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Governance Challenges of Developing Biomass-Based Value Webs: The Case of Maize in Ethiopia

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Executive Summary

In recent years, the need to move from an economy based on fossil resources to an economy based on biological resources has gained increasing attention. The bioeconomy has the potential to ensure sustainable growth by enhancing the usage of untapped biomass resources. This potential is particularly pronounced in sub-Saharan Africa and has attracted the attention of both governments and the international donor community. To use the potential of the bioeconomy in a sustainable way without jeopardizing food security, it is essential to increase the productivity and the efficiency of the production and utilization of biomass. Using the maize production in Ethiopia as a case study, this thesis aims to identify strategies that will contribute to a higher productivity and better utilization of biomass in the emerging bioeconomy. Maize has been selected for this case study because it is on one the one hand a major food crop in Africa while it has, on the other hand, the potential to provide biomass for multiple uses in the bioeconomy. Ethiopia is well suited for the case study because it is confronted with major challenges of food security, while it has at the same time a large underutilized potential to increase the production of biomass for the bioeconomy.

The thesis focuses on two themes: One is an analysis of the seed system, because maize seed supply has been identified as a major bottleneck to increasing productivity in the production of biomass. Ethiopia's seed sector has been plagued with problems of seed quality regulation, certification, dominance of informal seed sourcing, and inefficient distribution system, among other governance challenges. There have been major reform efforts in recent years, but there is not sufficient empirical evidence on how these reforms have fared. The second theme to the thesis is the utilization of the biomass from maize. This topic has been selected because there is a dearth of empirical evidence on the usage of the different components of maize (e.g. cob, stalk, leaves etc.) for several purposes, and its implications for household food security.

Against this background, the broad objective of this thesis is threefold: (1) to analyze the institutional arrangements for maize seed quality regulation, and uncover the governance challenges therein; (2) to identify the governance challenges in the hybrid maize seed distribution system and analyze farmers' preferences of the select attributes for hybrid seed distribution; and (3) to assess usages of the different components of maize biomass, and examine its implications for food security.

The thesis is based on a mixed methods approach. Data were collected using both qualitative and quantitative techniques. The study of seed quality regulation relies primarily on qualitative data collected through Process Net-Maps, focus group discussions, key informant interviews and direct observation in three maize growing districts. For the second and third objectives, data were collected using household survey and a choice experiment covering 325 farmers, Process Net-Maps, focus group discussions and key informant interviews. We employ the latent class and endogenous switching regression models to analyze the choice experiment data on farmers' preference for the distribution attributes and effect of farmers' diverse biomass use decision on food security, respectively.

The thesis contains five chapters: an introductory chapter (Chapter 1), three empirical chapters (Chapters 2-4), which correspond to the three research objectives indicated above, and a concluding chapter (Chapter 5).

The study presented in Chapter 2 established that the quality control system for maize seed is characterized by numerous governance challenges including corruption, lack of accountability, lack of capacity and incentives to fully implement reforms. The study suggests ways to resolve the governance challenges by means of enhancing internal as well as external quality control mechanisms, redefining certification standards, and by making certification services transparent, participatory and cost-effective. The second study on the maize seed system, which is presented in Chapter 3, identifies potential entry points for corruption and other governance challenges in the reformed seed distribution system. This study also covers the demand side of the reform by analyzing farmers' preferences for the attributes of different seed distribution mechanisms, such as seed quality, sales outlet, credit as a mode of payment, seed quantity, seed price and group formation. On the basis of the findings, different ways are presented that are suitable to overcome the governance challenges in hybrid maize seed distribution in Ethiopia.

As indicated above, the study presented in Chapter 4 deals with biomass utilization. The study finds multiple areas of use of biomass, but the majority of those are underdeveloped and underutilized. The endogenous switching regression model results further show households who diversify the use of biomass achieved better food security. The results suggest that for stimulating biomass production and utilization, it is crucial to enhance accesses to extension services, promote multi-purpose maize varieties and improve access to markets and value adding technologies.

The findings of the thesis contribute to the wider debates on governance and institutional challenges of ensuring food security through development of the bioeconomy, taking maize as an important bioeconomy crop. By investigating the roles of different stakeholders in the seed system, the study finds that the systems suffer from a number of governance and institutional challenges such as corruption, implementation gaps that arise due to capacity limitation and lack of political will to support private sector participation. The study suggests ways to overcome the governance challenges, which include enhancing internal as well as external quality control mechanisms, redefining certification standards, making certification services transparent, participatory and cost-effective, and a strong political will to fully implement reforms by promoting private sector participation. Additionally, the positive and homogeneous preferences for attributes like seed quality, types of sales outlets and access to credit that are shared by the majority of the surveyed farmers' show the extent to which reform outcomes deviated from the needs of farmers. The study identified farmers' preferences regarding the question of how they would like to access hybrid seeds and recommends ways to overcome the governance challenges in seed distribution in Ethiopia.

In addition to examining problems regarding production, the study confirmed that maize biomass utilization is crucial for food security and development of bioeconomy. The findings show that maize biomass is underutilized in the country because of lack of enabling conditions such as access to extension and information, marketing channels, availability of multi-purposes maize varieties and value-adding technologies. The findings led to the recommendation that policy innovation to provide better access to these conditions is essential to achieve growth in the maize sector and food security.

Zusammenfassung

In den letzten Jahren hat die Notwendigkeit eines Wandels von einer Ökonomie, die auf fossilen Ressourcen basiert, zu einer Ökonomie die auf biologischen Ressourcen basiert, zunehmend Beachtung gefunden. Die Bioökonomie hat das Potenzial ein nachhaltiges Wachstum durch eine Ausweitung der Nutzung von unerschlossenen Biomasseressourcen sicherzustellen. Dieses Potenzial is insbesondere in Sub-Sahara-Afrika sehr ausgeprägt und hat die Aufmerksamkeit von Regierungen und der internationalen Gebergemeinschaft gleichermaßen geweckt. Um die Potenