term viability of CF arrangements for all the actors involved. The paper uses the empirical example of two cassava outgrower schemes (state operated and private operated) in Ghana.

Cassava is a major staple crop in Ghana which has the advantage of being able to produce economic yields even under marginal production conditions. Cassava accounts for approximately 50% of all root and tuber production in the country and is second only to maize in terms of area planted (MoFA, 2015). It is, therefore, considered as a primary food security crop. This has made it a preferred crop among small-scale, resource-poor farmers (Polson & Spencer, 1991). Cassava is an annual crop that is mainly consumed in the form of cooked fresh roots and domestically processed products traded on the open market. However, it is slowly shedding its image as a "poor man's crop" and overcoming its seasonal marketing challenges due to the economic potential and increasing industrial applications of cassava biomass for food, feed, and energy (Kleih et al., 2013). Therefore, there has been increasing commercial use of the crop due to rising urban demand for processed cassava products and increased recognition of its industrial potential in the emerging bioeconomy (Koyama et al., 2015). This has led to the emergence of medium and large scale processors using various contractual arrangements to source cassava from farmers. Cassava roots are not as perishable as fruits and vegetables, which need to be harvested at a specific time to avoid losses. The roots can remain unharvested for some time after maturity. However, unlike grains that can be stored after harvest, cassava roots must be processed or consumed shortly after harvesting. Cassava roots begin to deteriorate within 24 to 36 hours after harvest (Iyer et al., 2010). This necessitates efficient procurement systems.

CF in Ghana thus far has been dominated by a range of public and private large scale production arrangements of horticultural and tree crops mainly for export (Baumann, 2000; Amevenku et al., 2012). Many of these arrangements have been characterised by contract conditions that allow agribusiness firms to maximise their short term returns at the cost of the long term sustainability of the schemes. They therefore only operate for a few years before collapsing (see Harou & Walker, 2010). This study uniquely highlights the role CF is playing in strengthening the link between biomass production and utilisation as the agricultural sector in sub-Saharan Africa gradually transitions from a food-supplying to a biomass-supplying sector. Therefore, smallholders growing traditional staple crops are increasingly presented

with the opportunity of participating in CF schemes for the first time. Poorly designed contracts may however expose farmers to additional risks and exploitation by larger agricultural actors. These contractual arrangements have hardly been analysed in the literature.

A complementary combination of qualitative and quantitative methods is employed to assess the sustainability of these institutional arrangements. First, in-depth interviews and focus group discussions are used to elucidate the contract design features of the schemes as well as both the firms' objectives and constraints, and farmers' perceptions of these features. Second, probit analysis based on primary survey data is used to determine the contract design features that influence farmers' decision to participate in each scheme. The paper draws on this comparative case study analysis to examine forms of CF that will promote the long term sustainability of viable firm-farmer contract arrangements. The study demonstrates that ad hoc or opportunistic investments that only address smallholders' marketing challenges are not sufficient to ensure mutually beneficial and sustainable CF schemes in fast developing domestic value chains. There is the need for direct firm investment in supporting outgrower operations. Therefore, even for a staple crop like cassava that does not traditionally have an intense cultivation pattern, embedded support services such as input supply and technical assistance are critical to smallholder participation and the long term success of outgrower schemes. Public-private partnerships may be the best avenue to sustainably providing these conditions.

The rest of the paper is organised into four sections: Section 3.2 briefly highlights prevalent contract design features of CF in developing countries. The data collection and analytical approach used in the study are described in Section 3.3. In Section 3.4 the empirical results are presented. Section 3.5 discusses the empirical findings and Section 3.6 provides the conclusion.

3.2 Firm-farmer contract relations

The relationship between the agribusiness firm and the farmer in contract production can be conceptualised as a four stage process (Barrett et al., 2012). A firm first chooses a procurement location; offers farmers a contract; farmers decide whether or not to accept the offered contract; finally both the firm and farmers choose whether or not to honour the terms of the contract based on how equitable and sustainable the established relationship is for both parties. Agricultural contracts essentially differ based on their intent to transfer decision-

rights and risks between the farmer and the contractor. Mighell and Jones, (1963) distinguish between three types of such contracts: Market specification contracts where there is a pre-production agreement by both parties on the conditions governing future sale of the produce; resource providing contracts where in conjunction with marketing arrangements the buyer supplies the farmer with key inputs; production management contracts where the farmer additionally agrees to adhere to precise production methods and input regimes. Most contemporary agricultural contracts incorporate various elements of these contract typologies (Hueth et al., 2007). This invariably implies trade-offs in terms of coordination, motivation and the transaction costs associated with the design of contractual arrangements (Bogetoft & Olesen, 2002). The following sections abstract prevalent contract design features that govern crop production in developing countries.

3.2.1 Output arrangement

The nature of a CF arrangement is central in assuring farmers of a marketing outlet and firms of the supply of essential raw materials. Contracts can either take the form of an informal oral agreement or a formal written agreement. Written contracts provide superior enforcement possibilities and typically specify pricing, roles and responsibilities, quality and quantity requirements, and conflict resolution mechanisms (Barrett et al., 2012). However, most CF arrangements in developing countries remain as simple verbal agreements predicated on social capital such as reputation and relationship-specific incentives (Bijman, 2008). Such informal arrangements are less costly for agribusiness firms and provide both parties with the option to opt-out of the arrangement. Some case studies have found that such self-enforcing agreements can work effectively (Key & Runsten, 1999; Masakure & Henson, 2005; Guo et al., 2007). However, there remains insufficient evidence on smallholders' preference for either oral or written agreements.

Another key aspect of CF arrangements is the pricing mechanism which is meant to insure farmers against the uncertainty of spot market price volatility. The pricing alternatives used in CF range from fixed pricing, variable or incentive based pricing to formula pricing (see Alexander et al., 2007; Miyata et al., 2009). Empirical evidence from several studies reveals the common use of fixed contract prices in developing countries (see Warning & Key, 2002; Minten et al., 2009). Therefore, firms tend to bear the marketing risk while smallholders bear the production risk. Farmers effectively accept to pay a risk premium in the event that spot market prices rise above the contract price. Nonetheless, this pricing option generally

increases the firm's risk exposure. Agribusiness firms can however employ risk management strategies that are not available to smallholders. This gives them a higher risk tolerance to market price fluctuations (Guo & Jolly, 2008). An important and yet often overlooked aspect of pricing arrangements is the extent to which farmers find the actual price determination mechanism equitable.

3.2.2 Quality standards

Agribusiness firms' quality requirements are a major motivating factor for CF (Eaton & Shepherd, 2001). Contractual arrangements typically include either pre-specified minimum quality standards (see Dolan & Humphrey, 2000; Berdegué et al., 2005) or variable quality standards for farmers' produce (see Miyata et al., 2009). Minimum quality standards may be suited to firms targeting single supply channels while variable quality levels may be appropriate for firms with different marketing outlets. From the farmers' perspective, minimum quality standards offer little incentive for improving quality, although there is a higher risk of complete rejection of produce. Variable quality standards on the other hand expose farmers to potential quality measurement error or bias (Abebe et al., 2013). Indeed, contractors may be tempted to falsify quality testing in order to reduce the price paid to farmers (Minot & Ronchi, 2014). Beyond price differentiation based on quality, current case study evidence on contract farming does not provide much insight into the influence the credibility of quality verification procedures has on farmer participation, particularly for crop production.

3.2.3 Input arrangement

The interlinkage of input and output markets is a fundamental element of CF in developing countries (Dorward et al., 1998). Smallholders often have limited access to inputs and technical assistance as input markets are not well developed and the state tends to lack the capacity to adequately provide these services (Little & Watts, 1994; Bijman, 2008). Contracts regularly include seasonal inputs provided on credit and technical assistance to smallholders (see Key & Runsten, 1999; Winters et al., 2005; Barrett et al., 2012). Such interlocking contracts confer lending advantages on agribusiness firms through monitoring of input use and control over crop management decisions that might jeopardise farmers' output quality or input repayment (Simmons et al., 2005). As a staple crop widely grown with low input use in sub-Saharan Africa, it is unclear whether input provision will effectively incentivise contract production of cassava among smallholders.

3.2.4 Contract enforcement

Conflicts between agribusiness firms and farmers in CF arrangements often arise due to misunderstandings related to the operational aspects of agreements and contract non-compliance (Glover & Kusterer, 1990; Grosh, 1994). Beyond firm-farmer dialogue or third party mediation of disputes, the main contract enforcement mechanism at the disposal of agribusiness firms in the case of oral arrangements is the termination or non-renewal of the contract with non-compliant farmers (see Warning & Key, 2002). Written contacts present both parties with the additional option of sanctions such as legal redress for contract breach. However, in developing countries legal institutions are often absent or ineffective in ensuring contract enforcement (Gow et al., 2000; Bellemare, 2010). In any case, smallholders typically lack the capacity to pursue legal action against firms. Even so, there is deficient empirical evidence on the extent to which farmers consider the means of contract enforcement in deciding whether to participate in CF.

The study aims to contribute to the CF literature by investigating which combination of output and input arrangements, quality standards and contract enforcement mechanisms are attractive and sustainable for both farmers and agribusiness firms. Farmers' evaluation of the contract design features that govern CF arrangements as revealed by their participation decision is an integral aspect of this empirical analysis.

3.3 Data and methods

This section presents a description of the data collection methods, followed by the method of analysis and profile of the outgrower schemes.

3.3.1 Data collection

At the time of data collection for this paper, five cassava outgrower schemes were identified throughout Ghana. The schemes ranged from informal oral arrangements to different forms of written agreements. The schemes studied in this paper are the two largest cassava outgrower schemes in Ghana. The first scheme is operated by a state owned agro-processing firm located in the Awutu Senya district of the Central region while the second scheme is run by a private agribusiness firm located in the Ho Municipal district of the Volta region (see Figure 3.1). Data collection was done in three stages for each scheme from July 2015 to December 2015, starting with the state-run scheme and subsequently with the privately operated scheme. First, in-depth interviews were conducted with government officials,

management personnel and staff of the two selected processing companies, some of their off-takers as well as with ten purposively sampled outgrowers in each scheme who have supplied the companies from the inception of the schemes. This was to fully understand how the schemes operate and how they may have evolved overtime.

Secondly, two focus group discussions were carried out for each scheme. The first set was done with ten purposively selected outgrowers (five males and five females) of each scheme identified from the companies' supply ledgers for 2015.[3] In both cases this was followed by focus group discussions with ten non-participating smallholder farmers from the same communities as the outgrowers. These focus groups also had the same gender profile of five males and five females each. Some of these farmers had previously taken part in the schemes and opted out. This was to gain contextual insight into farmers' understanding and experiences in the schemes. Specifically, the groups were asked to elaborate on their evaluation of the output and input arrangements, quality standards and contract enforcement mechanisms of the schemes. All the interviews and focus group discussions were audio recorded with the expressed permission of the respondents. The qualitative data collection methods of the study are summarised in Table 3.1.

In the final stage, a pre-tested questionnaire designed on the basis of the first two stages of data collection was administered to a total of 315 famers using a multistage sampling process. For the state-led outgrower scheme, the supply ledger for 2015 was used to identify the four highest supplying communities. Proportional random sampling based on supply was used to select 100 outgrowers from these communities to participate in the survey. Fifty (50) non-participating cassava growing farmers were similarly sampled from these communities from lists provided by community leaders. Subsequently, for the privately-run outgrower scheme, the supply ledger for 2015 revealed 65 active outgrowers all of whom were selected for the survey. These outgrowers were distributed across five communities. Twenty (20) non-participating farmers growing cassava were randomly sampled from each of these communities from lists provided by community heads.[4] Non-participant farmers had a high level of awareness and understanding of the contract terms and conditions of both schemes. This was due to extensive community outreach by the firms and farmers' interaction with outgrowers. Furthermore, some of the sampled non-participant farmers had previously been

[3] This refers to the period from January 2015 to September 2015 when the focus group discussions were conducted.

[4] All sampled farmers also met the firm's criteria of having a minimum of 2 acres of farmland.

outgrowers of the schemes. Overall, 70% of the farmers who participated in the survey had landholdings of 5 acres or less. The questionnaire collected a wide range of information on respondents' socio-economic characteristics as well as their experiences and perceptions of the contractual details of the schemes. The interviewers overtly presented themselves as researchers with no affiliation to either agribusiness firm. Neither firm was involved in the selection process of the respondents. All responses were kept confidential.

3.3.2 Method of analysis

The study employs the probit model to analyse the survey data. The model is used to estimate the factors that influence a given farmer's decision to participate in the outgrower scheme in each case. Considering the discrete nature of a farmer's decision of whether or not to participate in CF arrangements, binary choice models such as the probit and logit models are most suitable (Scott & Freese, 2006). In most applications, the choice between the probit and logit models does not make much difference. However, the probit model was selected for this study because it can account for non-constant error variances in more advanced econometric settings (Greene & William, 2007).

Consistent with the objectives of the study, a separate probit model was estimated for each outgrower scheme to account for the different production and marketing arrangements in the respective study areas. The regressors include socio-economic characteristics such as gender, education, farming experience, farm size and off-farm employment, having tested for the possibility of other socio-economic explanatory factors. Additionally, the importance of the contract design features to farmers' participation decision is included in the models as dummy variables. Specifically, farmers were asked whether particular contract design features were important in their participation decision (dummy takes a value of 1) or not (dummy takes a value of 0). This approach was used to validate the qualitative information collected on farmer perceptions.

The probit model is expressed as:

$$Yi = Xi\beta i + \mu i \quad (1)$$

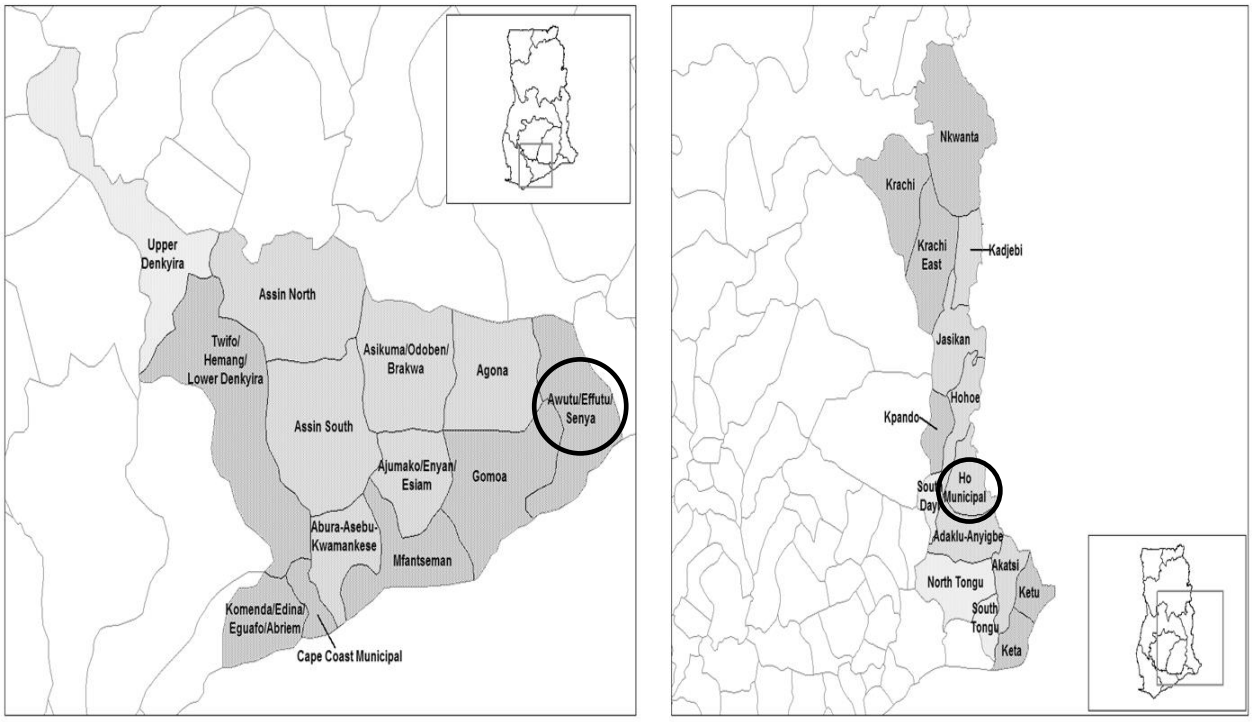
where Yi is the dependent variable (a farmer's decision of whether or not to participate), Xi is the vector of explanatory variables that influence a farmer's decision of whether or not to participate in the outgrower scheme, βi is the coefficients of the explanatory variables, and μi

is the error term capturing all unmeasurable effects that influence a farmer's participation decision. Specifically, the empirical probit model is specified as follows:

$$Yi = \beta_0 + \beta_1 NoC + \beta_2 PA + \beta_3 PS + \beta_4 PQ + \beta_5 Inputs + \beta_6 Assist + \beta_7 Delivery + \beta_8 Conflict + \beta_9 Sanct + \beta_{10} Edu + \beta_{11} Gend + \beta_{12} FarmExp + \beta_{13} FarmSize + \beta_{14} OffFarm + \mu i \quad (2)$$

where NoC denotes the nature of the contract for outgrowers, PA signifies the pricing arrangement, PS represents the payment system, PQ denotes the product quality specification, Inputs represents the input supply arrangement, Assist denotes the technical assistance arrangement, Delivery represents the crop delivery arrangement, Conflict denotes the conflict resolution procedure of the arrangement and Sanct signifies the sanctions to be meted out breach of contract. The a priori assumptions of these variables in the context of smallholder farming, such as cassava production in Ghana, have been addressed in Section 3.2.

In terms of the socioeconomic variables in the empirical model, Edu denotes the number of years of education of the farmer. It is expected that the likelihood of participation in contract farming increases with more years of education due to a better understanding of the contract terms, as well as the benefits of contract farming. Gend represents the gender of the farmer. Cassava production in Ghana is a male-dominated activity (Kleih et al., 2013). A major contributing factor to this social dynamic is the fact that women are disadvantaged in terms of access to productive resources, such as farmland. Therefore, it is expected that male farmers are more likely to participate in cassava contract farming. FarmExp denotes farming experience. A farmer may become more or less averse to the risks of contract farming based on the amount of farming experience. Thus, this variable can either have a positive or negative effect on a farmer's participation decision. FarmSize represents the total farm size of a farmer. As larger farm sizes are an indicator of wealth and influence, it is expected that farmers with larger farm sizes will be more likely to participate in contract farming. OffFarm denotes off-farm employment. A farmer with off-farm employment has a diversified risk portfolio with multiple income streams. Therefore, the expectation is that a farmer with off-farm employment will be more likely to participate in contract farming.



Public Scheme Private Scheme

Figure 3.1: Locations of case study outgrower schemes in Ghana

Source: Ghana Districts Repository

Table 3.1: Summary of qualitative data collection

Method	Public Scheme	Private Scheme
In-depth interviews (with stakeholders)		
Company management & staff	7	8
Government officials	5	2
Breweries	1	1
Food processing companies	-	2
Bakeries	-	1
Plywood manufacturing companies	-	3
Outgrowers	10	10
Focus Group Discussions (with farmers)	2	2

3.3.3 Profile of the schemes

The state owned agro-processing firm being studied was commissioned in 2003 as part of a Presidential Special Initiative (PSI) aimed at developing industrial cassava starch production for both the domestic and international market and by so doing also better the socioeconomic conditions of smallholders in the area. However, the firm was plagued with high operational costs and technological challenges which culminated in it temporarily shutting down on two occasions. This necessitated a more focused and sustainable operational strategy. In 2012, the firm signed an exclusive supply agreement with Guinness Ghana Breweries Limited (GGBL) to supply food-grade starch from cassava. The brewery uses the starch to produce one of its brands of beer for the domestic market. This is in line with an excise tax break announced by the government in 2012 for local content beers. The Customs and Excise Act 855 is an excise duty concession on a sliding scale for breweries using greater than 30 per cent local raw materials for the manufacture of excisable goods. The state firm sources half of its feedstock from its firm-managed farm and the other half from about 400 outgrowers. These outgrowers are all members of a farmers' association that represents their interests when dealing with the firm. There is a verbal agreement in place between the firm and its outgrowers based on trust and understanding. The outgrowers do not receive support from the firm in the form of technical assistance, credit or inputs. Supplied cassava roots must meet the firm's set quality standards to be accepted. The firm generates additional revenue from selling the by-products (the cassava peels and pulp) from the starch production process to local piggeries as feed.

The privately owned agribusiness firm was established in 2006. The firm produces high quality cassava flour (HQCF) and industrial grade flour which is sold to Accra Breweries Limited (a local subsidiary of SABMiller Plc), food processing companies, bakeries and domestic plywood manufacturing companies. There were also advanced plans for the firm to commence bio-ethanol and biogas production from cassava biomass at the time of data collection for the study. The firm sources approximately 70 per cent of its feedstock from its firm-managed farm and 30 per cent from outgrowers. At the time of the survey there were 65 outgrowers. The outgrowers are all members of a representative farmers' association. There is a standard seasonal written contract between the firm and each of its outgrowers. The firm provides technical assistance and optional inputs in measured quantities to the outgrowers. The cost of inputs provided is deducted from the value of the delivered cassava roots with no interest. The cassava roots must be a healthy approved variety to be accepted. The firm also sells the cassava peels and pulp from its production process as animal feed. The main design

features of both outgrower schemes are summarised in Table 3.2. Both agro-processing firms are located in areas where cassava is the predominant crop grown and the spot market is the only other marketing channel for farmers' produce.

Table 3.2: Salient outgrower scheme design features for case study firms

Scheme design features	Public firm*	Private firm**
Output Arrangement		
Nature of the contract	Oral contract communicated through the outgrower farmers' association	Written contract with individual outgrowers
Farmer selection criteria	No selection criteria	A minimum of 2 acres of farmland contingent on farm inspection by the firm
Contract duration	Optional seasonal arrangement	Binding seasonal arrangement
Supply quota	No specified quantity of produce to be supplied	No specified quantity of produce to be supplied
Outgrower quota	Unrestricted number of outgrowers	Maximum of 100 outgrowers
Pricing arrangement	Fixed seasonal price per ton whereby the amount paid is determined by a weighing bridge	Fixed seasonal price per ton whereby the amount paid is determined by the number of delivered tractor trailer loads
Payment procedure	Weekly invoice payment system for delivered produce	Cash payments upon delivery of produce
Quality Standards		
Product quality specification and verification	A minimum of 15% starch content of a recommended variety verified through laboratory testing of samples prior to delivery	Healthy appearance of an approved variety verified by physical inspection of produce upon delivery
Input Arrangement		
Input supply arrangement	No input supply arrangement	Supply of free planting material and agro-chemicals in measured quantities, the cost of which is deducted from final payment
Technical assistance	No technical assistance	Technical assistance is provided
Crop delivery arrangement	Specified delivery date without firm-provided transportation services	Transportation of the produce from farm to factory by the firm
Contract Enforcement		
Conflict resolution procedure	No established conflict resolution procedure	Mediation between farmer association executives and the firm
Sanctions	No sanctions	Fines and Legal action

***** Based on firm and outgrower interviews, and direct observation

****** Based on written contract agreements, firm and outgrower interviews, and direct observation

3.4 Results

This section begins with descriptive analysis of the socio-economic characteristics of the sampled farmers as well as an account of the contract design features in both schemes from the survey carried out. This is followed by an analysis of the firms' motivations for scheme design features based on the in-depth interviews with staff of the firms. Finally, the results of the probit analysis of the determinants of participation in the schemes are presented.

3.4.1 Descriptive analysis

3.4.1.1 Socio-economic characteristics

A comparison of the sampled groups of participating and non-participating farmers in both outgrower schemes is presented in Table 3.3. In the state-run outgrower scheme, both groups exhibited similar individual and household level characteristics in terms of age, household size, farming experience, land ownership and off-farm employment. However, outgrowers were found to have significantly higher levels of education on average. Although both groups were male dominated which reflected the gender profile of the scheme and cassava production in the area, there was a significantly larger number of males among the sampled outgrowers. With regards to income, there was not a significant statistical difference between the two groups. Outgrowers reportedly earned 18% higher total farm income compared to non-participating farmers for the year under consideration. Similarly, outgrowers earned 37% more non-farm income than non-participating farmers. With regard to the production characteristics, farmland showed the only significant difference between the two groups. Outgrowers had an average farmland size of almost 6 acres which was double that of non-participating farmers. Furthermore, as can be seen in Table 3.3, non-participating farmers had a higher average gross margin per acre for cassava production than outgrowers in the state-run scheme. However there was not a significant statistical difference between the two groups' gross margins. The gross margin per acre for cassava production is calculated by subtracting total variable costs per acre (wage labour and agro-chemical costs) from the revenue per acre obtained for cassava production.

In the privately operated scheme, there was not a significant difference between the two groups in terms of average age, household size, farming experience, land ownership and off-farm employment. Outgrowers were however significantly more educated than the non-participating farmers. There were also significantly more males participating in the scheme

than among non-participating farmers. Outgrowers notably earned 50% higher total annual farm income than non-participating farmers. Non-participating farmers on the other hand earned marginally higher non-farm income, but the difference was not statistically significant. In terms of the production characteristics, outgrowers had an average of 6 acres of farmland whiles non-participating farmers had an average of 4 acres of farmland. Outgrowers were also found to have significantly higher yield for cassava production. As shown in Table 3.3, outgrowers in the private scheme had a higher gross margin per acre for cassava production than non-participating farmers. The difference was statistically significant.

It must be noted that the difference in the average set of prices between the two case study areas, as shown in Table 3.3, reflects the fact that the state scheme is located in a peri-urban area with a relatively higher cost of living. The private scheme on the other hand is located in a rural area with a lower cost of living. The Ghana Statistical Service (2014) provides a source of reference for the cost of living across Ghana.

Table 3.3: Socio-economic characteristics of sample farmers

Variables	Public Firm			Private Firm		
	Participant farmers (*n=100*)	Non-participant farmers (*n=50*)	Equality test	Participant farmers (*n=65*)	Non-participant farmers (*n=100*)	Equality test
Individual Characteristics						
Age (years)	44.05 (11.52)	43.94 (10.29)	0.06	49.85 (11.78)	47.47 (12.05)	1.25
Household size (persons)	5.58 (2.39)	5.52 (2.18)	0.15	5.65 (1.80)	5.12 (2.50)	1.47
Educational level (years)	8.4 (3.30)	6.56 (4.27)	2.91***	9.14 (2.94)	7.45 (3.73)	3.08***
Gender (% of males)	78	60	2.31**	78	62	2.22**
Farming experience (years)	18.71 (11.92)	19.03 (11.18)	0.16	21.26 (13.02)	20.99 (11.43)	0.14
Land ownership (% of owners)	21	32	1.47	71	78	1.05
Off farm employment (% yes)	53	50	0.35	62	52	1.21
Farm income (GH¢ '000)	7.22[a] (13.40)	5.92[a] (13.64)	0.55	8.22[a] (17.51)	4.15[a] (4.65)	2.21**
Non-farm income (GH¢ '000)	2.30[a] (4.55)	1.46[a] (2.39)	1.22	2.05[a] (2.41)	2.40[a] (5.77)	0.46
Production Characteristics						
Farm size (ac.)	5.67[b] (6.23)	3.05[b] (2.92)	2.83***	6.18[b] (3.20)	4.28[b] (3.22)	3.70***
Distance to market (km)	1.89 (1.87)	2.46 (2.35)	1.62	2.91 (1.75)	2.86 (1.89)	0.19
Family Labour (mandays/ac)	3.37 (7.86)	4.14 (9.86)	0.52	0.75 (3.35)	0.98 (4.11)	0.38
Wage Labour (mandays/ac)	26.46 (27.76)	25.47 (32.38)	0.19	33.25 (35.98)	26.69 (28.53)	1.30
Cassava yield (ton/ac)	5.20 (3.11)	5.72 (2.11)	1.05	8.40 (1.53)	5.62 (1.97)	9.63***

Table 3.3 (continued): Socio-economic characteristics of sample farmers

Variables	Public Firm			Private Firm		
	Participant farmers (*n=100*)	**Non-participant farmers (*n=50*)**	**Equality test**	**Participant farmers (*n=65*)**	**Non-participant farmers (*n=100*)**	**Equality test**
Gross Margins for cassava						
Price (GH¢/ton)	220	222		120	150	
Revenue (GH¢/ac)	1,144	1,269.84		1,008	843	
Wage Labour (GH¢/ac)	470.95	496.02		335.66	300.42	
Fertiliser (GH¢/ac)	14.60	10.27		9.61	10.25	
Herbicides (GH¢/ac)	20.23	18.58		48.93	8	
GROSS MARGINS (GH¢/ac)	**638.22**	**744.97**	1.26	**613.80**	**524.33**	1.91**

Standard deviations are presented in parentheses

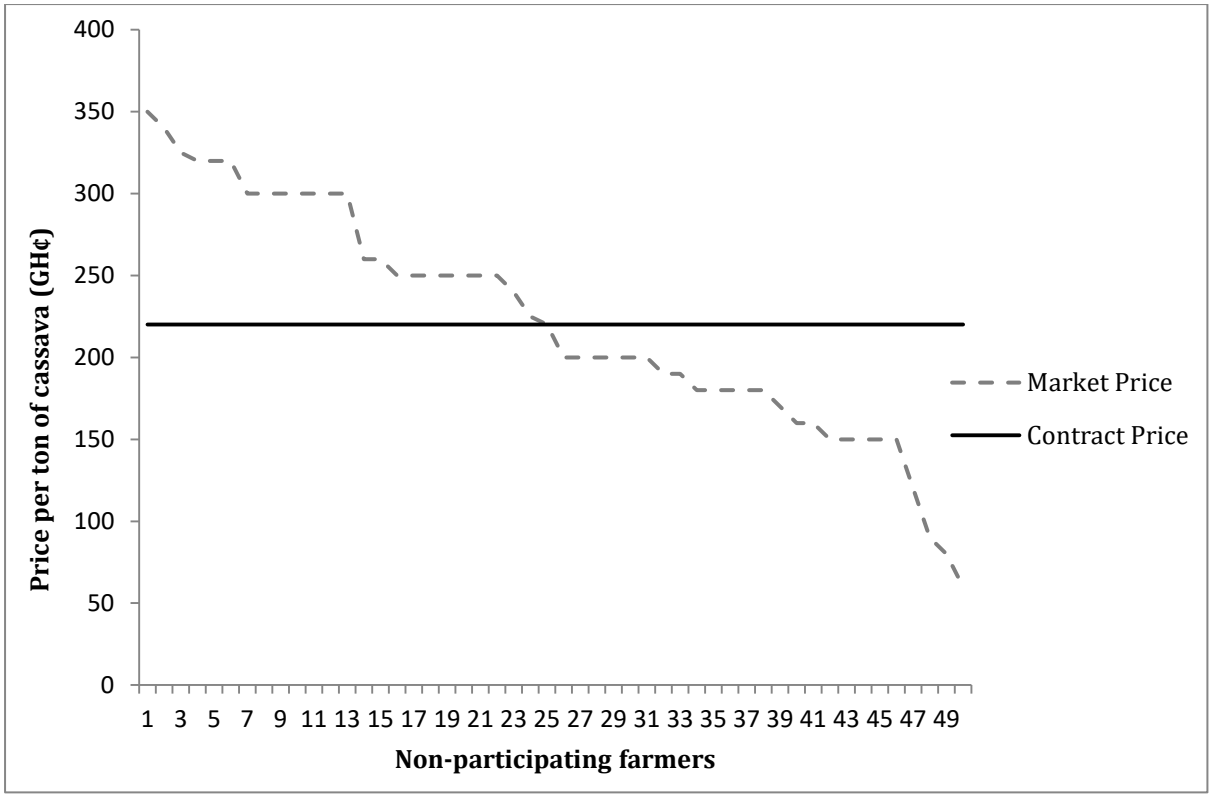
* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level

[a] Exchange rate October 2015: 4 GH¢/$.

[b] Farm size is calculated as the sum of a farmer's respective acreages in the event that he/she cultivates more than one plot.

3.4.1.2 Contract design features

In the state outgrower scheme, the average number of years of participation was four years among sampled outgrowers (Table 3.4). Outgrowers confirmed that their arrangement with the state firm was based on verbal commitments with no written proof. More than half (56%) of the outgrowers of the public firm reported receiving their invoices to be cashed at the rural bank within two weeks after delivering their produce while 21% complained of delayed payments within a month of produce delivery. The firm has mainly attributed this problem to intermittent financial challenges caused by delays in purchases from their sole off-takers. A small number (6%) however reported receiving their invoices at the time of sale as delivery coincided with weekly disbursements during periods when the firm had sufficient cash flow. Figure 3.2 shows the contract price offered by the public firm as compared to the variable spot market prices non-participating farmers in the survey received for their cassava roots. In terms of quality standards, 19% of the sampled outgrowers reported some of their produce (from at least one of their farmlands) being rejected for not meeting the product quality specification. Seven per cent of the outgrowers reported having conflicts with the firm about opportunistic behavior stemming from delayed payments and a lack of trust in the quality verification system following rejection of some of their produce. One outgrower reported a violation of contract terms after the firm approved delivery of the produce but later reneged on the purchase, citing technical challenges and the unreliability of the farmer's contact information to be accordingly notified.

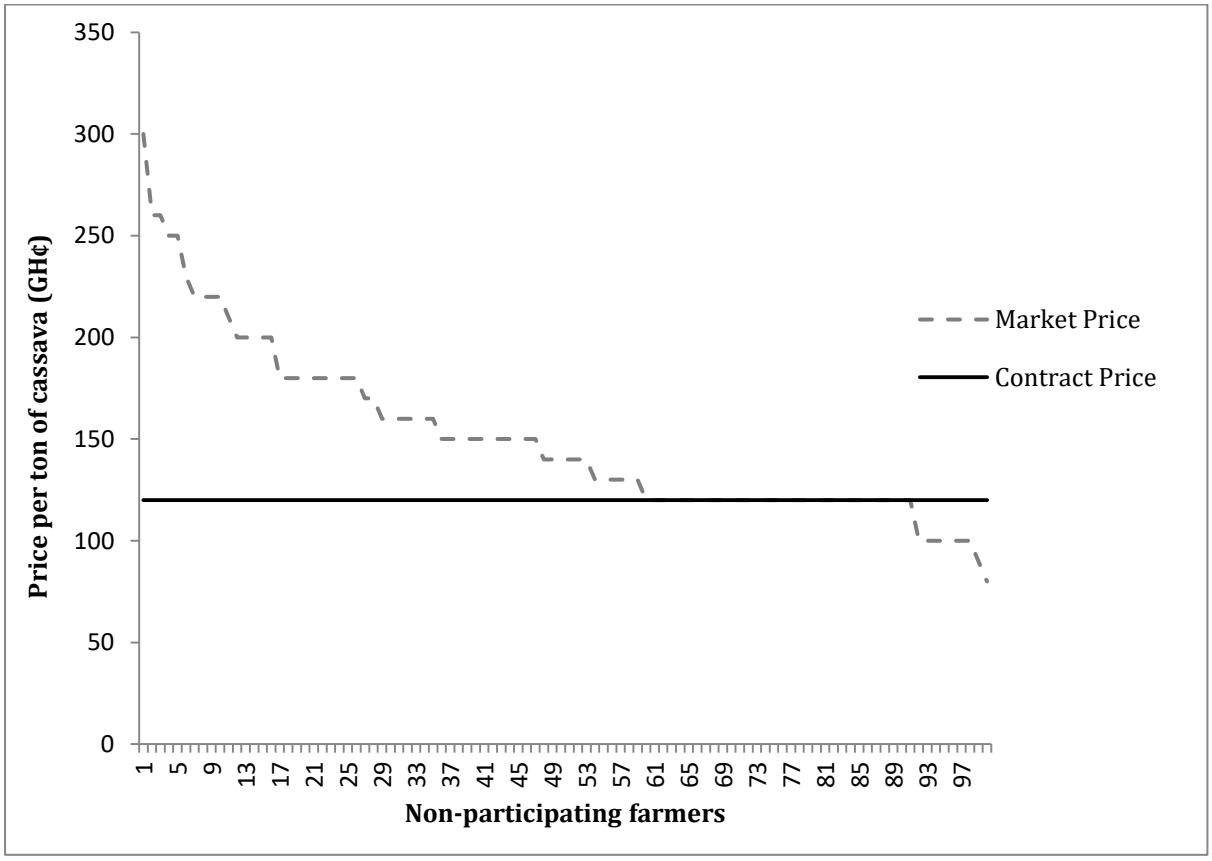


N (non-participating farmers) = 50

Figure 3.2: Contract price for state scheme and open market prices for cassava roots

In the private outgrower scheme, the average number of years of farmer participation was three years (Table 3.4). All the outgrowers confirmed that they each had a generic signed written contract with the firm which outlined the terms and conditions of the arrangement. Almost all the farmers (90%) confirmed cash payment at the time of produce delivery. The rest received their money within a week of delivering their produce. This was mainly due to a large number of coinciding deliveries whereby the firm ran out of available cash for immediate payments. Most farmers received their payments in the days that followed. Figure 3.3 shows that the contract price offered by the private firm was low as compared to the variable prices non-participating farmers in the survey received for their cassava roots on the open market. Only two outgrowers reported some of their produce being rejected mainly for being physically damaged. With regards to the input supply arrangement, majority of the outgrowers (94%) reported the use of firm-provided inputs. The standard supply of inputs includes 20 bundles of stem cuttings per acre (for free) and 0.75 pounds of acid equivalent of glyphosate per acre. Outgrowers also had the opportunity to access funds for farming activities as part of this arrangement. However, all outgrowers received technical assistance from the firm. This mostly entailed monthly visits from technical staff of the firm. Technical

assistance included guidance on better agronomic practices such as planting in rows. The valuation of farmers produce was a source of conflict for some of the outgrowers (9%). The outgrowers complained that the firm would deliberately overload tractor trailers with cassava roots when transporting their produce, knowing that the amount paid to farmers is contingent on the number of trailers rather than the weight of the produce. Three of the outgrowers also complained of the firm violating the terms of the contract by deducting amounts higher than the cost of firm-provided inputs from their final payments. The firm in these instances insisted the farmers had miscalculated the cost of the inputs they had been advanced.



N (non-participating farmers) = 100

Figure 3.3: Contract price for private scheme and open market prices for cassava roots

Table 3.4: Contract characteristics

	Public Firm Outgrowers	Private Firm Outgrowers
Participation (mean years)	3.83	2.63
Output Arrangement		
Nature of the contract		
Oral/informal	100%	-
Written/formal	-	100%
Time of Payment		
At the time of delivery	6%	90%
Within 1 week of sale	17%	10%
Within 2 weeks of sale	56%	-
Within one month of sale	21%	-
Quality Standards		
Rejection of any produce	19%	3%
Input Arrangement		
Use of firm inputs	-	94%
Technical assistance from firm	-	100%
Number of visits		
Once per month	-	94%
Several times per month	-	6%
Once per season	-	-
Other	-	-
Contract Enforcement		
Conflict with the firm		
Opportunistic behaviour	7%	9%
Violating contract terms	1%	5%
Number of Observations	100	65

3.4.2 Firm motivations for scheme design features

In-depth interviews with the management personnel of both firms revealed that while the private firm made a profit in the year under consideration, the public firm registered losses in its operations. Insufficient supply of cassava roots from outgrowers to supplement the firm's own cassava production was a major contributing factor to this underperformance. In this regard, analysis of the interviews with the firms also revealed their motivations for the

various design features of the schemes. This captured some of the key differences between the schemes as shown below.

First, the fixed pricing arrangement of the public firm is set based on firm negotiations with the executives of the outgrower association and representatives of GGBL. The firm takes into account farmers' cost of production, transportation cost and market price trends in the catchment area as well as the price for starch offered by GGBL. The fixed price increases the firm's exposure to price risk but also allows for planned budgeting. The private agribusiness firm also uses a fixed pricing arrangement. However, because costs such as crop delivery and technical assistance are paid for by the firm, the seasonal price mainly reflects the market value of the firm's main product. These motivations are reflected in the following quotations from the in-depth interviews:

> "*We set the price with their [outgrowers] executives and Guinness, so they know what goes into it. Unlike the unstable price on the open market, this gives the farmers a sense of financial certainty and allows both of us to plan well. […]. We use a weighing bridge to determine the tonnage supplied by the outgrowers so there is no error or misunderstanding.*" (Production manager, Public firm)

> "*We give the farmers a lot of support so the price we pay is mainly based on the going rate for the flour we sell, the HQCF. We look at our selling price and try to be reasonable with the farmers in the price we offer. […]. Each tractor trailer we use in transporting the roots weighs 2.5 tonnes with a full load. That is how we know the quantity they [outgrowers] supply.*" (Production manager, Private firm)

In terms of quality standards, the public firm's minimum starch requirement of 15% has been set in line with the firm's exclusive supply arrangement with GGBL. Accordingly, farmers who approach the firm with the intention of supplying cassava are given a list of recommended varieties to grow. These improved varieties are intended to give farmers the highest probability of meeting the quality specification. The private firm on the other hand sells to different markets with different quality requirements. As such, the firm accepts cassava roots of variable quality, provided outgrowers supply healthy roots of an improved variety. These reasons are expressed in the following statements:

"*Previously we didn't demand any specific variety. But Guinness demands a high level of quality. That is why we now have specific varieties we recommend. In fact, 15% is still on the low side for us. At least 20% would have been ideal but we also accept that that would be difficult for a lot of the farmers to meet.*" (General manager, Public firm)

"*Because we have different uses for the cassava, once they [outgrowers] grow an improved variety we have supplied them with we accept it. The only thing we look out for is that the roots are healthy and not damaged.*" (Production manager, Private firm)

In reference to inputs, the public firm does not have a supply arrangement with outgrowers. This is mainly due to the resource constraints of the firm and the size of the outgrower scheme. The private firm on the other hand provides outgrowers with stem cuttings and herbicides to ensure high output of the raw material supply. These motivations are reflected in the following interview excerpts:

"*We can't afford to supply inputs. They [outgrowers] are too many. And supplying them with fertiliser or herbicides also comes with responsibility of monitoring how they use them to make sure they don't divert them, and we don't have the manpower to do that.*" (General manager, Public firm)

"*We want the outgrowers to treat cassava as a cash crop. So we supply them with planting material and chemicals. This way, they can get more money and we can get more roots from them. […]. We go round and make sure every farmer uses the chemicals correctly because it is an investment we are making.*" (Outgrower coordinator, Private firm)

Concerning contract enforcement, the public firm has not seen the need to establish a conflict resolution procedure or sanctions given the informal nature of the arrangement. Conversely, the private firm resorts to fines for input diversion and legal action against outgrowers for contract violations such as side-selling. The firm views this as the most effective means of discouraging contract breaches by farmers. These reasons are supported by the following statements:

"*Our arrangement is simple and straightforward so there are no sanctions. There is also no conflict resolution process in place per se. […]. Well, sometimes farmers complain about delays in payment because they always want instant cash but they are aware that that is how our system works. And they always get their money.*"
(Production manager, Public firm)

"*If we catch them [outgrowers] diverting inputs they pay for it with interest which we [the firm] decide on. […]. We have caught some of them side-selling and we have terminated their contracts and taken them to court to pay us back. Since we started doing that side-selling has gone down.*" (Outgrower coordinator, Private firm)

Information on the evolution of the schemes provided by the firms was consistent with that of the outgrowers who were interviewed. The public company initially provided outgrowers with inputs, technical assistance and instant cash payments until it run into financial and technical difficulties. The public scheme has been running in its current form since the company's supply agreement with GGBL in 2012. The contract arrangements under the private outgrower scheme on the other hand have not changed since its inception in 2006. These interviews provide insight into the significance of the probit model results for both schemes.

Two separate models were estimated for the state and private outgrower schemes due to the difference in their marketing arrangements and management structures, as revealed by their contract designs. Thus, merging them in a pooled dataset would fail to provide robust findings of how independent variables affect the participation decision of farmers in the schemes.

3.4.3 Empirical probit model estimates for the state outgrower scheme

The estimates derived from the probit model for the state outgrower scheme are presented in Table 3.5. The results indicate the factors that either positively or negatively affected smallholder participation in the scheme. The oral contract with the firm increased the likelihood of farmer participation in the outgrower scheme. The state firm has been operating in the study area for an extended period of time and has had an outgrower scheme from its inception. According to information from the focus group discussion with outgrowers,

farmers have a high level of trust in the relationship based on the firm's reputation and recurrent transactions.

The pricing arrangement also increased the likelihood of participation. This arrangement insures risk-averse farmers against volatile spot market prices for cassava. The outgrowers' farmer association enjoys significant bargaining power in negotiations to set the seasonal price as a satisfactory price is the firm's only guarantee of outgrower participation. Beyond that, the firm provides an objective and acceptable means of valuing farmers' produce through the use of a weighing bridge, leaving little margin for error.

Conversely, the payment procedure decreased the likelihood of participation. The weekly invoice payment system often led to delays in payment. While there does not appear to be any risk of non-payment by the firm, inefficiency in the payment system has been a major source of dissatisfaction for outgrowers and a deterrent to smallholder participation. Additionally, the payment system which required farmers to receive their money through a bank increased their transaction cost.

The fixed product quality specification of the state firm also decreased the likelihood of participation. The minimum starch requirement increased the risk of complete rejection of farmers' produce due to information asymmetry as farmers have no means of knowing or verifying the starch content of their produce.

The lack of an input supply arrangement and a transportation arrangement similarly decreased the likelihood of participation in the outgrower scheme. As a traditional staple crop, cassava is generally viewed by most farmers as a crop that does not require a lot of inputs. However, the firm provides farmers with a more reliable marketing outlet for large quantities of cassava than spot markets. This has provided an incentive for farmers to improve their productivity through the use of improved planting material and agro-chemicals. Furthermore, although transportation is factored into the seasonal price, farmers complained that access to reliable transport services for bulk delivery was hard to come by at affordable prices.

The individual characteristics of farmers did not significantly influence the decision to participate in the scheme. The age variable was found to be highly correlated to the farming experience variable and was therefore omitted from the model estimation. The reliability of the model estimation was confirmed using the uncentred variance inflation factor (VIF) test.

The result showed a mean of 2.34 which indicated that there was not a problem of multicollinearity.

Table 3.5: Factors influencing participation in the state outgrower scheme

Variable	Coefficient	Robust Std. Err.	Marginal Effect
Oral contract	1.394***	0.316	0.203
Fixed pricing arrangement	0.969***	0.359	0.136
Weekly payment system	-1.128***	0.367	-0.171
Fixed product quality specification	-1.103***	0.418	-0.164
Lack of input supply	-0.926***	0.330	-0.139
Lack of technical assistance	-0.167	0.451	-0.039
Lack of crop delivery arrangement	-1.048***	0.342	-0.143
Lack of conflict resolution procedure	-0.485	0.439	-0.062
Education	0.040	0.039	0.012
Gender	0.352	0.313	0.033
Farming experience	-0.010	0.015	-0.001
Farm size	0.036	0.040	0.005
Off-farm employment	-0.392	0.348	-0.048
Constant	0.398	0.572	
Observations	150		
Wald chi2	52.82***		
Log pseudolikelihood	-40.93		
Pseudo R^2	57.13%		

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level
State scheme; VIF, uncentred, 2.34.

3.4.4 Empirical probit model estimates for private outgrower scheme

Table 3.6 reports the probit model estimates for the private outgrower scheme. The results show that the written contract with the firm increased the likelihood of farmer participation in the outgrower scheme. Indeed, as contractual arrangements become more complex particularly with input supply and specialised production practices, written contracts become more beneficial to both firms and farmers. Conversely, the pricing arrangement decreased the likelihood of farmer participation. Price negotiations between the firm and outgrower association appear to be a formality rather than a collaborative process as the firm seems to focus solely on its profit margin. Furthermore, the biased valuation of farmers' produce using

the number of trailers delivered rather than a weighing system has been a source of contention between outgrowers and the firm.

The system of on-the-spot cash payments used by the private firm increased the likelihood of farmer participation. Smallholders tend to prefer immediate cash payments following delivery of their produce to satisfy their current household consumption requirements. Similarly, firm-provided inputs and technical assistance at the various stages of production also increased the likelihood of farmer participation. Smallholders believed such support would help improve their productivity significantly.

The private firm's provision of crop delivery services gave outgrowers access to dependable transport services that is well synchronised with the firm's demand for their produce. This increased the likelihood of smallholder participation as an important post-production feature of the scheme especially given the highly perishable nature of cassava. Conversely, sanctions meted out for contract violations in the form of fines and legal redress in the private outgrower scheme decreased the likelihood of farmer participation as farmers found these sanctions to be excessively harsh.

Similar to the state outgrower scheme, it was found that individual farmer characteristics did not significantly influence the decision to participate in the outgrower scheme. Again, the age variable was also found to be highly correlated to the farming experience variable and was omitted from the estimation. There was no concern of multicollinearity in the model as implied by the mean uncentred VIF test result of 2.62.

Table 3.6: Factors influencing participation in the private outgrower scheme

Variable	Coefficient	Robust Std. Err.	Marginal Effect
Written contract	0.597**	0.268	0.095
Fixed pricing arrangement	-0.940***	0.296	-0.144
Instant cash payments	0.699***	0.279	0.109
Variable product quality specification	0.308	0.297	0.054
Input supply arrangement	0.996***	0.261	0.152
Technical assistance	0.909***	0.273	0.152
Crop delivery arrangement	0.836***	0.322	0.147
Conflict resolution procedure	0.659	0.390	0.101
Sanctions	-0.871**	0.284	-0.134
Education	0.052	0.045	0.013
Gender	0.526	0.345	0.079
Farming experience	0.017	0.014	0.003
Farm size	0.082	0.055	0.011
Off-farm employment	0.260	0.268	0.044
Constant	-3.041	0.585	
Observations	165		
Wald chi2	90.70***		
Log pseudolikelihood	-49.74		
Pseudo R^2	55.04%		

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level
Private scheme; VIF, uncentred, 2.62.

3.5 Discussion

CF arrangements have great potential to simultaneously increase smallholders' productivity and overcome marketing challenges. In this regard, smallholder participation in CF arrangements is widely viewed by policymakers as important for poverty reduction and rural development. However, the growing case study evidence on the impacts of CF in Africa pays little attention to the critical role contract design plays in the sustainability of these arrangements between agribusiness firms and farmers. The current analysis used a comparative case study approach to highlight contract conditions that will promote the long term sustainability and viability of outgrower schemes in the burgeoning cassava sub-sector in Ghana. The study uniquely focused on rapidly developing domestic value chains in the emerging bioeconomy. The findings add empirical weight to the argument that state-led contract farming schemes are generally not an effective government mechanism for

overcoming market failures that inhibit the commercialisation of agricultural production by smallholders. Indeed, the continued existence of inefficient state-led schemes often signals the lack of an enabling environment for the private sector to effectively take over these functions.

The interviews conducted for the study reveal that the public firm's outgrower scheme constitutes a low investment informal CF model. The firm does not invest resources in outgrowers' cassava production and as such does not incur monitoring costs. Correspondingly, the quantitative results show that farmer participation is positively influenced by the oral and informal nature of the agreement. Farmers have the option to opt-out of the arrangement at any point in time. This eliminates the issue of side-selling and allows farmers to take advantage of periods of high local spot market prices. The consequence, however, is limited control over the quantity and quality of produce supplied which increases the risk of the firm not meeting the specific needs of its off-taker. The firm must compete with other buyers who may offer higher prices. This is reflected in a pricing arrangement that farmers find favourable in terms of their collective bargaining power and the valuation of their produce. However, the empirical evidence suggests that the scheme, which initially aimed to improve the socioeconomic conditions of smallholders in the area, is ultimately not beneficial to either the firm or outgrowers. The firm receives an insufficient supply of cassava roots from outgrowers. Outgrowers' productivity and revenue from cassava production also do not appear to have increased through the arrangement.

The private firm's outgrower scheme represents a relatively more capital intensive and formalised CF arrangement as revealed by the interviews conducted with company staff. Due to the provision of inputs, technical assistance, and crop transportation, the firm retains more control over the quality and volumes of outgrowers' output. This makes for more efficient sourcing of cassava roots. Consistently, the quantitative results show that these contract features along with instant cash payments positively influenced smallholder participation in the scheme. Interestingly, even though the firm offers a low contract price with a contestable price determination mechanism, they appear to be able to effectively enforce the contract and control side-selling. This goes contrary to the argument that agricultural commodities with well-developed local markets are not suitable for contract farming because they are associated with a high risk of pervasive side-selling (Minot, 2007; World Bank, 2014). The firm is able to earn a profit using the CF arrangement. Outgrowers also have high farm productivity and earn comparatively higher returns from cassava production.

Contrary, to the results past studies (Minten et al., 2009; Miyata et al., 2009; Maertens & Velde, 2017), individual characteristics such as education, farming experience and farm size which are considered critical to farming efficiency did not significantly influence the decision to participate in the schemes. This emphasised the importance of contract design to farmers' participation decision as revealed by the study's results. It must, however, also be noted that the use of different statistical models and data collection techniques may present a nuanced picture. Future studies may benefit from the collection of longitudinal data for richer analysis of farmers' participation decision.

The findings of the study further demonstrate that firm investment in supporting farm production is critical to the success of outgrower schemes. Cassava may not be an input-intensive crop. Nonetheless, there is still the need for embedded support services in outgrower schemes. Farmers desire arrangements that address both production and marketing challenges. Abebe et al. (2013) found that smallholders' decision to participate in CF is even more dependent on input market uncertainty than on output market uncertainty. In order for the public firm to improve the economic viability of its model, the scheme must facilitate the adoption of improved technologies to stimulate increased farm productivity among outgrowers through an input supply arrangement. The seed market for cassava in Ghana is missing. Public sector extension agents are the primary source of supply for vegetative propagules (stem cuttings) of improved varieties that have been developed by the research system. These stem cuttings are often distributed to influential farmers with the expectation that they will in turn be disseminated to smallholders. This is often not the case as most smallholders do not get access to improved cultivars. Alene et al. (2015) reported that the area planted to improved cassava varieties in Ghana only increased from 25% to 36% between 1998 and 2009. It is therefore a challenge for many smallholders to grow varieties recommended by the firm. As Wiggins and Sharada (2013) observed, smallholders are also susceptible to purchasing adulterated agro-chemicals because they are often more affordable. Likewise, access to reliable transport services for bulk delivery of produce is often inaccessible at affordable prices. The lack of suitable access routes to farms often means that drivers charge higher prices or refuse to transport produce. Firm involvement in providing such post-harvest logistical support is critical given the perishability of the crop, quality requirements and the poor state of the existing road infrastructure in rural areas. An alternative to the firm providing such services directly could be arrangements with

intermediaries such as aggregators or lead farmers who have closer proximity to smallholders and could facilitate bulking and crop delivery.

Notably, the bargaining position of the firms in their respective value chains is also a determining factor of the contract features of the outgrower schemes. This is particularly important for quality standards which can often be one of the most contentious issues in contract arrangements as reported by Henson et al. (2005). The differentiated marketing strategy of the private firm enabled a system of variable quality standards which reduced the risk of complete rejection of farmers' produce. Comparatively, the fixed product quality specification of the public firm is a direct consequence of its exclusive supply agreement with GGBL. This uncertainty over complete rejection discouraged participation in the public scheme as it largely eliminated the incentive of a guaranteed market. Transparency in quality assurance systems is therefore imperative to maintaining smallholders' trust in CF arrangements, especially as they adjust to stricter quality requirements in increasingly competitive value chains for high-value products. Barrett et al. (2012) found that firms appear more likely to fabricate quality testing or speciously reject perishable commodities on the grounds of quality when supply is guaranteed from a large pool of smallholders. Indeed, a study by Torero and Viceisza (2011) showed that third party quality testing improved farmers' trust in the validity of results as this was perceived to be a more objective system.

Overall, the increased use of cassava biomass associated with commercialisation of the sub-sector in Ghana's emerging bioeconomy has necessitated more organised sourcing arrangements. Government policies like the PSI on cassava starch and the tax incentive policy for local content beers have also served as catalysts to these institutional arrangements. Results from the public scheme reveal that although cassava is a staple crop that has traditionally been cultivated with minimal inputs, ad hoc or opportunistic investments that merely provide a marketing outlet for smallholders are not sufficient to ensure the success of outgrower schemes. The evidence highlights the tendency of public sector schemes to be bureaucratic and lack financial autonomy. Private sector ventures, on the other hand, tend to adopt authoritarian management styles and can also be prone to opportunistic behaviour in contract arrangements with smallholders. Therefore, public-private partnerships in cassava outgrower schemes present a viable and sustainable remedy that harnesses the strengths of both sectors and overcomes their institutional weaknesses. These arrangements would allow schemes to take advantage of government support such as grants and input subsidy programs while also benefitting from the private sector's financial autonomy, systems of accountability

and highly-trained and specialised staff. It is the recommendation of this paper that this approach should be pursued by policymakers. Ultimately, smallholder participation and the sustainability of cassava outgrower schemes in Ghana's emerging bioeconomy are contingent on a fully-integrated and comprehensive farm-to-market approach within a conducive enabling environment for agricultural contracting.

3.6 Conclusions

The study's findings highlight the point of divergence between the low investment model of the state outgrower scheme which has led to insufficient supply from outgrowers and the more capital intensive arrangement of the private firm that benefits from the productive capacity of smallholders. The state outgrower scheme, initially established to improve smallholders' socioeconomic conditions, offers farmers some favourable contract conditions. However, a lack of embedded support services has not enabled outgrowers to increase their productivity and revenue from cassava production in the scheme. CF arrangements must, therefore, address both production and marketing challenges to be sustainable and mutually beneficial to farmers and firms.

As competitive value chains continue to develop in Africa's evolving agricultural sector, there is the need for equitable and transparent contract design features, as well as direct firm investment in supporting farm production activities within an enabling environment. Public-private partnerships can provide these necessary conditions for ultimately unlocking the potential of CF in Africa's bioeconomy.

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4. WHY DO MAIZE FARMERS IN GHANA HAVE A LIMITED CHOICE OF IMPROVED SEED VARIETIES? AN ASSESSMENT OF THE GOVERNANCE CHALLENGES IN SEED SUPPLY

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Abstract

The liberalisation of commercial seed systems has largely been seen as an essential means of improving agricultural productivity in Sub-Saharan Africa. Yet, access to improved seed varieties has remained a major constraint in many countries in spite of liberalisation and other reform efforts. This paper analyses the governance challenges involved in seed systems from a theoretical and an empirical perspective. The paper applies theoretical concepts of New Institutional Economics to identify potential governance challenges involved in the different stages of the seed supply system. The commercial maize seed sector in Ghana is used for an empirical case study. Ghana has passed a seed law that aims to increase the availability of improved seed varieties to farmers by providing more opportunities to the private sector. However, there is still a chronic lack of varietal diversity, indicating that governance challenges in the seed system remain despite the reform efforts. For data collection, a participatory mapping technique known as Process Net-Map was applied, together with expert interviews involving a diverse set of stakeholders. The empirical evidence reveals that, in line with the theoretical considerations, governance challenges indeed affect all stages of the seed supply system. These challenges include limited involvement of smallholders in setting breeding priorities, restricted private sector participation in source seed production, limited ability of an under-resourced public regulatory body to ensure high seed quality through mandatory seed certification and overdependence on a weak public extension system to promote improved varieties. The paper discusses the policy implications of the findings.

Keywords: Seed systems; Governance challenges; Varietal development; Seed production; Seed quality; Ghana

4.1 Introduction

The use of improved crop varieties is essential for increasing agricultural productivity in Africa (Walker & Alwang, 2015; World Bank, 2007). Maize is the most important cereal crop in Sub-Saharan Africa and as such considerable attention has been paid to potential productivity gains through the use of improved varieties (Smale et al., 2013; Alene et al., 2009; Hassan et al., 2001; Byerlee & Eicher, 1997). This desired outcome hinges upon an efficiently functioning seed system to ensure the delivery of these varieties to farmers (Langyintuo et al., 2008; Tripp, 2001; Morris, 1998). However, only a few African countries, such as Kenya and Mozambique, provide evidence of successful commercial seed sector development (World Bank, 2016). It is widely accepted that a major cause of the sector's poor performance has been the combination of a public sector monopoly of seed supply and a weak capacity of the public sector organisations in charge (Tripp & Rohrbach, 2001). In recent years, many African governments have liberalised their seed sectors, though to a varying extent, which has generally resulted in increased private sector participation. Nonetheless, the transition to an effective private sector-driven seed system has been hampered by a lack of complementarities in public and private investments, leading to deficiencies in the institutional linkages between the various stages of seed production, from breeding to commercial seed delivery (Langyintuo et al., 2010). These governance challenges of seed supply systems have only been partly addressed in the literature (see Langyintuo et al., 2010; Tahirou et al., 2009; Tripp, 2000). Countries like Ghana have sought to overcome the problem of farmers having poor access to improved seed varieties by reforming the institutional framework of the commercial seed sector.

Ghana passed a new seed law, the Plants and Fertiliser Act, in 2010. The Act entailed a commitment by the state, supported by the donor community, to relegate responsibility for seed multiplication and marketing to the private sector. The main aim of liberalising the sector was to increase the availability of improved seed varieties to farmers by providing more opportunities for the private sector.[5] The most noteworthy aspects of the law are that it authorises both the development of varieties by the domestic private sector as well as access to foreign varieties produced by both public and private organisations. The law also permits the production of any class of seed by any approved entity (public or private) and leaves the

[5] The new law repealed the Plant Quarantine Act of 1965 and the National Redemption Council Decree 100 of 1972 (Alhassan & Bissi, 2006). Although the new law was already in force at the time of submitting this article in early 2017, the attendant seed regulations were at an advanced stage for ratification by Parliament following amendments to fit regional seed regulations of the Economic Community of West African States (ECOWAS).

door open for the possibility of privatised seed certification (GoG, 2010). These changes have enabled the emergence of domestic private seed companies. By 2013, their number had reached ten (Tripp & Mensah-Bonsu, 2013). However, a chronic lack of varietal diversity has still remained a major concern of Ghana's maize seed system. One open pollinated variety (OPV) released in 1992 called Obatanpa continues to overwhelmingly dominate commercial seed production. This is a concern because maize is the most important cereal crop in Ghana, accounting for 55 per cent of total grain output in Ghana (MoFA, 2015a). Maize is important for food security as it is widely consumed in all regions of the country and covers the largest area among the food crops produced in Ghana. Apart from its traditional food uses, maize grain is also used in the food processing industry, breweries and in the poultry industry as a primary source of feed. Due to industrialisation and urbanisation, demand for maize from these sectors is also rising (Andam et al., 2017; Andam et al., 2015). Yet, productivity of maize has been low. Average yields reached only 1.7 metric tons per hectare in 2014 (MoFA, 2015a). As further detailed in Section 4.3, 60 per cent of the maize area was planted to improved varieties in 2012, and Obatanpa accounted for almost 70 per cent of the area under improved varieties (Ragasa et al., 2013). Even though 18 improved maize varieties have been developed and officially released since Obatanpa was introduced in 1992, only a few of these varieties are produced as commercial seed. Hence, they are mostly not available to farmers.

A large number of technology adoption studies on maize in Africa have focused on the socio-economic and agro-ecological factors that influence farmers' decisions to adopt improved varieties (see, e.g., Khonje et al., 2015; De Groote et al., 2013; Lunduka et al., 2012; Langyintuo & Mungoma, 2008; Feleke & Zegeye, 2006; Alene et al., 2000; Nkonya et al., 1997). For the case of Ghana, Morris et al. (1999) and Ragasa et al. (2013) analysed the constraints and incentives of farmers that have contributed to the dominance of Obatanpa. There is, however, a dearth of in-depth studies that investigate the supply-side factors accounting for the observed lack of varietal diversity. Accordingly, the analytical question pursued in this paper is: Why do maize farmers in Ghana have a limited choice of improved seed varieties? The paper aims to address this gap in the literature by analysing the governance challenges that affect the performance of Ghana's maize seed system in delivering improved varieties. The paper also addresses the question of why these challenges persist in spite of the institutional changes introduced by the reform of the seed law in 2010.

Using Ghana as a case study, the paper makes two contributions to the literature on seed systems in Africa: First, based on the theoretical concepts of economics, particularly New

Institutional Economics, the paper provides a comprehensive overview of the potential governance challenges in each component of the seed supply system. Second, the paper applies Process Net-Map to empirically analyse these governance challenges. Process Net-Map is a relatively new empirical method that has been developed to identify governance challenges in processes that involve multiple actors. The tool is used to identify the influential actors in seed delivery and examine the systemic and yet often neglected governance challenges affecting seed supply. This approach unravels the complexities of multi-stakeholder governance where very often actual processes differ from formally prescribed procedures. As such, this study is not only instructive for Ghana but also for other countries in Africa with evolving commercial seed sectors. The study finds that the well-known constraints caused by the dominance of public sector institutions in seed supply, have not been overcome by reform efforts that aimed to promote the private sector. By analysing the governance challenges that occur at the different stages of seed supply, the study identifies the reasons why the strategy to increase access to improved seed varieties by facilitating private sector participation has not been successful in Ghana, so far.

The rest of the paper is organised as follows: Section 4.2 presents potential governance challenges of seed supply based on economic theory and the literature on seed sector development in Africa. Section 4.3 outlines the current state of Ghana's maize seed system. The research design and data used for the analysis are described in Section 4.4. Section 4.5 presents the results of the Process Net-Maps and expert interviews. Section 4.6 discusses the empirical findings and Section 4.7 concludes and derives policy implications.

4.2 Potential governance challenges of seed systems

4.2.1 Overview of the seed system

In the literature on seed systems, a distinction is usually made between "formal seed systems," which involve modern techniques of plant breeding and government certification of varieties and "informal" or "traditional seed systems," which involve traditional forms of breeding and seed exchange by farmers and local communities. While informal seed systems remain important (Sperling & McGuire, 2010), the focus of this paper is placed on formal seed systems and their governance challenges.

A formal seed system, in this paper also referred to as commercial seed system, encompasses a series of interdependent activities, which can be grouped into three major stages, as shown

in Figure 4.1. (1) Varietal development; (2) seed multiplication and certification; (3) seed marketing and promotion. The first step, the development of new varieties, requires breeding, which is a research activity. To ensure that farmers get access to new varieties that indeed have advantages over existing ones, the testing of new varieties is required, which is typically part of a variety release procedure. To make the new varieties available to farmers on a large scale, several stages of seed multiplication are necessary. These are typically referred to as the production of (a) breeder seed (the first generation of seed), (b) foundation seed (the second generation of seed) and (c) commercial seed (the final product used by farmers). In each stage of seed production, quality must be assured, which is typically achieved through seed certification. Marketing and promotion activities are then required to ensure that farmers have knowledge of the improved seed varieties and can purchase them.

For an analysis of governance challenges that may occur in the different stages of seed supply, it is useful to distinguish three sectors, or types of governance structures (cf. World Bank, 2007): The private sector (the market), the public sector (the state), and the third sector (non-governmental and community-based organisations). All three governance structures are prone to their own governance challenges which can be referred to as market failure, state failure and community failure respectively (Birner & Anderson, 2007). Market failure occurs if the market system, which is based on private sector governance, leads to an allocation of resources that is not optimal from the society's perspective (Bator, 1958). As further detailed below, market failure is inherent at various stages of the seed supply system, which has stimulated government intervention. However, public sector institutions are confronted with their own challenges, which may be referred to as "state failure." Third sector organisations can also play an important role at the different stages of the seed supply system to overcome market and state failures. Nonetheless, they also face their own challenges, which, in analogy, can be labelled "community failure." In this paper, these "failures" of the public, the private and the third sector are referred to as "governance challenges."

The following sections examine the underlying reasons for these governance challenges in the case of seed supply. Maize is used as an example. For maize, both OPVs and hybrid varieties are available. As further detailed below, the governance challenges involved in the supply of OPVs, which farmers can reproduce themselves, differ to some extent from the governance challenges involved in the supply of hybrid varieties. Figure 4.1 gives an overview of these governance challenges.

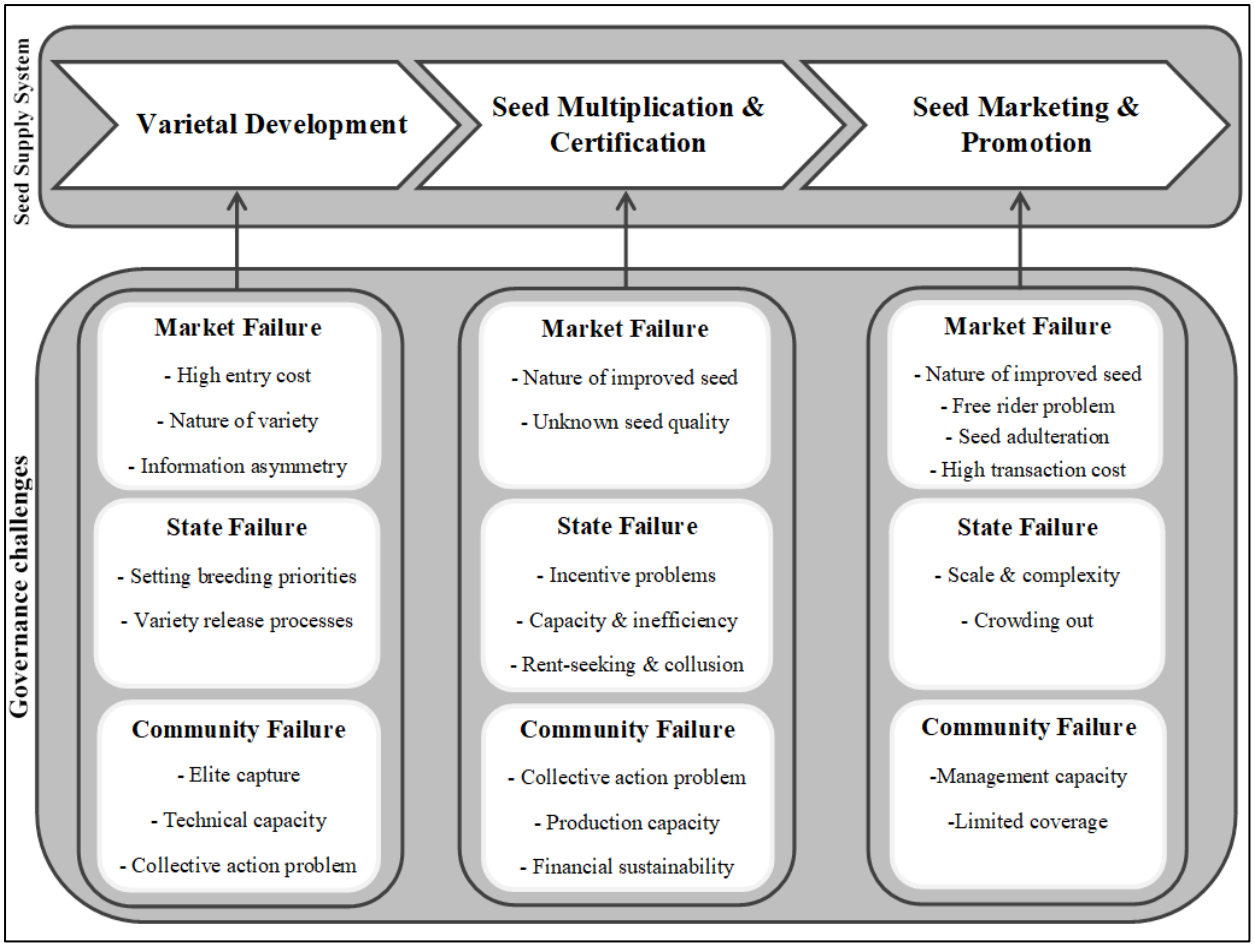

Figure 4.1: Overview of governance challenges affecting seed supply

4.2.2 Varietal development

4.2.2.1 Market Failure

Varietal development is capital intensive as it requires access to germplasm, trial fields, physical equipment and the scientific expertise that is necessary to undertake an effective breeding program. Moreover, varietal development is a long-term process. Thus, economies of scale may deter private sector investment in varietal development or allow one firm to monopolise this activity especially in very small markets (Jaffee & Srivastava, 1994). Most emerging seed companies are therefore dependent on varieties that were developed by the public sector. High capital requirements are also one reason for the dominance of large multinational seed companies in private sector varietal development and explain recent takeover bids among these companies. Secondly, the payoff for this long term investment can be uncertain depending on the nature of the variety. Farmers can recycle the seed of OPVs for

several planting seasons. OPVs also facilitate seed exchanges among farmers, allowing some farmers to benefit from new seed varieties without ever having to purchase them (Alene et al., 2000). This public good characteristic of non-excludability constitutes a disincentive for private companies to invest in the development of OPVs. An institutional solution would be restricting the rights of farmers to multiply their own seeds. However, such a provision is difficult to enforce and involves high transaction costs, especially in developing countries where the number of smallholders is large and infrastructure is not well developed. Accordingly, the sustained dominance of OPVs in West and Central Africa has perpetuated the lack of private sector involvement in maize varietal improvement in the sub-region (Alene et al., 2015).[6] Hybrids are a technical solution to the non-excludability problem as seed must be purchased every season to achieve undiminished yields. Seed companies are therefore able to fully realise the returns from their investment in developing hybrids. Thus, the widespread diffusion of hybrids among small scale farmers in Eastern and Southern Africa has led to considerable private sector investment in maize breeding (see De Groote et al., 2015).[7]

Variety development also involves market failure that results from information asymmetry. If a new variety does not have significant advantages over existing varieties, or if it is even inferior, a private seed company that developed such a variety has no incentives to disclose this information. This creates a disincentive for farmers to purchase seeds of new varieties unless the government (or another independent organisation) tests new varieties and ensures that inferior varieties do not enter the market.

4.2.2.2 State Failure

The market failures described above provide the rationale for government involvement in varietal development. The non-excludability problem of OPVs has been a major reason for government-supported crop breeding programs (Minot et al., 2007). The focus of such programs has usually been placed on major crops that are important for food security and export. The state-run programs mostly rely on the Consultative Group on International Agricultural Research (CGIAR) for improved germplasm, but this is only useful if it can be

[6] Premier Seed Ltd in Nigeria was the only private seed company in West and Central Africa that invested in maize research with about six full-time equivalent researchers working on maize breeding in 2009 (Alene et al., 2015).

[7] The private sector was responsible for 53% of the maize variety releases in Eastern and Southern Africa between 2000 and 2010 (De Groote et al., 2015).

incorporated into a well-functioning domestic breeding program. In the case of maize, many African countries remain fully reliant upon public sector breeding programs as the only source of improved varieties adapted to local conditions, even after liberalisation efforts in the seed sector. However, governance problems facing the public sector affect the effectiveness of such programs. The low capacity of public research organisations and missing linkages between research and extension result in inadequate feedback from farmers. Such feedback would be essential to inform the system about farmers' objectives for varietal development. This deficit often leads to a considerable mismatch between the type of varieties produced by breeders and those required by farmers (Louwaars, 2005; Cromwell et al., 1992).

The information asymmetry problem regarding new varieties is typically addressed by state regulation – all new varieties of major crops, be they produced by the public sector or the private sector, are typically subject to a process of testing and release. This regulatory approach involves its own governance challenges. Low capacity of the institutions in charge leads to protracted processes that limit the range of improved varieties available to farmers (Tripp et al., 1997).

4.2.2.3 Community Failure

Informal seed systems rely entirely on local communities, but as outlined above, they are not the focus of this paper. Communities can also play an important role in formal systems to address the problems of market and state failure identified above. "Participatory Plant Breeding" (PPB) approaches have become rather common, and they are often part of formal seed systems (Sperling et al., 2001). Depending on the type of PPB approach, communities may be involved in all stages of the formal seed system displayed in Figure 4.1.

With regard to varietal development, government breeding programs often use PPB to involve farmers in setting breeding priorities, develop breeding strategies and in selecting breeding lines. The nature of participation in these approaches is consultative and the aim is to achieve a better match between government breeding programs and farmers' demands (Sperling et al., 2001). A governance challenge facing this approach is "elite capture", a well-known problem of participatory development approaches (Platteau & Gaspart, 2003). The farmers involved in PPB may be those who already have a connection to the research system because they are better educated and better off, and they may not necessarily represent the

perspectives of poorer, marginalised and female farmers unless the programs make specific efforts to reach these groups.

In principle, the role farmers or farmer-based organisations (FBOs) play in variety development can be more far-reaching than just a consultative role. However, a review of participatory breeding in CGIAR-supported programs found that farmers lack the skills and resources to conduct with adequate precision the extensive operations required in early stages of variety development, such as making crosses and growing large segregating populations (CGIAR/TAC, 2001: 23). Moreover, FBOs face the classical free rider problem of collective action (Ostrom, 1990): There is a disincentive to incur the transaction costs of participating in PPB programs or otherwise exert pressure on the public sector to develop desired varieties, because the benefits of such efforts will also accrue to those who did not participate.

4.2.3 Seed multiplication and certification

4.2.3.1 Market Failure

The market failure that is caused by the problem of non-excludability in the use of OPVs extends to seed multiplication. Seed companies will find it difficult to successfully sell OPVs if the seed price is substantially higher than that of commercial grain. Seed enterprises may, therefore, prefer to concentrate on the production of hybrids where annual seed sales are assured (Tripp & Ragasa, 2015). This can lead to a commercial seed system devoid of OPVs. Indeed, deregulation of the maize seed sector in Africa has seen the introduction of an increasing number of both foreign and domestic private sector companies involved in commercial seed multiplication, which focus particularly on hybrids (ACB, 2015).

Information asymmetry is not only a problem for variety development, but also for seed multiplication. Seed producers invariably have more information than farmers about the origin and quality of commercial seed (Byerlee et al., 2007). By visual inspection, farmers can detect some aspects of seed quality (such as obvious damage), but they cannot assess important aspects such as genetic purity. Akerlof (1970) demonstrates how information asymmetry about product quality and potential fraud adversely affects market performance. This problem of market failure can also be observed with regard to seed multiplication. Farmers may opt to use seed saved from their own harvests or utilise more familiar informal seed distribution channels rather than purchase seed of unknown quality from a seed company. The majority of small scale farmers in Africa obtain their seed from these informal

sources (McGuire & Sperling, 2016; Louwaars & De Boef, 2012). Seed certification can address this challenge, but it involves its own governance challenges, as discussed below.

4.2.3.2 State Failure

If public sector institutions carry out variety development, they need to produce breeder seed, which can then be multiplied by private companies. Breeder seed production is confronted with incentive problems because the public research institutions in charge of breeding are seldom separately funded for carrying out this task. Therefore, they must determine the amount to be invested in seed production as opposed to further breeding activities. As incentive systems are based on the number of newly released varieties rather than seed multiplication, there is a disincentive for public sector organisations to produce sufficient quantities of breeder seed (Tripp & Rohrbach, 2001).

Due to the market failure problems discussed above, public sector organisations have not only been involved in breeding and the production of breeder seed, but also in further steps of seed multiplication and seed marketing. For these activities, governments have often set up parastatal seed companies, which have experienced the typical governance challenges of public sector management, such as understaffing and lack of funds. As a consequence, public seed companies in Africa typically produced insufficient foundation seed for a limited range of varieties such that commercial seed supply has been dictated by foundation seed availability rather than actual market demand (Erenstein et al., 2011).

Governments have also set up seed certification systems to address the market failure of quality assurance discussed above. These systems also face governance challenges due to resource constraints. Spatially dispersed seed production fields must be repeatedly inspected at specific stages of the growing season. The inability to mobilise these resources often causes costly delays and losses. This invariably encourages rent-seeking and collusion between influential seed producers and officials. Most African countries operate mandatory and highly centralised government-funded seed certification systems for food crops like maize that are confronted with these challenges (Tripp & Louwaars, 1997).

4.2.3.3 Community Failure

In principle, communities could play an important role in seed multiplication to overcome the market and government failures pointed out above. They may especially be involved in the multiplication of OPVs since producing seed for hybrid is more difficult to manage given the

requirement of larger field isolation distances and the increased difficulty of detecting off-types (Monyo et al., 2004). However, the governance problems affecting community involvement in varietal development are also relevant for seed multiplication. The formation of FBOs for community-based seed production can be hindered by the collective action problem. Farmers may have limited incentives to join such groups as they largely rely on farmer-saved seeds or acquire seed varieties through the traditional practice of seed exchanges (see Beyene, 2010). Secondly, farmer-led seed multiplication programs are prone to production capacity challenges. Farmer groups can find it difficult to effectively manage production activities such as seed selection, post-harvest handling and seed quality control on a commercial scale (see Osman, 2008). Furthermore, non-governmental organisations (NGOs) that support local-level seed production schemes often face problems of financial sustainability. Consequently, Tripp and Rohrbach (2001) reported the absence of sustainable community-based seed production in Africa as group activities invariably ceased once the implementing organisation withdrew support.

4.2.4 Seed marketing and promotion

4.2.4.1 Market Failure

Market failure in seed marketing and promotion can occur for a number of reasons. First, the public good feature of non-excludability arising with OPVs tends to lead to a preference for only promoting and marketing hybrid seed. While seed marketing is a particularly weak point in Africa's commercial seed sector development, dominant seed companies in a number of African countries have fairly well established distribution networks for their hybrid maize seed (Tripp, 2000). Second, private companies lack the incentive to invest in the promotion of public varieties as this may prove beneficial to competing companies (Tripp & Byerlee, 2000). This is an indication of the free rider problem where those benefitting from a service are not paying for it, which results in an under-provision of the service. Third, information asymmetry about the actual content of packaged commercial seed results in the common problem of seed adulteration by seed retailers (Langyintuo et al., 2010). In addition, the high transaction cost of marketing seed to spatially dispersed smallholders in remote and low potential areas also serves as a deterrent to seed companies and agro-dealers.

4.2.4.2 State Failure

Due to the market failure explained above, governments have been involved in seed marketing and promotion through public seed companies as well as public agricultural extension services. The challenges faced by public seed companies involved in these tasks have already been described above. Public agricultural extension are also facing numerous governance challenges which are well documented in the literature (see, e.g., Feder et al., 2010). With regard to seed promotion, the scale and complexity of extension service provision commonly presents the biggest problem (cf. Pritchett & Woolcock, 2004). The budgetary and practical considerations of reaching large numbers of geographically dispersed heterogeneous smallholders in Africa have rendered public extension services rather ineffective in promoting the adoption of new varieties (Tahirou et al., 2009; Langyintuo et al., 2008). Moreover, public seed distribution programs can crowd out private investment by discouraging the development of wholesale and retail seed trade networks because farmers become accustomed to the government distributing subsidised or free seed (Kelly et al., 2003; Tripp, 2000).

4.2.4.3 Community Failure

The creation of sales cooperatives or community seed banks can be an effective approach to resolving the market and state failures in seed marketing and promotion (Thijssen et al., 2008). However, the sustainability of such approaches requires skills in management and marketing, which members often lack. Witcombe et al. (2010) observe that the lack of a business-oriented approach to the development of seed trade networks has been a major reason accounting for lack of sustainability of community-based organisations. NGOs could play an important role in seed promotion, as well. However, they typically have limited coverage due to their size, limited geographic coverage and financial constraints (cf. Birner and Anderson, 2007).

4.3 Ghana's Commercial Seed Sector

Ghana's evolving commercial seed sector supplies only a small percentage of the total demand for seed. About 80 per cent of the seed used in the country is sourced from the informal sector, which entails farmer-saved seed, seed exchanges among farmers and purchases from local grain or seed markets (MoFA, 2015b). Similar to most African countries, maize is the predominant crop in the commercial seed system. The average annual

certified maize seed production between 2001 and 2014 was 2,230 metric tons. This represents 60 per cent of all commercial seed production. Between 1970 and 2010, twenty-seven improved maize varieties were released in Ghana. Table 4.1 shows that Ghana's varietal output is average as compared to other countries in West and Central Africa. Yet, one OPV, Obatanpa, accounts for 96 per cent of maize seed production while newer varieties have failed to have significant commercial seed production (PPRSD, 2002-2015). These unsuccessful varieties have included several hybrids (Tripp & Ragasa, 2015). A comparison of the studies by Morris et al. (1999) and Ragasa et al. (2013) indicate that the total maize area planted to improved varieties in Ghana increased marginally from 54 per cent in 1997 to 60 per cent in 2012. However, the share of Obatanpa more than doubled over this period. In 1997, Obatanpa accounted for 30 per cent of the maize area planted to improved varieties. In 2012, the share of Obatanpa increased considerably to approximately 70 per cent of the maize area planted to improved varieties. It must be noted that the annual certified seed production of Obatanpa is insufficient to cover this area with fresh seed every year, given the average seed rate of 20 kilograms per hectare (Ragasa et al., 2013).

Table 4.1: Improved maize varieties released in West and Central Africa, 1970-2010

Country	Number of varieties released
Nigeria	111
Cameroon	44
Benin	36
Burkina Faso	32
Ghana*	27
Mali	21
Togo	13
Guinea	12
Côte d'Ivoire	11
Senegal	10
DR Congo	10
Total	**327**

Source: Alene et al. (2015)

Obatanpa is a medium maturity white OPV. This quality protein maize variety (QPM) was developed by the public research system in Ghana under the Ghana Grains Development Project (GGDP) and promoted extensively by the Sasakawa Global 2000 (SG 2000) program.[8] The variety has not only been widely adopted in Ghana but also across a number of other African countries (Badu-Apraku et al., 2004). Although Obatanpa is an improved variety,[9] it was released over two decades ago and is therefore unlikely to play a significant role in any further commercial seed sector development (Tripp & Mensah-Bonsu, 2013). The national annual average yield for maize over the past decade is 1.7 metric tons per hectare (MoFA, 2015c). Based on on-station and on-farm trials, achievable yields of newer OPVs and hybrids could be between 5 and 8 metric tons/hectare. The low adoption of improved technologies such as improved varieties is a major reason accounting for this yield gap (Ragasa et al., 2013). Thus, the availability of new and higher yielding improved varieties in the seed system is vital to increased maize productivity.

The seed sector reform opened the door for international companies to get involved in seed supply. So far, two multinational seed companies, DuPont Pioneer and Pannar, have had local representatives in Ghana since 2012. They were exclusive importers of the hybrid maize seed varieties of these companies. There has been no in-country seed production of foreign maize varieties. The imported seeds had limited over-the-counter sale and were mainly used by large scale contract farming schemes (Ragasa et al., 2018). In mid-2015, the importation of commercial maize seed was banned by the government, which argued that this measure was necessary to foster growth of the local seed industry (Tripp & Ragasa, 2015). The new law appears to be ambiguous on this matter. It allows access to foreign varieties, yet it is not clear on whether the commercial seed necessarily has to be produced in Ghana (GoG, 2010: 20). As a consequence, foreign maize seed companies are no longer present in Ghana.

[8] This was an outcome of a joint institutional effort to improve the nutritional value of maize grain protein aimed at overcoming malnutrition in the large population of low-income groups who depend on maize as the main component of their dietary protein intake (Sallah et al., 2003).

[9] Obatanpa has a potential yield of 4.6 metric tons/hectare based on on-station and on-farm trials (Ragasa et al., 2013).

4.4 Research Methods

This section first explains the research design used for the study, followed by a description of the data collection methods.

4.4.1 Research Design

The study employed a two-step data collection procedure. In the first step, the participatory mapping technique based on in-depth interviews and visualisation known as Process Net-Map was conducted with an array of purposively sampled experts in the seed supply system. The respondents were selected based on their extensive experience and understanding of how the entire commercial maize seed system operates. Net-Map is a participatory mapping method developed for analysing how complex systems with multiple actors function (Schiffer, 2007). Process Net-Map is a variant of the method that was developed to identify governance challenges in processes of policy-making and implementation (see Raabe et al., 2012). In this study, the tool was used to gain detailed insights into the process of commercial maize seed supply in Ghana. At the same time, the tool made it possible to identify the relevant stakeholders. A detailed description of this method is presented in Section 4.4.2 below. Guided by the Process Net-Maps, the second step involved in-depth interviews with selected experts from all identified stakeholder categories using purposive sampling. These respondents were selected based on their high level of experience carrying out specific activities in the seed system. Additional in-depth interviews were conducted using snowball sampling to ensure exhaustive expert information. The respondents included agricultural researchers, public officials and regulators, donors, seed producers (individual seed growers), local private seed companies, input dealers, extension agents, maize farmers and other stakeholders throughout the country. In total, 71 stakeholders were involved in this study (see Table 4.2). Direct observation of seed supply activities, such as maize seed processing, certification, storage and sale was also conducted. Each interview involved a series of open-ended questions and follow-up questions to best capture the respondent's expert opinion on the governance challenges in the commercial maize seed system and his views on how these challenges may be overcome. The two-step research design was complemented with an extensive review and synthesis of relevant policy and legal documents as well as project reports. The document review served as triangulation to validate the findings.

4.4.2 Data Collection

Data collection was carried out between July 2015 and January 2016. The Process Net-Map technique was applied with eleven respondents, each of whom represented stakeholders involved in different activities in the seed supply system, including crop breeding, seed production, seed inspection and extension services. The application of Process Net-Map involved three steps: (1) The respondents were first asked to list all the actors involved in the seed system. These actors were recorded on a large sheet of paper. (2) Subsequently, the respondents were asked to describe the sequence of activities of maize seed supply and to identify the respective roles of all participating actors. This process was mapped out using numbered arrows to denote each step, hence revealing how the actors are linked. (3) In the third step, respondents ranked the influence level of the actors on a scale of 0-8. The level of influence was defined as the stakeholders' level of importance in achieving the desired outcome of seed supply, which was that farmers widely adopt a new maize variety through an efficiently functioning seed system. To visualise the influence levels in a way that facilitated the discussion, poker chips were stacked up next to the respective actor to form "influence towers". The height of these "towers", i.e. the number of chips, represented the influence level assigned by an actor to the respondent. Thus, actors assigned an influence level of 8 were perceived to be the most influential and were given the highest influence tower. After visualising the respective influence level, the respondents were asked to explain why they assigned this influence level to the respective actor. Follow-up questions were then asked about the governance challenges in the seed system. The visualisation of the seed system in the form of the Process Net-Map in front of the respondent facilitated the identification of these challenges. Digitalised copies of the Net-Maps were later shared with the respondents for verification.

The subsequent interviews focused on the governance challenges related to respondents' specific seed system activities. The Process Net-Map exercises and interviews were conducted in person on a one-on-one basis at the convenience of the respondents. All the interviews, including those from the Process Net-Map exercises, were audio-recorded with the expressed permission of the respondents to enable an effective content analysis. Some of the respondents were contacted again during data collection to clarify responses that had remained unclear.

Table 4.2: Overview of Process Net Maps and expert interviews

Stakeholder Category	Number of Net-Maps	Number of Interviews (including Net-Maps)
CGIAR Centres	1	1
Research Institutions	1	4
Universities		1
Government Agencies (policy, regulation, extension)	4	16
Development Partners/Donors	1	5
Non-Governmental Organisations		2
Agricultural Consultants	1	1
Local Private Seed Companies	2	8
Seed Producers (individual seed growers)	1	8
Agro-Input Dealers (Seed Dealers)		9
Agro-processing companies		1
Maize Farmers		15
Total	**11**	**71**

4.5 Results

This section presents the findings of the Process Net-Maps in the form of an aggregated map and details the actors, their roles and perceived levels of influence. Afterwards, the empirical findings of the governance challenges affecting the seed supply system are presented.

4.5.1 Aggregated Process Net-Map

The analysis of the eleven Process Net-Maps revealed the same basic steps for commercial maize seed supply in Ghana. While there was no contradiction, respondents provided different levels of detail for the different stages of maize seed supply. The Process Net-Map in Figure 4.2 represents an aggregation of the most detailed number of steps and actors involved at each stage of the process based on the eleven maps produced. The average influence levels were reported as there was minimal variation in the respondents' perceptions of the influence of different actors (see Table 4.3). These influence levels were computed by summing the scores of the eleven respondents and dividing the sum by eleven. The mean

scores were rounded off to the nearest whole number. They are depicted in the form of circles next to the actors in Figure 4.2. The number in the circles displays the rounded mean score. The governance challenges in the system are depicted in the form of stars.

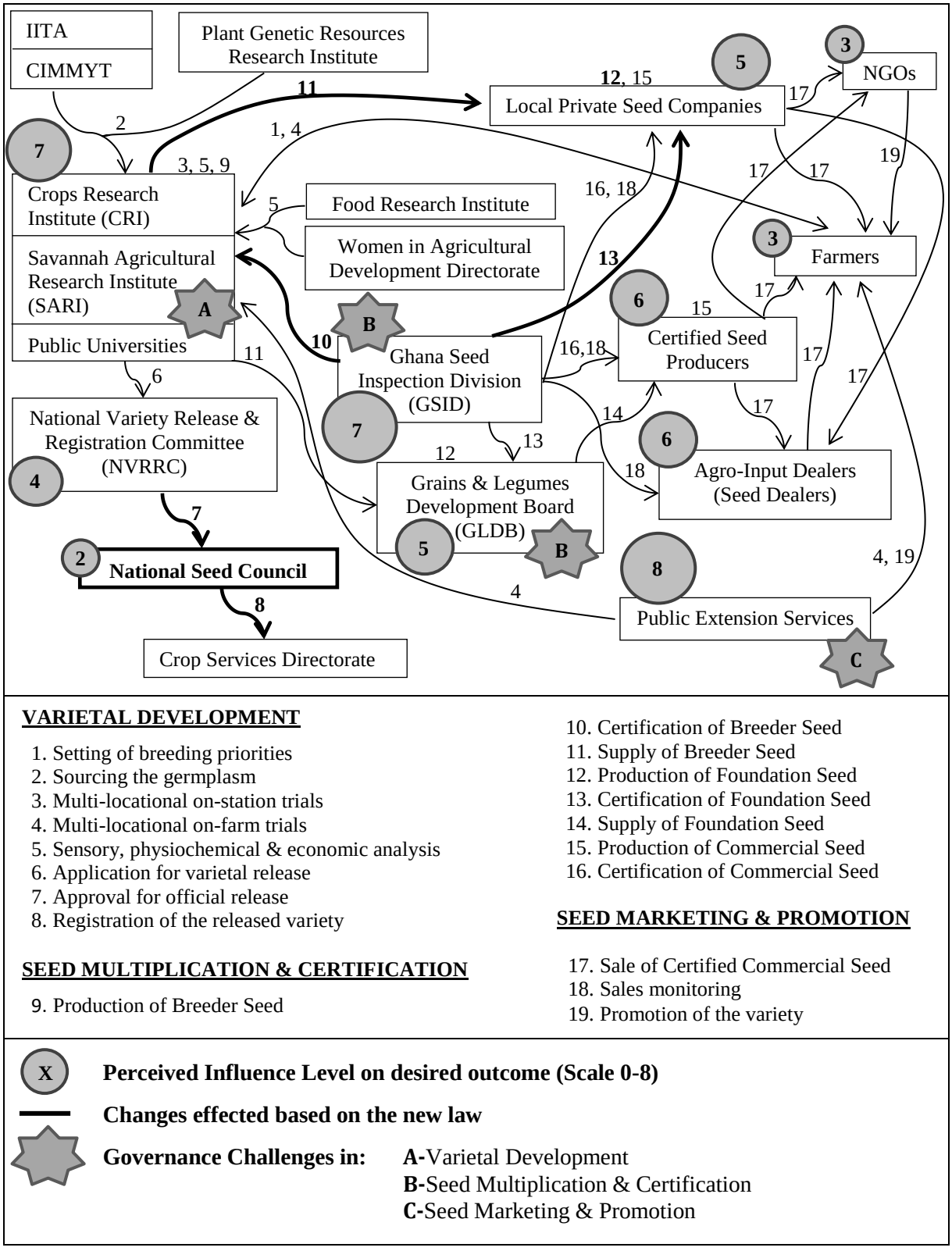

Figure 4.2: Aggregated Process Net-Map of commercial maize seed supply in Ghana

Table 4.3: Mean and Range of Influence Scores of Actors

Actors	Mean Influence Level	Range
Public Extension Services	8	1
Crops Research Inst./ Savannah Agricultural Research Inst./ Public Universities	7	1
Ghana Seed Inspection Division	7	1
Certified Seed Producers	6	1
Agro-Input Dealers (Seed Dealers)	6	2
Grains & Legumes Development Board	5	2
Local Private Seed Companies	5	2
National Variety Release & Registration Committee	4	3
Farmers	3	1
Non-Governmental Organisations	3	2
National Seed Council	2	1

Note: The range is the difference between the highest and the lowest reported influence level of an actor

4.5.2 Actors and their roles in commercial maize seed supply

The results show that two national agricultural research institutes (NARIs) have been solely responsible for all locally developed improved maize varieties in Ghana: the Crop Research Institute (CRI) and the Savannah Agricultural Research Institute (SARI). CRI has the mandate for crop research in the coastal savanna, the forest belt and the forest-savanna transition agro-ecologies of Ghana while SARI handles crop research for the Guinea savanna and the Sudan savanna agro-ecologies. Both NARIs belong to the Council for Scientific and Industrial Research (CSIR). They determine breeding priorities to overcome current production and postharvest challenges in consultation with farmers as shown in Steps 1 and 2 of Figure 4.2. Subsequently, they obtain germplasm from collaborating international research centres, particularly from the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA). Indigenous landraces are also occasionally sourced from the Plant Genetic Resources Research Institute (which also belongs to CSIR) to address specific adaptability and utilisation issues. The Plant Genetic Resources Research Institute is the national genetic resources agency and operates a

national gene bank. Some public universities have established breeding programs as well, but they are yet to release any improved maize varieties. Under the new seed law, varieties developed by the private sector from both domestic and foreign sources are also permitted.

For a period of two years, on-station trials are carried out at the experimental stations of the research institutions in all five agro-ecological zones of the country (Step 3). These trials are followed by two years of adaptive field trials carried out in all agro-ecologies because maize is grown in all the agro-ecologies of Ghana (Step 4). At this stage, farmers who are selected with the assistance of extension agents of the Ministry of Food and Agriculture (MoFA) assess a new variety together with the breeders on their own farms by comparing it to existing varieties. In addition, a sensory, physiochemical and economic analysis is carried out, before the variety is presented to the National Variety Release and Registration Committee (NVRRC) for a final evaluation (Steps 5 and 6). The sensory analysis to determine the suitability of the variety for its intended end uses is conducted by the Women in Agricultural Development Directorate of MoFA, and the physiochemical analysis is carried out by the Food Research Institute of CSIR. Economists at CRI and SARI conduct the economic analysis.

The NVRRC, a technical committee comprising representatives of all major stakeholders in the commercial seed sector, visit the breeder seed fields at least twice during the growing season. The first field inspection is carried out at the flowering stage and the second at the harvesting stage. The release committee determines whether or not the variety release process should proceed based on these inspections and supporting data. The National Seed Council officially releases the variety based on the recommendation of the NVRRC (Step 7). The National Seed Council, which was formed under the new law, is the main oversight body in the seed sector. The Council consists of nine members; three ex-officio positions are held by the minister and two directors of MoFA, one position is held by a director of CSIR; three positions are held by representatives of the Seed Growers Association, the National Farmers' Association, and the Biotechnology Research Institute respectively; and two members are nominated by the President. Under the new law, the released variety is registered in a national catalogue for crop varieties managed by the Crop Services Directorate of MoFA (Step 8).

Upon initial approval of the variety by the NVRRC, the responsible research institution commences breeder seed production so that at the time of official release, breeder seed will be available (Step 9). Under the new law, all classes of seed must be certified by the Ghana

Seed Inspection Division (GSID) of the Plant Protection and Regulatory Services Directorate (PPRSD) of MoFA.[10] This certification process starts with breeder seed certification (Step 10). Certified breeder seed is supplied to the Grains and Legumes Development Board (GLDB), a parastatal of MoFA, as well as directly to local private seed enterprises (Step 11). Prior to the new law, GLDB was the only institution mandated to produce foundation seed.[11] As indicated above, ten domestic seed companies have emerged, which have started to produce the foundation seed they require for the production of commercial hybrid maize seed. GLDB still produces and processes the bulk of foundation seed using contract growers (Step 12). Foundation seed produced by GLDB and seed companies is inspected and certified by GSID (Step 13).

Certified maize foundation seed is sold to private small-scale seed producers who are registered with GSID (Step 14). These seed producers (individuals and small cooperatives) produce commercial seed under the supervision of GSID (Step 15). Certified commercial seed is primarily sold through agro-input dealers (seed dealers) that are registered by GSID to sell seed (Steps 16, 17 and 18). Seed producers usually establish agreements or contracts with seed dealers to market their seed. Certified commercial seed can also be sold directly by the seed producers. Commercial seed is packaged in bags issued by GSID, which display a unique code assigned to each producer or cooperative. As product differentiation is permissible under the new law, the emerging seed companies have started to use their own seed packages. These seed companies are also highly dependent on the seed dealers to market their seed.

The Agricultural Extension Services Department of MoFA is principally responsible for varietal promotion and all forms of seed extension (Step 19). Agricultural extension agents (AEAs) are tasked with informing farmers about the benefits, sources and proper use of improved seed. To a lesser extent, NGOs also engage in varietal promotion through field demonstrations and handing out free seed samples to farmers. Community-based organisations have not played a significant role in Ghana's commercial maize seed system thus far.

[10] The Plant Protection and Regulatory Services Directorate is the institution sanctioned to regulate and coordinate all plant protection services. It is subdivided into four divisions which includes the Ghana Seed Inspection Division.

[11] GLDB assumed the task of foundation seed production after the collapse of the government-owned Ghana Seed Company (GSC) in 1989. GLDB inherited some of its infrastructure (Lyon & Afikorah-danquah, 1998).

4.5.3 Influence level of actors

As described above, the respondents were asked to score the influence of the actors on the desired outcome that farmers widely adopt a new maize variety. As shown in Figure 4.2, public extension services were perceived as having the highest influence on this outcome (influence level = 8). Public extension has the unique role of bridging the gap between research and farmers. Thus, the high score is based on the core function of extension to promote the use of improved seed varieties among farmers. Research institutions and the GSID were both assigned the next highest score (influence level = 7). As the respondents explained, this influence level was assigned because researchers are seen as the originators of a variety and are responsible for maintaining the genetic purity of the variety, while GSID is tasked with quality assurance at all stages of seed production as well as at all sales points. Certified seed producers were assigned an influence level of 6 as they are the main source of commercial seed of an improved variety. Similarly, seed dealers are seen as critical to the marketing of commercial seed (influence level = 6). Emerging local private seed companies had an influence level of 5 due to the fact that they also produce commercial seed, particularly for hybrid maize varieties. These companies also participate in an increasing number of activities in the seed supply system, such as foundation seed production and varietal promotion, though presently in a limited capacity. Correspondingly, GLDB was also assigned an influence level of 5 based on its pivotal role in foundation seed production. The NVRRC's role in determining varietal superiority was perceived to have an influence level of 4. The select group of farmers contacted by research institutions in setting breeding priorities was assigned an influence level of 3. This low level was attributed to the irregularity and the limited extent of farmer representativeness in this exercise. NGOs were equally assigned an influence level of 3. Their efforts in varietal promotion and seed distribution, though commendable, were perceived to have limited scope. Indeed, most seed sector activities by NGOs are concentrated in Northern Ghana. The National Seed Council had the lowest influence level on the outcome (influence level = 2) because the newly formed council was perceived as essentially following the recommendation of the NVRRC in releasing a new variety.

4.5.4 Governance challenges of the commercial maize seed system

This section presents the empirical analysis of the governance challenges affecting the different stages of the seed supply system. The theoretical considerations presented in Section

4.2 are applied here. Figure 4.2 highlights the identified governance challenges in the form of stars.

4.5.4.1 Varietal development

As discussed in Section 4.2.2, market failure in varietal development can stem from high entry costs. Concordantly, private investments by local seed companies in developing proprietary breeding programs in Ghana have mainly been hindered by the cost outlay of varietal development. The interviews revealed that the absence of a plant variety protection law is also an obstacle.[12] Thus far, there has been no private sector involvement in maize varietal development in Ghana. Public breeding programs serve as the sole source of maize varieties, as depicted in Steps 1 through 8 of Figure 4.2. According to the information collected for this study, researchers in the NARIs' breeding programs only involve farmers at the later stage of on-farm trials. At the initial planning stages of varietal development, farmer input is largely absent. A NARI maize breeder noted;

> "*Participatory rural appraisals and focus group discussions with farmers are done with communities from time to time to determine farmers' preferences for maize varieties. About every 5 to 10 years.*"

Research and Extension Linkage Committees (RELCs) were set up in 2001 to strengthen the linkages between research institutions and extension services. These regional platforms are meant to bring researchers, extension agents and farmers together to facilitate dialogue with the aim of making research more demand-driven. However, the research-farmer linkages in these committees have also proved to be weak, mainly due to poor representation of smallholder farmers. This points to state failure in setting breeding priorities, as mentioned in Section 4.2.2. A former MoFA official observed;

> "*The RELCs produce priorities that are not necessarily what the farmers want because the committees are not representative of the everyday smallholder*."

The NARIs seem to be unable to match the success of Obatanpa in satisfying farmers' needs across the country's varied maize production zones. There are instances where varieties have

[12] At the time of submitting this article in early 2017, a draft plant breeders' rights bill intended to provide ownership and protection for new varieties developed by any public and private entities is awaiting parliamentary approval.

failed to meet farmers' preferences with regard to criteria such as grain size and milling quality. Furthermore, while many of the newer varieties are also quality protein maize varieties, almost all of the newer OPVs are early maturing (75-90 days to anthesis), which invariably results in comparatively lower yields.

Consequently, the newer OPVs fail to have a yield advantage over Obatanpa. Moreover, Obatanpa has proved to have a remarkably stable performance, even when recycled seed is used. This is reflected in the following statement by a NARI social scientist;

> "*Obatanpa is probably the most stable maize variety to have come out of our research system […] most farmers successfully reuse their seed for several seasons.*"

Questions have also been raised regarding the authenticity of the stated performance potential of some improved varieties developed by the NARIs. Needless to say, farmers' agronomic practices are a critical factor that contributes to varietal performance. Nonetheless, these varieties are bred with cognisance of farmers' prevailing agronomic practices (hence the importance of on-farm trials), and yet there tend to be significant discrepancies between stated and actual performance, particularly in terms of yield. A retired MoFA agronomist observed;

> "*On the ground, the other varieties do not perform as well as Obatanpa, even some hybrids. On-farm tests are not sufficient proof of performance because the plots used are so small, so you don't see the effect. The yields, storability and other desired characteristics of some of these other varieties are not as stable over a number of seasons.*"

The quality of the varieties developed by the research system also reflects the effectiveness of the NVRRC and the newly formed National Seed Council, who are the gatekeepers.

4.5.4.2 Seed multiplication and certification

As mentioned in Section 4.2.3, public sector seed multiplication and certification can lead to capacity and inefficiency problems. In the current system, the NARIs sell breeder seed upon request to GLDB as well as to private seed companies, as shown in Step 11 of Figure 4.2. The price at which the NARIs have to sell breeder seed to GLDB is subject to a pricing ratio

(1:2:4) set by the NVRRC,[13] which starts with the determination of the commercial seed price.[14] The foundation seed price is set at double that of commercial seed, and breeder seed price four times that amount. According to interview information, this pricing system does not cover the cost of breeder seed production. Moreover, GLDB often delays payments. Some local private seed companies have signed a memorandum of understanding with the NARIs to obtain inbred lines for hybrid seed production at a price that allows the NARIs to recover their costs. Given the capital-intensive nature of breeder seed production,[15] the NARIs are often unable to supply adequate quantities of breeder seed. Related to this problem is the maintenance of breeder seed. The need to maintain a large number of different varieties also involves considerable costs, since the seeds must be stored under climate-controlled conditions. Therefore, breeder seed of a number of the older maize varieties is no longer available. The research institutions cite financial and physical resource constraints as the main reasons for this problem. A NARI maize breeder expressed this concern as follows;

> "*A lot of our released varieties are extinct now because if a variety is not demanded for 2 to 3 years, we cannot afford to keep producing seeds of those varieties every season. And unfortunately, we don't have the capacity to store and maintain all the germplasm.*"

Breeder seed quality presents another challenge. Local private seed companies that obtain parental material directly from the NARIs for hybrid maize production reported to have experienced problems with breeder seed quality on several occasions.

At present, GLDB still produces the bulk of foundation seed. Though domestic seed companies are now permitted to produce foundation seed for their own commercial seed production (Step 12), none of them has been sanctioned yet by the GSID to produce foundation seed for sale to other seed companies and producers. The information collected for this study as well as observation of facilities suggests that GLDB is overburdened with this role. This is due to financial constraints, a typical problem of publicly funded

[13] The NVRRC essentially doubles up as the Seed Advisory Technical Committee which oversees seed pricing due to identical stakeholder representation on both committees.

[14] The seed producers association of Ghana (SEEDPAG) presents their cost of production at an annual stakeholder forum to set a standard seed price for OPVs and hybrids that is not mandatory but generally adhered to.

[15] Breeder seed production is an expensive process due to high production, testing and storage costs of ensuring varietal purity.

organisations. Visual inspection showed that the seed conditioning equipment is not state of the art. The seed threshing, drying and cleaning equipment used by GLDB is over 30 years old and frequently breaks down. GLDB also runs the only three existing large-scale cold storage rooms for seed in the country. These cold rooms have maximum capacities of 750, 250 and 150 tons, respectively. Each of them is used to store foundation seed as well as commercial seed for some seed producers and local seed companies. Thus, GLDB only has the capacity to produce foundation seed in limited quantities. As a consequence, GLDB concentrates on a small number of maize OPVs, mainly Obatanpa, since this variety has the highest demand. GLDB generally avoids multiplying hybrid maize varieties, because its production is more onerous and expensive. On occasion, GLDB must also ration foundation seed provision to seed producers when demand exceeds supply.

The systemic problem of seed quality, which has been discussed in Section 4.2, is very much present at this stage of seed production as well. Seed producers have intermittently raised issues regarding the quality of foundation seed. This is obviously the consequence of the low capacity and antiquated seed conditioning equipment and facilities.

GSID has the sole responsibility of quality assurance at all stages of seed production (Steps 10, 13 and 16 of Figure 4.2). GSID is tasked with field inspections, monitoring of conditioning sites and undertaking seed tests.[16] Under the new law, mandatory seed certification extends to foundation and breeder seed. Similar to GLDB, GSID is greatly under-resourced. As an industry expert revealed;

> "*Currently, there are only 35 active seed inspectors nationwide. Many of them double up as seed samplers and seed analysts, as well. The division is also sorely lacking logistics such as essential seed laboratory equipment, vehicles for the inspectors and even computers.*"

As a consequence of this limited capacity for seed regulation, GSID's regulatory oversight of source seed production (breeder and foundation seed) has become a mere formality. Interview information suggests that field inspectors readily certify breeder seed without proper testing. The NARIs are seen to be fully competent and well equipped with the expertise to ensure high breeder seed quality. However, even with the experience and expertise of the NARIs, the absence of effective regulation can lead to complacency. Quality

[16] Ghana applies the International Seed Testing Association (ISTA) rules for seed testing.

assurance of foundation seed production by GLDB faces a similar challenge. The National Seed Council has the authority to sanction private seed companies to produce foundation seed for sale. However, GSID has concerns with authorising dispersed companies to commercially produce foundation seed as this will increase GSID's regulatory responsibilities. The following statement of a respondent reflects this concern;

> "*Private companies selling foundation seed will be challenging to regulate because GSID is even struggling to handle commercial seed certification as it is.*"

GSID is most active at the commercial seed stage of the production chain. Field inspectors are required to visit all the production fields of seed producers and seed companies at least five times during the certification process.[17] However, this goal is seldom achieved. The small number of inspectors is simply unable to monitor all the dispersed seed production fields. Very often, the seed producers and local seed companies have to incur the cost of transportation of inspectors to ensure field visits. Seed producers and seed companies are already charged for each inspection. Thus, many seed producers operate with minimal supervision and quality assurance at the production stage. Another major concern is the conflict of interest arising from some GSID inspectors engaging in commercial seed production. This is forbidden by law, but not strictly enforced. A seed producer expressed concerns as follows;

> "*Some of the seed inspectors themselves are seed producers. The referees are playing the game. So who is going to regulate the regulators? And these inspectors have an unfair advantage in securing breeder and foundation seed.*"

This conflict of interest is an empirical finding of state failure in seed multiplication and certification that is not covered under the theoretical considerations presented in Section 4.2.

[17] Field inspections are to be done as part of the initial application process to become a registered seed producer/company; followed by a pre-planting inspection; two inspections at the pre-flowering and post flowering stages; and a final inspection during harvesting.

4.5.4.3 Seed marketing and promotion

With reference to Section 4.2.4, market failure in seed marketing and promotion can be caused by seed adulteration, a free rider problem, and high transaction costs. State failure can also occur due to the transaction intensity and discretionary nature of these activities.

A key duty of inspectors after seeds are produced is to supervise the filling and sealing of seed bags by seed producers and local seed companies. Certified maize seed is packaged in 1kg polythene bags, which are subsequently placed in 45kg bags. The 1kg seed bags are produced in response to the small quantities of commercial seed purchased by most small scale farmers. Standard packaging material issued by GSID is used, except for five seed companies who use their own brands. This generic packaging material has proved easy to imitate. This practice is motivated by the fact that the price of certified commercial seed is approximately twice the price of maize grain for OPVs and five times the price of grains of hybrids. Thus, it is common that merchants sell maize grain packaged as certified seed. Field inspections at the time of harvest determine the number of packages issued to a producer. This could also lead to seed adulteration as the number of field inspectors is rather limited. However, unregistered seed dealers appear to be the main source of fraudulent commercial seed, rather than seed producers or even collusions between seed producers and merchants. This is reflected in the following statement by the owner of a local seed company;

> "*Fake seed being sold by these unlicensed agro-input dealers everywhere has become the bane of the seed industry. A lot of farmers have grown disillusioned with the quality of certified seed and don't want to invest.*"

There have been a number of cases where farmers who purchased sub-standard maize seed have lodged complaints with GSID. Yet, there is still no formalised procedure in place for addressing such complaints. The new law provides severer penalties for duplicitous activity in the commercial seed sector. There have been a few confirmed cases of incarcerations for seed adulteration following the passing of the new law. However, the monitoring system of seed dealers is rather limited, as GSID lacks the resources to implement effective regulation at sales points (Step 18 of Figure 4.2).

In terms of varietal promotion, seed dealers usually lack sufficient information about the characteristics and management of varieties to effectively promote them. Many farmers do

not even have access to these seed dealers whose marketing channels fail to extend to most rural areas.[18] Local seed companies and seed producers are also reluctant to invest in the promotion of products that can be sold by direct competitors, given the non-exclusivity rights of varieties developed by the NARIs. As a consequence, other than public sector AEAs, only NGOs have engaged in any significant varietal promotion.

The commercial seed sector mainly depends on MoFA's AEAs to promote the use of improved seed varieties amongst farmers (Step 19 of Figure 4.2). Yet, similar to GLDB and GSID, public extension services are grossly under-resourced to be able to effectively perform this function. The current extension-farmer ratio in Ghana is 1:1,500 as opposed to the recommended ratio of 1:500 (MoFA, 2015c). This human resource problem is coupled with a lack of logistics such as vehicles and working gear, as well as operational funds to carry out demonstrations, field days and farmer field schools.

4.6 Discussion

This study aimed to contribute to the literature on the governance challenges of developing seed systems in Africa, taking the chronic lack of varietal diversity in Ghana's commercial maize seed system as an empirical example. From the theoretical considerations presented in Section 4.2, it is evident that each sector has its own governance challenges in seed supply. State failure in seed supply systems has motivated the liberalisation and restructuring of the African seed industry. However, our case study of Ghana suggests that these efforts have not been sufficient in ensuring an effective seed supply system. The reasons are discussed in the following sub-sections.

4.6.1 Breeding strategies

In spite of privatisation efforts, maize varietal development in Ghana has remained a purely public sector activity. The number of improved varieties that the public system released is comparable to that of other countries in the sub-region (Table 4.1). Yet, only Obatanpa remains popular among maize farmers. The demand for improved varieties is invariably linked, at least in part, to the performance of the research system. This is reflected in the high average influence level (influence level=7) assigned to the research system in the Net-Map exercise. This study indicates that the state failure of deficient farmer participation in the

[18] Krausova and Banful (2010) identified a total of 3,425 agricultural input dealers in Ghana in 2009 ranging from small transient retailers to large input wholesalers. Most input dealers were concentrated in urban and peri-urban areas with 59% of them selling seed.

NARIs' breeding strategy has resulted in instances where varieties failed to meet farmers' preferences. Some preferences were correctly identified; most notably increased yield and storability, but the new varieties did not outperform Obatanpa in this respect. This presumptive breeding approach has made maize varietal development a "hit or miss" exercise. However, without survey data on farmers' evaluations, there is limited scope to accurately estimate the extent to which wrong priorities versus inefficiency in meeting priorities account for breeding shortfalls. Private sector involvement in varietal development can lead to more efficient outcomes as evidenced by the maize breeding efforts of domestic companies in countries like Kenya and Zambia (see De Groote et al., 2015). However, state-managed breeding programs which emphasise participatory breeding strategies could also produce the varieties that farmers' desire. Collective action by farmers can make such programs more accountable (cf. Sperling et al., 2001).

4.6.2 Managing seed multiplication

The production and management of source seed is another activity which has traditionally been the domain of the public sector in Ghana's seed system. As the originators of maize varieties, the NARIs are also tasked with breeder seed production. Consistent with the findings of Tripp and Rohrbach (2001), this case study confirms that there are no specific budget allocations for breeder seed production. Breeding activities typically take priority when apportioning limited resources because varietal releases are a primary measure of the NARIs' performance. This state failure of an incentive problem has led to the maintenance of only a restricted number of breeding lines with focus on Obatanpa. A solution to this problem could be that seed companies make in advance binding contracts with public research institutions for the amount of breeder seed that they want to purchase.

GLDB mirrors the resource constraints of the NARIs in the production of foundation seed. The state failures of capacity and inefficiency problems have resulted in a focus on bulking a select number of OPVs that are comparatively cheaper to produce than hybrids and have significantly higher market demand. The influence level of 5 that was assigned by respondents to GLDB reflects the parastatal's monopoly of this stage of seed multiplication. In many African countries, breeder seed will mostly come from the public sector, but there is no reason why private entities should not produce and market foundation seed, provided that the demand for commercial seed is sufficient to allow for full cost recovery of foundation seed production (Tripp, 2000). In Zambia, for example, foundation seed is produced entirely

by the private sector (World Bank, 2014). Despite the potential quality and efficiency gains of privatised foundation seed production as evidenced by Zambia's seed system, this study finds that in Ghana, there is a reluctance of the public sector to relinquish control over this stage of seed production. This resistance appears to be stemming mainly from the increased regulatory responsibilities that would follow from foundation seed production by the private sector. There is also a need to better understand the political economy of this resistance, as there may be vested interests as well.

4.6.3 Quality assurance

Another key issue in the commercial seed system has been quality assurance. The mandatory certification of all classes of seed under the new law places GSID in a very influential position, as reflected in respondents' perceptions (influence level=7). However, the findings reveal that this extended regulatory oversight does not appear to have substantially improved maize seed quality in Ghana. GSID is yet another government agency that is overburdened and under-resourced. As a consequence, GSID's limited regulatory resources are mainly dedicated to commercial seed inspection and certification. Less attention is paid to source seed quality assurance and retail inspections. Previous studies have established the chronic market failures of poor quality commercial seed, seed adulteration and the regulatory challenges thereof (Langyintuo et al., 2010; Tahirou et al., 2009; Tripp & Louwaars, 1997). This paper further highlights the state failure of major seed quality issues with source seed production which invariably contributes to poor quality commercial seed. Charging official fees based on the costs of mandatory government-run seed certification can help to overcome the regulatory challenge of limited resources (World Bank, 2016). Another viable approach is finding an effective means by which public sector agencies share regulatory responsibilities with private seed companies. This could take the form of seed companies that are accredited to assume some certification responsibilities, as practiced in Zimbabwe where several seed companies are licensed to certify seed. Other options include a Quality Declared Seed System[19] as practiced in Tanzania and Zambia, and authorising the sale of "truthfully labeled seed"[20] (van Gastel et al., 2002; Tripp, 2000).

[19] Under the system design, seed producers are tasked with meeting set quality standards. The system is particularly suited to countries with limited regulatory resources as it relies on randomised field and sales point inspections rather than general mandatory inspections (FAO, 2006; FAO, 1993).

[20] The seed producer must ensure that the seed is tested and the results indicated on the label. Seed producers are legally liable for stated seed quality.

4.6.4 Varietal promotion efforts

The overreliance on a public extension system that has limited resources for varietal promotion has resulted in the problem that most farmers in Ghana are oblivious to varieties on offer in the seed system. Ragasa et al. (2013) reported that lack of awareness was the main reason cited by farmers for not purchasing certified maize seed varieties. In line with these findings, respondents in this study identified extension services as having the highest influence level of 8. The study's findings suggest that donor-sponsored projects have been the most effective channels of maize varietal promotion in Ghana in the past. Sasakawa Global 2000 was the most extensive technology transfer program in Ghana in over a decade. As a consequence, Obatanpa, which was promoted by this program, has enjoyed an unrivalled level of promotion among farmers compared to other varieties. However, the seed system cannot remain reliant on external funding for promotional activities, especially given the central role extension agents play in the diffusion of agricultural innovations (Rogers, 2003). State failure in seed promotion can be overcome by increased financial and logistical support to public extension services. Public research institutions could also be more proactive in promoting their varieties by allocating resources to technology transfer activities. Alternatively, exclusive licensing of public sector varieties to seed companies provides an incentive for private sector investment in seed promotion. Such licensing would solve the market failure of a free-rider problem in seed promotion.

Overall, the perceived levels of influence assigned by respondents to the various actors underline the fact that even in a liberalised seed system, public sector institutions continue to play a critical role in Ghana. Their deficiencies, which have persisted for many years, have not been overcome by the involvement of private actors. The aim that increased private sector participation would lead to increased maize varietal diversity in Ghana has, therefore, not been achieved thus far. To address the observed governance challenges, public institutions would require a more effective participation of farmers in their breeding programs, better cost recovery strategies and increased investment by the government. A pro-privatisation bias and a pro-hybrid seed bias may not be the only effective means of developing an effective seed supply system. The case of Obatanpa demonstrates that if an improved variety meets farmers' needs and there is a concerted effort to promote it, diffusion among farmers can be very successful. Moreover, the development of effective community-based organisations that enable communities to manage their own seed production could also play an important role in

increasing the availability of improved seed varieties to farmers. Indeed, this is an aspect of the African seed industry that deserves further attention.

Finally, the study provides some insights on research methods. Process Net-Map proved to be an effective tool for an empirical investigation of the governance challenges in seed supply that had been identified on a theoretical basis in the first part of this paper. The tool was especially useful in elucidating the complexities of the multi-stakeholder governance in maize seed supply. Process Net-Map relies on visualisation, which proved very useful in revealing implicit knowledge and identifying sensitive governance issues, which are not easily discovered in other types of interviews. However, the tool also has its limitations. In particular, it is better suited for analysing existing situations than for identifying untapped potentials, such as the potential role that community-based seed organisations could play in improving seed supply in Ghana.

4.7 Conclusions

In this paper, the governance challenges involved at the different stages of formal seed supply systems were analysed from a theoretical and an empirical perspective. Ghana's commercial maize seed sector was used as a case study. The analysis, which was based on Process Net-Map and expert interviews, revealed that a combination of market and state failures account for the lack of varietal diversity in commercial seed provision. The theoretical concepts and the empirical findings provide instructive insights for seed system development, which are likely to be relevant for other African countries.

The findings indicate that addressing state failure in varietal development greatly hinges on increased smallholder involvement in setting breeding priorities. Public sector source seed production and government-run mandatory certification systems, which are prevalent in Africa, are jeopardised by the lack of binding contracts and official fee schedules to enable cost recovery. This shortcoming perpetuates the state failure that occurs in the form of incentive problems as well as capacity constraints and inefficiency. Source seed production by the private sector continues to be limited and certification modalities appear to undermine the ongoing liberalisation efforts. State and market failures in seed promotion also persist due to a lack of adequate state investment in public extension services and due to the absence of exclusive licensing rights of public varieties to the private sector. These findings indicate that there is a need to pay more attention to the political economy of such seed sector reforms.

Overall, the findings indicate that more emphasis should be placed on exploiting the complementary roles that the public sector, the private sector and the yet underdeveloped third sector can play in ensuring that farmers in Africa get better access to improved seeds.

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5. DISCUSSION AND CONCLUSIONS

This thesis set out to explore the policy and institutional environment needed to foster the development of biomass-based value webs in Ghana in the emerging bioeconomy. As part of the BiomassWeb project that focuses on the entire biomass production system of locally adapted crops in Sub-Saharan Africa, the study investigated the governance and institutional challenges related to the development of the emerging value webs of cassava and maize in Ghana. The thesis therefore addressed three main research objectives. First, it explored the policies and institutional arrangements needed to foster the development of a competitive and sustainable cassava value web. Second, it examined which contract conditions are sustainable for both farmers and agribusiness firms in cassava contract farming. Third, it empirically analysed the governance challenges of the commercial maize seed supply system. Each of these three main objectives constituted a separate chapter of the thesis. Ghana was chosen for the study on account of its high potential for biomass production and its relatively large investments in agribusiness (Duku et al., 2011; OECD, 2008).

The academic relevance of this study lies in its contribution towards addressing the governance and institutional challenges of biomass value webs in the emerging bioeconomy in Africa. Guided by the conceptual framework developed in Chapter 1 (Figure 1.1), this discussion chapter summarises the empirical findings and examines what this means for the institutions, processes and actors that are relevant for the development of biomass value webs. Accordingly, the chapter presents a summary of the main findings, discusses the academic and practical implications for governance of biomass value webs in the emerging bioeconomy, outlines the methodological limitations of the case studies and makes recommendations for future research and policy reforms.

5.1 Summary of the main results

Chapter 2 addresses the requisite policy and institutional environment needed to foster the development of a competitive and sustainable bioeconomy within an African context. The novel concept of ‘biomass-based value webs’ is combined with Porter’s Diamond model to analyse the extent to which Ghana is positioned to develop a competitive cassava value web. Empirical data collection involved mapping the physical biomass flows, applying the ‘Net-Map’ tool to identify all the actors in the emerging value web and their linkages, as well as in-depth interviews with the identified actors.

The empirical results show that there are significant coordination problems between actors in the emerging cassava value web due to weak institutional linkages. Farmers have low incentive to increase production due to marketing challenges. This results in processors operating well below installed capacity due to insufficient supply of cassava from farmers. Industrial end-users in turn remain reluctant to use cassava based products due to inconsistent supply from processors. Public research institutions have been the driving force of innovation in the value web. The Food Research Institute has been instrumental in the development and application of cassava products. The primary crop breeding institutions and the public universities have also been effective in developing improved cassava cultivars. However, uptake among farmers has remained relatively low. The limited number of agricultural extension agents to promote these technologies has been a contributing factor to the low adoption rate. Access to formal sources of financing for farmers and processors also remains a critical challenge. Banks and microfinance institutions offer high interest rates for loans and credit facilities that make them inaccessible to most enterprises. These institutional challenges have inhibited the role supporting institutions are supposed to play in facilitating much needed investments in 'factor upgrading' in cassava production and processing in Ghana. Unsuccessful government initiatives such as the Presidential Special Initiative on cassava starch and the absence of legislation such as a composite flour policy or a biofuel blend policy have also been major contributing factors to the unrealised industrial potential of cassava in Ghana thus far.

Chapter 3 addresses the increased importance of contract farming in Africa due to growing competition for biomass-based raw materials, emphasising the need for sustainable contractual arrangements. A comparative case study approach of a state-run and a private sector operated cassava outgrower scheme in Ghana is used to investigate which contract farming arrangements are equitable and sustainable for both farmers and agribusiness firms. A complementary combination of in-depth interviews, focus group discussions and primary survey data is employed to assess the sustainability of these institutional arrangements.

The findings reveal that although cassava is a staple crop in Ghana that has traditionally been cultivated with minimal inputs, ad hoc or opportunistic investments that merely provide a marketing outlet for smallholders are not sufficient to ensure the success of outgrower schemes. The public firm's outgrower scheme constitutes a low investment informal contract farming model. The firm does not invest resources in outgrowers' cassava production and as such is not saddled with monitoring costs. There is also no prior commitment to buy from any

specific suppliers. The consequence however is limited control over the quantity and quality of produce supplied which increases the risk of the firm not meeting the specific needs of its off-taker. Thus the scheme, which initially aimed to improve the socioeconomic conditions of smallholders in the area, is ultimately not beneficial to either the firm or outgrowers. The firm receives an insufficient supply of cassava roots from outgrowers. Outgrowers' productivity and revenue from cassava production also do not appear to have increased through the arrangement. The private firm's outgrower scheme represents a more capital intensive and formalised contract farming arrangement. Due to the provision of inputs, technical assistance and crop transportation, the firm retains more control over the quality and volumes of outgrowers' output. This makes for more efficient sourcing of cassava roots. Even though the firm offers a low contract price with a contestable price determination mechanism, they appear to be able to effectively enforce the contract and control side-selling. The firm is able to earn a profit from the arrangement. Outgrowers also have high farm productivity and earn comparatively higher returns from cassava production than other farmers. The evidence highlights the tendency of public sector schemes to be bureaucratic and lack financial autonomy. Private sector ventures on the other hand tend to adopt authoritarian management styles and can also be prone to opportunistic behaviour in contract arrangements with smallholders. Therefore, public-private partnerships in outgrower schemes can present a viable remedy that harnesses the strengths of both sectors and overcomes their institutional weaknesses.

Chapter 4 addresses the governance challenges of commercial seed supply in Africa. The study applies theoretical concepts of New Institutional Economics to identify potential governance challenges involved in the different stages of the seed supply system. The commercial maize seed sector in Ghana is used for an empirical case study. For data collection, the participatory mapping technique known as Process Net-Map is applied, together with expert interviews involving a diverse set of stakeholders.

The results from the analysis revealed that a combination of market and state failures account for the lack of varietal diversity in commercial maize seed provision in Ghana. The well-known constraints caused by the dominance of public sector institutions in seed supply, have not been overcome by reform efforts that aimed to promote the private sector. The state failure of deficient farmer participation in the national agricultural research institutes' breeding strategy has resulted in instances where varieties failed to meet farmers' preferences. Some preferences were correctly identified; most notably increased yield and

storability, but the new varieties did not outperform the dominant variety, Obatanpa, in this respect. This presumptive breeding approach has made maize varietal development a “hit or miss” exercise. There is also the state failure of an incentive problem in breeder seed production. Breeding activities typically take priority when apportioning limited resources because varietal releases are a primary measure of the national agricultural research institutes’ performance. This has led to the maintenance of only a restricted number of breeding lines. The Grains and Legumes Development Board mirrors the resource constraints of the national agricultural research institutes in the production of foundation seed. The state failures of capacity and inefficiency problems have resulted in a focus on bulking a select number of open pollinated varieties that are comparatively cheaper to produce than hybrids and have significantly higher market demand. The Ghana Seed Inspection Division is yet another government agency that is overburdened and under-resourced. As a consequence, the limited regulatory resources are mainly dedicated to commercial seed inspection and certification. Less attention is paid to source seed quality assurance and retail inspections. This has led to the state failure of major seed quality issues with source seed production as well as market failures of poor quality commercial seed and seed adulteration. The overreliance on a public extension system that has limited resources for varietal promotion has resulted in the state failure of the poor promotion of improved seed varieties among most farmers in Ghana. There is also the market failure of a free-rider problem in seed promotion. Local seed companies and seed producers are reluctant to invest in the promotion of varieties developed by the national agricultural research institutes, given the non-exclusivity rights of these varieties.

5.2 Contribution to the literature

The thesis makes several contributions to the academic literature by engaging with the wider debates on biomass utilisation and new biomass demands, contact farming as a procurement system as well as commercial seed sector development in Africa.

Chapter 2 contributes to the growing literature on diversified biomass utilisation in Africa. The chapter empirically investigated the role of government policy and institutional coordination between public, private and third sector actors in facilitating the effective utilisation of crop biomass in the emerging bioeconomy. The results emphasise how staple crops like cassava can have cascading utilisations beyond food that do not necessarily impact negatively on food security. This chapter contributes to the debate on the impact of the non-

food uses of crop biomass on food security by applying the novel multidimensional concept of biomass-based value webs. The results show that bioeconomy strategies and ensuring food security need not be mutually exclusive. Therefore, the findings support the claim that such strategies have the potential to actually improve food security and economic development, particularly by utilising crop residues and by-products for economic gains (see Cardoen et al., 2015; Johnson & Altman, 2014; Liu et al., 2008). The literature shows that very few policies in Africa have supported this approach of optimising the utilisation of bioeconomy crops (see BÖR, 2015; Jumbe et al., 2009). The study however underscores the need for bioeconomy strategies in Africa to be driven by the interests of economic actors such as farmers, agribusinesses and industrial end-users. This approach is exemplified by the excise tax on local content beers that has successfully promoted the production of cassava based beer in the brewery industry not only in Ghana but also in countries like Mozambique (see Parmigiani & Rivera-Santos, 2015). Past policy attempts such as the Presidential Special Initiatives on cassava in Ghana and Nigeria were greatly influenced by the African Union (AU). These policies were ultimately unsustainable because they were not demand-driven and failed to actively involve private and third sector actors from the onset (see Sanni, 2011). Thus, the study's findings make the contribution of demonstrating that economic incentives rather than external political initiatives should be the impetus behind bioeconomy strategies in Africa to ensure sustainability. Further research is therefore required to delve into the political incentives that drive government policies aimed at developing the emerging bioeconomy in Africa.

Chapter 3 contributes to the literature on the importance and sustainability of contract farming in Africa. The chapter empirically investigated the role of contract design in facilitating sustainable contract farming arrangements between farmers and agribusinesses. This study complements the contract farming literature that has mainly focused on contractual relationships for high-value export products from Africa (see e.g. Balineau, 2013; Jones & Gibbon, 2011; Bolwig et al., 2009; Kherallah et al., 2002). It uniquely focuses on rapidly developing domestic value chains in the emerging bioeconomy. The findings add empirical weight to the argument that state-led contract farming schemes are generally not an effective government mechanism for overcoming market failures that inhibit the commercialisation of agricultural production by smallholders (see Ochieng, 2010; Dannson et al., 2004; Grosh, 1994). The results reveal that common contract provisions characteristic of the aim of promoting smallholder inclusion such as financial support for inputs and technical

assistance are absent in the state scheme. The evidence supports the claim that the continued existence of inefficient state-led schemes often signals the lack of an enabling environment for the private sector to effectively take over these functions (see Oya, 2012). The government has neglected public investments in extension, infrastructure and regulatory reforms that would reduce the costs and risks inherent in agricultural contracting. Instead, the state participates directly in the market. On the other hand the study also finds that the growing spot market for cassava in Ghana is actually contributing to more sustainable contract farming arrangements. This goes contrary to the argument that agricultural commodities with well-developed local markets are not suitable for contract farming because they are associated with a high risk of pervasive side-selling (see World Bank, 2014; Minot, 2011; Minot, 2007). The results show that the competitive buying environment for cassava is leading agribusinesses to offer better contract conditions to farmers to reduce the incidence of side-selling. At the same time, contract terms that clearly detail the penalties for non-compliance are being incorporated into these arrangements. This combination of favourable contract conditions and explicit penalties for contract breaches is promoting contractual arrangements within an increasingly competitive market context. This also raises the question of the extent to which innovations in contract design and operational modalities by the private sector can help overcome the legal, regulatory and institutional constraints of contract farming.

Chapter 4 contributes to the literature on seed system development in Africa. It empirically investigated the governance challenges in seed supply following the liberalisation of the commercial seed sector. The study uniquely applies a comprehensive theoretical overview of the potential governance challenges in seed supply to the empirical data. The evidence suggests that despite liberalisation efforts driven by donor initiatives, the public sector remains reluctant to fully relinquish control over seed production to the private sector. This is in line with past observations that the extent of actual seed sector reforms in Africa has generally been superficial (see e.g. Alemu et al., 2008; Muhhuku, 2002; Tripp & Rohrbach, 2001). However, the findings also reveal that a public sector dominated seed supply system based on open pollinated varieties can be effective under the right conditions. This goes contrary to the overwhelmingly pro-privatisation and pro-hybrid seed literature on commercial seed sector development (see e.g. Abate et al., 2015; Mathenge et al., 2014; Smale & Mason, 2014; Ariga & Jayne, 2009). With respect to varietal development, the results suggest that the lack of a plant variety protection law has been an impediment to

private sector investment. This supports the literature claiming that enforceable intellectual property rights are necessary to stimulate private investment in crop improvement (see Kolady et al., 2012; Naseem et al., 2010; Kanwar & Evenson, 2003). In terms of regulation, the findings show that the government regulator does not have the capacity to ensure that certification regulations are consistently adhered to. This supports the claim that mandatory seed testing and certification has not been an effective means of ensuring high seed quality for farmers across Africa (see Yami & Asten, 2017; Guei et al., 2011; Tripp, 2006). Similar to other studies, the results of the study also reveal that such certification regulations tend to undermine liberalisation efforts by effectively restricting the distribution of new varieties and alternative methods of seed provision (see Wattnem, 2016; Rohrbach et al., 2003). Overall, the critical insights from this study emphasise the influence of public sector activities in the commercial seed sector even after reforms. This raises unanswered questions of the vested interests and policy beliefs (see Mockshell & Birner, 2015) behind the resistance by public officials to liberalisation efforts in commercial seed supply.

5.3 Implications for governance of the bioeconomy

In line with the conceptual framework in Chapter 1 (Figure 1.1), the empirical results of the thesis sheds light on the roles public, private and third sector actors are playing as the agricultural sector transitions from a food-supplying to a biomass-supplying and processing sector in the emerging bioeconomy. As shown in the framework, the development and functioning of biomass value webs (the lower domain) depends on the roles and various interactions between different international, public, private and civil society actors in the governance system (the upper domain). These interactions include policy processes, regulation, funding, knowledge transfer, exchange of goods and services as well as lobbying.

5.3.1 The role of the public sector

In developing the bioeconomy, it is important for the government to be committed to supporting both food production and new demands for the non-food uses of crop biomass as shown in the conceptual framework. The results from Chapters 2 and 4 of the thesis show that the government has retained significant control over emerging biomass value webs, focusing mainly on food production. Chapter 4 reveals that maize varietal development has remained a purely public sector activity with the national agricultural research institutes concentrating on developing a number of quality protein maize varieties for direct human consumption. There is however also growing demand for maize in other industries such as

the poultry and brewery industries that is currently not being met. Similarly, Chapter 2 reveals that government support for the development of the cassava sub-sector in Ghana has been directed at improving farm productivity to ensure food security. There has been less emphasis on commercialisation and industrial development, even though this is also essential for developing biomass value webs. Accordingly, the interactions between the government and other actors such as knowledge institutions and farmers, as depicted in the upper domain of the conceptual framework, have centred on efficiency gains at the input supply and biomass production stages of the value web with food as the main output.

An exception to the government's focus on food production was found to be the Presidential Special Initiative (PSI) on cassava starch introduced in 2001. This initiative aimed at promoting new uses of cassava at the biomass trading and processing stage of the value web. However, as shown in the upper domain of the conceptual framework, such policy initiatives have largely been influenced by supranational organisations such as the African Union (AU) and the Economic Community of West African States (ECOWAS). It must be noted that the motivation behind such regional policy directions might be disguised donor initiatives as the system remains heavily dependent on donor funding. Even though the support of these external actors is certainly necessary for developing the bioeconomy, it will not be sufficient if the impetus only comes from them. The findings from Chapters 2 and 3 shows that the PSI on cassava starch, which involved the establishment of a government-owned starch processing factory, represents a top-down approach that has proved to be unsustainable due to coordination failures and a lack of complementary investments by private sector actors. Conversely, these case studies reveal that initiatives such as the excise tax on local content beers, influenced by the brewery industry, has successfully promoted the production of cassava based beer in Ghana. Therefore, integrated approaches to bioeconomy strategies based on the economic incentives of private and third sector actors prove to be more sustainable than strategies based on external political initiatives. Such 'home-grown strategies' foster increased institutional involvement in biomass demand and supply arrangements along the value web.

5.3.2 The role of the private sector

Vibrant private sector enterprises are a critical component to developing the bioeconomy. The results from Chapters 3 and 4 reveal that the roles of private sector actors along biomass value webs, as depicted in the upper domain of the conceptual framework, have thus far been

hampered by a less than conducive enabling environment. Chapter 3 shows that the state participates directly in cassava trading and processing instead of investing in extension, infrastructure and regulatory reforms to propel private sector dynamism. This observation not only applies to cassava but also to maize. Chapter 4 reveals that despite reform efforts aimed at privatising source seed production, the public sector retains significant control over maize breeder seed and foundation seed production. Thus, the shift from direct government involvement in economic activities along the value web to creating an enabling environment for the private sector to takeover has been slow.

A knock on effect of the current business environment has been a lack of private sector investments. The results from Chapters 2 and 4 of the thesis show that there has been limited private sector participation at the input supply, the biomass trading and processing as well as the consumption stages of the value web as depicted in the lower domain of the framework. Chapter 2 reveals that medium and large scale cassava processors tend to struggle to compete with the price of imported goods due to the high costs of finance. Consequently, potential end-users of cassava products, such as the pharmaceutical and textile industries, are unwilling to switch from cheaper imported alternatives and commit resources to develop the needed domestic supply chains. Likewise, Chapter 4 indicates that private sector investment in maize varietal development has been discouraged by the lack of a plant variety protection law. Chapter 4 also demonstrates the reluctance of private seed companies to invest in the promotion of public maize varieties given the non-exclusivity rights of these varieties. The lack of investments by the private sector has limited the development of new markets and the industrial-scale utilisation of crop biomass for the non-food uses displayed in the lower domain of the framework.

5.3.3 The role of the third sector

The third sector can potentially play an important role in the development of the bioeconomy, especially if there are deficiencies in the public and private sectors. This would require strong farmer-based organisations. However, the results from Chapters 3 and 4 of the thesis highlight the fact that farmers of staple crops are still not well organised. Thus, they are unable to effectively exert pressure on the public and private sectors to produce the needed productivity-enhancing technological and institutional innovations at the input supply and biomass production stages of the value web as shown in the lower domain of the framework. This is true both for cassava and maize. Chapter 3 shows that cassava smallholders have yet

to form strong farmer-based organisations that can help ensure that contracts with agribusiness firms are equitable. Similarly, Chapter 4 reveals the lack of collective action by farmers to ensure that the national agricultural research institutes are developing maize varieties that farmers' desire by using participatory breeding strategies.

NGOs can also play an important role in supporting both government and private sector activities for the development of the bioeconomy. Their interventions can help overcome market and state failures at the various stages of the value web. Towards that end, they can also help build the capacity of farmer-based organisations. As shown in the upper domain of the conceptual framework, these organisations are funded by donors. Their incentives may therefore be suboptimal because they are driven by foreign ideas. This can lead to unsustainable outcomes. Chapter 2 shows that the interventions of Sasakawa Global 2000 in maize breeding and seed production have not been very effective in the long run, even though they had a positive impact in the short run. NGOs may also have limited coverage in supporting activities along biomass value webs. The findings of Chapters 2 and 3 reveal the absence of any noteworthy interventions by NGOs in support of the development of the cassava value web.

Overall, the thesis results demonstrate that growth of the private and third sectors are critical to developing the bioeconomy. Gradual state withdrawal must coincide with the government creating an enabling environment for the private sector to thrive. Collective action among farmers must also be encouraged and strengthened through the promotion of farmer-based approaches. Therefore, the driving force behind strategies for more efficient biomass production and utilisation in the emerging bioeconomy must come from private sector actors and community-based organisations in order to be sustainable. Donors can only play a supportive role for these coordinated public, private and third sector initiatives.

5.4 Limitations of methods

The thesis employed a range of analytical techniques and data collection methods in the empirical case studies. Each of these approaches has both strengths and limitations. The limitations of the methods are acknowledged with the aim of benefiting future empirical research.

In Chapter 2, the Net-Map tool was applied to identify how all the actors in the emerging cassava value web are linked and elicit the challenges and opportunities of developing a

cassava based bioeconomy. Ideally, this participatory mapping exercise should be carried out with a representative group of knowledgeable stakeholders to facilitate comprehensive mapping (see Schiffer & Hauck, 2010). It however proved challenging to assemble stakeholders for the group exercise. To overcome this limitation, multiple Net-Map exercises were conducted on an individual basis with some of the stakeholders. This approach was further complemented with information from subsequent in-depth interviews with other stakeholders.

In Chapter 3, the two case studies assessing the sustainability of cassava outgrower schemes were based on a mixed method approach. In-depth interviews and focus group discussions were combined with household surveys conducted at both study sites. Although there is not an established minimum sample size for rigorous probit analysis, larger sample sizes could have produced more robust results. The sample sizes of the surveys were the result of the availability of cassava farmers in relation to the time and resource constraints of the field research. It must also be noted that in the case of the survey for the private outgrower scheme, all 65 outgrowers were included in the study. Furthermore, though a mixed methods approach was employed, the study emphasised in-depth qualitative analysis of contract design rather than an impact assessment of the schemes. An econometric tool such as propensity score matching would have been better suited if the aim of the study was to carry out a rigorous impact evaluation.

In Chapter 4, the Process Net-Map tool was applied to investigate the governance challenges in seed supply. Similar to the Net-Map tool used in Chapter 2, the ideal situation of assembling stakeholders for the exercise proved challenging. This necessitated the need for multiple Process Net-Map exercises with individual stakeholders which were complemented with information from subsequent in-depth interviews. Furthermore, within the context of the study, the Process Net-Map tool was especially useful in elucidating the existing complexities of the multi-stakeholder governance in maize seed supply. However, it proved less suitable in identifying untapped potentials, such as the potential role that community-based seed organisations could play in improving seed supply in Ghana.

5.5 Policy recommendations

In line with the main objective of this thesis, current governance and institutional challenges of emerging biomass-based value webs were evaluated. Accordingly, the results presented in

the three empirical chapters of the thesis provide a range of insights on the policy reforms needed to address these challenges. These broad-based policy reforms are proposed below.

a) Strengthening the capacity and incentives of agricultural knowledge institutions

The results from Chapter 2 and Chapter 4 highlight the need for increased government investment in agricultural knowledge institutions such as public research institutions and extension services. Public research institutions remain heavily reliant on donor funds to carry out their activities. This affects the autonomy of these institutions in setting their research priorities as donors have the political capital to greatly influence the research agenda (see Birner & Wittmer, 2003). This can contribute to research outcomes that have very little uptake or adoption as evidenced in Chapter 4. The government must therefore increase budgetary allocations to public research institutions to foster the context-specific demand-driven research required for innovation and economic growth. Similarly, the public extension system requires increased financial and logistical support as well as manpower in terms of more agricultural extension agents.

The results from Chapter 4 also reveal that the current incentive system for public research institutions mainly rewards the development of new technology such as improved seed varieties. There is therefore little incentive for these institutions to invest in technology transfer activities to validate the investments in research (cf. Tripp & Rohrbach, 2001). This calls for the government to design and implement a new incentive system that places more emphasis on technology transfer. This will encourage research institutions to be more proactive in promoting their research output, particularly in collaboration with other institutions in the public, private and third sectors.

b) Promoting the use of local content across industries

The results from Chapter 2 show that policies that encourage the use of local content can incentivise industrial end-users to switch from imports to local products. This has been exemplified by the increasing use of cassava as a raw material in the brewery industry in Ghana following a tax incentive policy. The government should similarly promote local content policies across other industries such as the confectionary, pharmaceutical and energy industries in order to incentivise investment and stimulate increased local demand (see Sanni, 2011). This could lead to more efficient use of the entire crop biomass. Such policies would also help ensure better coordination between farmers, processors and industrial end-users.

Potential processors would be assured of a market for their products which would in turn incentivise farmers to increase their yield and production volumes.

c) Fostering public-private partnerships

The findings from the study suggest that public-private partnerships are an effective mechanism for facilitating the development of agro-industries. The results from Chapter 3 show that the government can be more effective by limiting its role as an economic actor and focusing on creating an enabling environment for public-private partnerships. This includes infrastructural development, a strong legal system, common goals among participating entities and clarity concerning institutional roles. Public-private partnerships serve to promote the participation and development of the private sector (see e.g. Thangata et al., 2011). This strategy is also particularly useful in areas such as input supply where there might be partial or complete market failures.

d) Strengthening the regulation of agricultural input markets

The findings of the study highlight the need for more state support in regulating the quality of agricultural inputs such as commercial seeds, fertilisers and pesticides (whether locally produced or imported) that are available on the market. The results from Chapter 4 reveal that regulation of seed quality is mainly focused on commercial seed production and certification. Less attention is paid to retail inspections, where adulteration is prevalent, due to resource constraints. The government must therefore invest more resources in equipping state agencies to monitor the sales points of agricultural inputs. This would help curb chronic problems of poor quality and adulterated products. However, regulation should not just be a function of the state. Alternative regulation modalities that actively involve private sector participation such as trademarks and truth-in-labelling should also be explored with reference to best practices from other countries.

e) Supporting the development of Farmer-Based Organisations

The results from Chapter 3 and Chapter 4 demonstrate the absence of strong organised groups of farmers in smallholder agriculture in Ghana. This is evidenced by the lack of collective action among farmers to demand better contract conditions from agribusinesses, and better varieties from the public research system. There is therefore the need for the government to support the formation and development of farmer-based organisations (FBOs) as a means of providing services to smallholders. This would help ensure cost-effective, inclusive and

community-driven development. Functional FBOs would also provide smallholders with increased bargaining power in their transactions with other agricultural actors (see e.g. Markelova et al., 2009). As part of efforts to sustainably develop such groups, the government, in collaboration with NGOs, should facilitate technical training and capacity building programs for FBOs.

In conclusion, with African countries' high potential to produce crop biomass, the transition to an economy centred on the use of bio-based resources holds great promise for sustainable economic development. This thesis underscored the critical role of policies, governance structures and institutional arrangements in fostering this process. It has shown that there are a number of governance and institutional challenges that need to be addressed en route to developing a vibrant bioeconomy in Africa. Thus, the transition remains a long road that has only been partially travelled.

5.6 References

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APPENDICES

Appendix 2.1: Centrality measures of Fund flows

	(Out)Degree Centrality	(In)Degree Centrality	(Out)Closeness Centrality	(In)Closeness Centrality	Betweenness Centrality
World Bank	1	0	0.31	0.25	0
IITA	1	0	0.26	0.25	0
FAO	1	0	0.31	0.25	0
BMGF	1	0	0.26	0.25	0
IFAD	1	0	0.31	0.25	0
Institute of Industrial Research	0	1	0.25	0.27	0
Food Research Institute	0	2	0.25	0.28	0
Aggregators	0	0	-	-	0
GRATIS	0	0	-	-	0
Input Suppliers	0	0	-	-	0
Soil Research Institute	0	1	0.25	0.27	0
CRI/ SARI	0	2	0.25	0.28	0
Ministry of Food & Agriculture	9	3	0.33	0.27	27
Farmers	0	2	0.25	0.30	0
Fabricators	0	0	-	-	0
Banks & microfinance institutions	2	2	0.27	0.28	3
Micro-processors	0	2	0.25	0.29	0
Universities	0	1	0.25	0.27	0
Stakeholders' platform	0	0	-	-	0
Outgrower & Value Chain Fund	1	0	0.27	0.25	0
EximBank	1	0	0.26	0.25	0
Medium & Large scale processors	1	3	0.26	0.30	3
Bakeries	0	0	-	-	0
Piggeries	0	0	-	-	0
Supermarkets	0	0	-	-	0
Breweries/ Distilleries	0	0	-	-	0
Plywood manufacturers	0	0	-	-	0
Packaging companies	0	0	-	-	0
Traders	0	0	-	-	0

Appendix 2.2: Centrality measures of Knowledge flows

	(Out)Degree Centrality	(In)Degree Centrality	(Out)Closeness Centrality	(In)Closeness Centrality	Betweenness Centrality
World Bank	0	0	-	-	0
IITA	2	2	0.35	0.34	0
FAO	0	0	-	-	0
BMGF	0	0	-	-	0
IFAD	0	0	-	-	0
Institute of Industrial Research	6	5	0.38	0.36	7.57
Food Research Institute	12	12	0.41	0.40	119.13
Aggregators	0	0	-	-	0
GRATIS	2	2	0.33	0.33	0
Input Suppliers	0	0	-	-	0
Soil Research Institute	3	3	0.34	0.33	0
CRI/ SARI	8	7	0.39	0.37	21.50
Ministry of Food & Agriculture	9	9	0.39	0.38	27.97
Farmers	6	6	0.38	0.37	12.13
Fabricators	0	2	0.25	0.33	0
Banks & microfinance institutions	0	0	-	-	0
Micro-processors	3	3	0.36	0.35	0
Universities	8	8	0.39	0.38	19.83
Stakeholders' platform	2	2	0.32	0.32	0
Outgrower & Value Chain Fund	0	0	-	-	0
EximBank	0	0	-	-	0
Medium & Large scale processors	7	7	0.38	0.37	15.87
Bakeries	1	1	0.34	0.33	0
Piggeries	0	0	-	-	0
Supermarkets	0	0	-	-	0
Breweries/ Distilleries	1	1	0.34	0.33	0
Plywood manufacturers	1	1	0.34	0.33	0
Packaging companies	1	1	0.34	0.33	0
Traders	0	0	-	-	0

Appendix 2.3: Centrality measures of Business linkages

	(Out)Degree Centrality	(In)Degree Centrality	(Out)Closeness Centrality	(In)Closeness Centrality	Betweenness Centrality
World Bank	0	0	-	-	0
IITA	0	0	-	-	0
FAO	0	0	-	-	0
BMGF	0	0	-	-	0
IFAD	0	0	-	-	0
Institute of Industrial Research	0	0	-	-	0
Food Research Institute	0	0	-	-	0
Aggregators	2	2	0.33	0.33	0
GRATIS	2	2	0.33	0.33	1.25
Input Suppliers	2	2	0.33	0.33	0
Soil Research Institute	0	0	-	-	0
CRI/ SARI	0	0	-	-	0
Ministry of Food & Agriculture	0	0	-	-	0
Farmers	5	5	0.35	0.35	11.25
Fabricators	3	3	0.34	0.34	2.75
Banks & microfinance institutions	0	0	-	-	0
Micro-processors	5	5	0.33	0.33	6.5
Universities	0	0	-	-	0
Stakeholders' platform	0	0	-	-	0
Outgrower & Value Chain Fund	0	0	-	-	0
EximBank	0	0	-	-	0
Medium & Large scale processors	11	11	0.37	0.37	57
Bakeries	2	2	0.33	0.33	0
Piggeries	2	2	0.33	0.33	1.25
Supermarkets	1	1	0.32	0.32	0
Breweries/ Distilleries	1	1	0.32	0.32	0
Plywood manufacturers	1	1	0.32	0.32	0
Packaging companies	1	1	0.32	0.32	0
Traders	2	2	0.32	0.32	0

Appendix 2.4: Net-Map Interview Guide for the Cassava Value Web

Application: The aim of this discussion is to develop a shared understanding of the current institutional structure of the various interconnected cassava value chains in Ghana (the cassava value web).

A. Mapping the institutions in the Cassava Value Web

1. Who are the actors involved in the cassava sub-sector in Ghana, accounting for all existing commodity chains?

2. What are the actors' respective roles in the cassava value web?

3. How are the actors linked? Specifically in terms of;

    a. **Fund Flows:** Money or financing meted out for particular activities
    b. **Knowledge Flows:** Linkages involving the transfer of information, technical know-how, training and capacity building
    c. **Business Linkages:** Transactions involving the exchange of goods and services (service delivery).

B. Identification of Potential Bottlenecks/Problems

1. Please identify where there are bottlenecks/problems/challenges in the current functioning of the cassava value web.

2. Please give reasons for the identified bottlenecks/challenges/problems.

3. Please identify where there are opportunities specifically in terms of promoting innovative use of cassava biomass in the value web.

4. Are there any additional actors who had not been considered in the Net-Map that could potentially play an important role in the development and production of new cassava based products?

C. Suggestions to Improve the process

1. What strategies can be employed to overcome the current bottlenecks in the value web?

2. What strategies can be employed to fully exploit the existing opportunities for the innovative use of cassava biomass in the value web?

Appendix 3.1: Contract Farming Household Questionnaire

Household Identifiers

Region: _____

District name: _____

Community name: _____

Enumerator's Name: _____ Date Completed: ____/_____/_____

Section A: General Information

ID	Question	Answer
A1	Name of Respondent	
A2	Contact (eg. Phone number)	
A3	Gender	**1**_□ Male **2**_□ Female
A4	Age (in years)	
A5	What is your position in the household (relationship to head of the household)?	**1**_□ Head **2**_□ Spouse **3**_□ Son/Daughter **4**_□ Son/Daughter-in-law **5**_□ Other related **6**_□ Other unrelated
A6	What is the highest level of education you have completed?	**0**_□ None **1**_□ Primary **2**_□ JHS **3**_□ SHS/ O Level **4**_□ Tertiary **5**_□ Koranic **6**_□ Vocational **7**_□ Other (_____)
A7	Can you read and write in English?	**1**_□ Yes **2**_□ No
A8	What is your marital status?	**1**_□ Single **2**_□ Married or living together **3**_□ Separated **4**_□ Divorce **5**_□ Widowed
A9	What is the size of your household?	Male (over 18 years) …….. Female (over 18 years) ……. Children (under 18 years)…… Total ……..
A10	How many dependents do you have (with no labor or money contribution to the household)?	

Note: The household is defined as a group of people who share expenses and live and eat together most of the time, that is, more than 6 months of the year or more than three days of the week.

Note: The head of household is defined as the household member who makes most of the economic decisions. You may accept the judgment of the respondent.

What is your main economic activity?	How many years have you been engaged in this activity?	What proportion of your annual income was from this activity last year? (%)	What is your second most important economic activity? [Go to A17 if A14= 7]	How many years have you been engaged in this activity?	What proportion of your annual income is from this activity last year? (%)	Do you belong to a farmer based organisation?
1. Crop production **2.** Livestock **3.** Commerce **4.** Other business **5.** Employee **6.** Others (Specify…….)			**1.** Crop production **2.** Livestock **3.** Commerce **4.** Other business **5.** Employee **6.** Others (Specify…….) **7.** None			**1.** Yes **2.** No
A11	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**

Section B: Assets

HOUSING

B1.Type of dwelling (current)

1	Several Huts/Buildings (Same Compounds)
2	Several Huts/Buildings (Diff. Compounds)
3	Room(s) (Compound house)
4	Single family house
5	Apartment/Flat
6	Others (specify)

B2. How many rooms does this household occupy? ***(Do not include bath, toilet, kitchen)*** _____

B3. Do other households share this dwelling with you?

1 Yes **2** No

B4. If yes, how many?

B5. What is the material of the roof of the house?

1	Mud
2	Thatch
3	Wood
4	Iron Sheets
5	Cement/Concrete
6	Roofing Tiles
7	Asbestos
8	Other (Specify)

B6. What is the material of the walls of the house?

1	Mud/Mud bricks
2	Stone
3	Burnt bricks
4	Cement/Concrete
5	Wood/Bamboo
6	Iron Sheets
7	Cardboard
8	Other (Specify)

How many of the following goods does your household own in working condition?	Number (0= none)	What year acquired (four digits)	
Other building/ house			**B7**
Improved charcoal/wood stove			**B8**
Kerosene stove			**B9**
Gas stove			**B10**
Radio			**B11**
Electric fan			**B12**
Refrigerator			**B13**
Land-line phone			**B14**
Mobile phone			**B15**
Bicycle			**B16**
Car or truck			**B17**

How many of the following types of farm equipment does your household own?	Number [0=none]	
Cutlass		**B18**
Axe/pick-axe		**B19**
Sprayer		**B20**
Water Pump		**B21**
Irrigation pipe		**B22**
Plough		**B23**
Yoke		**B24**
Harrow		**B25**
Shovel		**B26**
Hoe		**B27**
Animal cart		**B28**
Power tiller		**B29**
Tractor		**B30**

How long does it take to get to […], using the usual forms of transport from your household?			
	Mode 1 Car 2. Motorbike 3. Bicycle 4. Walking	**Mins.**	
the nearest motorable road?			**B31**
the nearest weekly market place?			**B32**
the nearest daily market place?			**B33**
the district capital [give name]?			**B34**

If they own more than one, record most recent purchase

Section C: Contract Farming Arrangements for CASSAVA PRODUCTION

Are you participating in a contract farming arrangement? **[Have you supplied Ayensu with cassava this year]**	If NO, WHY [Move to **C19**]	What is the form of this arrangement?	How many years have you participated in the contract farming arrangement? **[How many years have you supplied Ayensu with cassava]**	What is the duration of the contract/ arrangement?	How did you learn about the arrangement?	Do you market all your cassava produce through the arrangement	If YES, WHY	If NO, WHY	If **C9**=NO, what proportion of your produce do you market through the contract arrangement? **[proportion usually sold to Ayensu]** (%)
1. Yes **2.** No	**1.** Lack of trust in the relationship **2.** Farmer selection criteria **3.** Low contract price **4.** Selling restrictions **5.** Other (Specify…….)	**1.** Written (formal) **2.** Oral (informal)		**1.** One harvest (one crop cycle) **2.** Six (6) months **3.** One (1) year **4.** Over 1 year **5.** 2-5 years	**1.** Ayensu Factory **2.** Caltech **3.** Cooperative **4.** Another farmer **5.** Extension officer **6.** Government official **7.** Other (Specify……)	**1.** Yes **2.** No	**1.** Terms of the contract/arrangement **2.** Lack of alternative marketing options **3.** Favorable price **4.** Other (Specify…….)	**1.** Terms of the contract/arrangement **2.** Alternative marketing options **3.** Favorable prices through other outlets **4.** Other (Specify…….)	
C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**

How was the sales price determined for your produce at your last harvest under the arrangement? **[How was the sales price given by Ayensu determined at your last harvest]**	Has your income from cassava production increased since engaging in this arrangement? **[Since you started supplying Ayensu]**	Does the contract specify the standards for the cassava?	[If yes] What is the main characteristic it specifies?	Have you encountered any conflict with your trading partner (buyer)?	[If yes] What is the nature of the conflict	What is the main benefit of participating in this arrangement?	What is the main challenge you have experienced in participating in this arrangement?
1. Prior negotiation with buyer **2.** Determined by buyer **3.** Market price	**1.** Yes **2.** No	**1.**Yes **2.** No	**1.** Size **2.** Maturity **3.** Starch content **4.** Healthy appearance **5.** Other (specify……..)	**1.** Yes **2.** No	**1.** Cheating (Opportunistic behaviour) **2.** Violating the contract terms **3.** Price **4.** Quality **5.** Other (specify…….)	**1.** Ready Market for Produce **2.** Better Prices for Produce **3.** Increase in Yields **4.** Better Access to Inputs **5.** Better Access to Extension Service **6.** Access to credit **7.** Access to land **8.** Transport of produce **9.** Cash loans **10.** Other (Specify……..)	**1.** Dependence on the processing company as a market outlet **2.** Price of produce **3.** Price of inputs **4.** Quality standards for produce **5.** Transport of produce **6.** Other (Specify……..)
C11	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**

Which features of the contract farming arrangement influenced your decision of whether or not to participate in the scheme?			
Features	Yes	No	
Nature of the contract			**C19**
Pricing arrangement			**C20**
Payment procedure			**C21**
Product quality specification			**C22**
Input supply arrangement			**C23**
Technical assistance			**C24**
Crop delivery arrangement			**C25**
Conflict resolution procedure			**C26**
Sanctions			**C27**

C28. Do you intend to participate in this arrangement at your next harvest? **1.** Yes **2.** No

Section D: Agricultural Land and Crop Production (All crops)

D1. How much land do you use for farming activities……..acres/hectares?

Plot number	What crop was planted on plot [##] during the last season?	How large is each of these plots of land that is used in the arrangement?		How large is each of these plots of land that is **NOT** used in the arrangement?		How much [crop] was harvested from this plot during the last season?		Does this plot belong to your household? [either purchased land or allocated by traditional authorities]	[If D7=1] How did your household obtain this plot?	[If D7=2] How much did your household pay in rent for this plot?	
		Area	Area unit 1 Acre 2 Hectare	Area	Area unit 1 Acre 2 Hectare	Quantity	1. Tonnes 2. Kg 3. Maxibag 4. Minibag 5. Crate 6. Bowl 7. Piece 8. Basket	1. Yes 2. No, household rents it from others 3. No, provided by Ayensu/ Caltech 4. No, borrowed at no cost 5. No, household sharecrops land	1 Allocated by family 2 Allocated by chief 3 Allocated by govt. 4 Purchased 5 Gift 6 Inherited 7 Other	Value in GHc	**Time unit** 1 month 2 season 3 year
D2	**D3**	**D4a**	**D4b**	**D5a**	**D5b**	**D6a**	**D6b**	**D7**	**D8**	**D9a**	**D9b**

Crop codes; 12 - Cassava// 13 - Maize// 14 - Plantain// 15 - Yam// 16 - Okro// 17- Tomatoes// 18 – Pepper// 59 – Other Fruit// 69 – Other Vegetable// 79 - Other crop

What is the main source of water for this plot?	How long does it take you to go from your house to this plot by walking?	What is the quality* of the soil on this plot?
1 Rainfed 2 Rain & water harvesting 3 Surface irrigation 4 Groundwater irrigation 5 Other	Minutes	1 Poor 2 Average 3 Good
D10	**D11**	**D12**

D13. Which cassava varieties do you grow?

**** Explanation of soil quality: "Poor" means low yield in a normal rainfall year because sandy, rocky, or weed-infested.***

"Medium" means average yield with normal rainfall.

"Good" means good yield with normal rainfall because soil is dark, soft-textured, and weed-free.

Section E: Crop Inputs (For All Crops)

Enumerator: Copy each unique crop code from D3 into E1, then complete E2 to E10. This table is at the crop level for the last major season

For the [crop] grown, how much .. . . . . did this household use in the last harvest?										Was any seed/pm or agro-inputs provided on credit to this household for [crop]? 1 Yes, seed/pm 2 Yes, agro-inputs 3 Yes, both 4 Neither	[If E8=yes] Who provided these inputs on credit? 1. Input dealer 2. Ayensu/Caltech 3. Ag trader 4. Processor 5. NGO 6. Govt, MoFA 7. Other	[If E8=yes] Were you required to sell all or part of the harvest to the provider? 1. Yes all 2. Yes part 3. No
...seed/planting material (pm) saved from harvest..		…purchased seed/ planting material… (state the unit price below)		…chemical fertiliser..		… pesticides, herbicides, & spraying services…		...tractor hire..	…. manure			
Quantity	Unit 1 Acre 2 Hectare 3 Poles 4 Ropes 5 Plots 6 kg	Quantity	Unit 1 Acre 2 Hectare 3 Poles 4 Ropes 5 Plots 6 kg	Value in GHc	Qty in Kg or litres	Value in GHc	Value in GHc	Value in GHc	1. Yes 2. No			
E1a	**E1b**	**E2a**	**E2b**	**E2c**	**E3a**	**E3b**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**

Note: For fertiliser, if the response is given in bags, please convert to kg. A standard fertiliser bag is 50 kg.

Section F: Labour Inputs for CASSAVA production

F1. Labour inputs for cassava plot(s) of ……. acres

Farm activity (where applicable)	Code	Family Labour			Hired and Exchanged Labour			Contract	
		Number of workers	# of days	Daily Wage (GH¢)	Number of workers	# of days	Daily Wage (GH¢)	Price (GH¢)	Acres
	Activity	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Land clearing/ stumping	101								
Ploughing	102								
Harrowing	103								
Ridging	104								
Planting/ seeding	105								
1st Herbicide /weedicide application	106								
1st weeding: Manual	107								
2nd Herbicide /weedicide application	108								
2nd weeding: Manual	109								
Fertiliser application	110								
3rd weeding: Manual	111								
Harvesting	112								

Section G: Crop Utilisation and Sales (For all crops)

How much [crop] was last harvested? (can be calculated from D6, sum across plots for each crop)			How much of this was consumed by the household? **[same unit as G1c]**	How much was sold? **[same unit as G1c]**	[If sales] Was market access easy?	[If sales] What was the main outlet?	How promptly were you paid?	Who bore the transportation costs of the produce?
Crop Code	Qty	1. Tonnes 2. Kg 3. Maxibag 4. Minibag 5. Crate 6. Bowl 7. Piece 8. Basket			1 Very easy 2 Easy 3 Difficult 4 Very difficult	1 Ayensu Factory 2 Caltech 3 Market trader 4 Processor 5 Consumer 6 Cooperative 7 Other (specify……..)	1 Paid before harvest 2 At time of Sale/delivery 3 Within 1 week of sale 4 Within 2 weeks of sale 5 Within 1 month of sale 6 Over 1 month	1 Farmer 2 Buyer
G1a	**G1b**	**G1c**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**

What was the quantity of the sales through this outlet at your last harvest? **[same unit as G1c]**	What was the selling price of the produce through this outlet?		Was any quantity sold through another outlet **If NO move to G14**	[If yes] What was the outlet	What was the quantity of the sales through this outlet at your last harvest? **[same unit as G1c]**	What was the selling price of the produce through this outlet?		Was any of the crop lost?	[If Yes] What was the amount lost? **[same unit as G1]**	What was the cause?
	GHc per unit	1. Tonnes 2. Kg 3. Maxibag 4. Minibag 5. Crate 6. Bowl 7. Piece 8. Basket	1 Yes 2 No	1 Ayensu Factory 2 Caltech 3 Market trader 4 Processor 5 Consumer 6 Cooperative 7 Other (specify……..)		GHc per unit	1. Tonnes 2. Kg 3. Maxibag 4. Minibag 5. Crate 6. Bowl 7. Piece 8. Basket	1 Yes 2 No		1 No market outlet 2 Pest and diseases 3 Lack of storage 4 Other
G8	**G9a**	**G9b**	**G10**	**G11**	**G12**	**G13a**	**G13b**	**G14**	**G15**	**G16**

Section H: Other Income

Other income activity	Code	In the past 12 months, have you received income from [activity]? 1. Yes 2. No	If G2="yes". Complete G3 and G4.	
			How many months out of the past 12 months did you receive income from [activity]? Months	For each of these months that you were involved in [activity], how much **MONTHLY INCOM**E did you take home? GHc/month
	Activity	**H2**	**H3**	**H4**
Firewood & other forest products	101			
Agricultural trading	102			
Other trading	103			
Grain milling	104			
Local beer brewing & malting	104			
Agricultural processing business	106			
Tailoring and textiles	107			
Artisanal (mason, carpenter, etc)	108			
Other business	109			
Other wage laborer (paid by hour or day)	110			
Public-sector employee	111			
Other salaried employee (paid by month or yr)	112			
Pension	113			
Remittances from family members or friends	114			
Other assistance programs	115			
Other (specify) _____	116			

Note: "Other" could include land rental income, interest income, or property rental income

Section I: Information and Advisory Services

Do you have access to extension services? 1 Yes 2 No	[If Yes] For how many years have you had access to extension services?	How often did you get the service in the past 12 months? 1. Once per week 2. Several times per week 3. Once per month 4. Several times per month 5. Once per year 6. Other (specify)	Who provides these services? 1. Government, MoFA 2. NGO 3. Caltech 4. Ayensu 5. Other	For which crops have you received assistance? [Crop Code]	What was the major crop concern addressed? 1. Use of fertiliser/ other agro-chemicals 2. Irrigation 3. Plant in rows 4. Plant on Ridges 5. New Seed varieties/pm 6. Pest infestation 7. Weather related issues 8. Blight/Crop Disease 9. General Information 10. Other (specify)
I1	**I2**	**I3**	**I4**	**I5**	**I6**

Appendix 4.1: Process Net-Map Interview Guide for the Maize Seed Supply System

Application: The aim of this discussion is to develop a shared understanding of the current structure of Ghana's commercial seed system with regards to maize varietal development and seed dissemination under the new seed law (Plants & Fertiliser Act 2010).

A. Mapping of Step by Step process of varietal development and seed dissemination

1. Who are the actors involved in the generic process of developing an improved maize variety and its dissemination in the commercial seed system under the new law?

2. Where does the process start? Please describe the process step by step.

3. How are the actors linked? (information transfer, funds, service delivery, resource supply, technology, etc.)

B. Power /Influential Ranking of Actors

1. Which of the actors do you perceive to have influence on the intended outcome that a new maize variety is widely adopted?

2. Kindly rank the influence of these actors on the process using a scale of 0-8.

3. Please give reasons as to why you ascribe different influence levels to these actors.

C. Identification of Potential Bottlenecks/Problems

1. Please identify where there are bottlenecks/problems/challenges in this process.

2. Please give reasons for the identified bottlenecks/challenges/problems.

D. Suggestions to Improve the process

1. What strategies can be employed to overcome these bottlenecks?

2. What should be changed in the current system to bring about needed improvements?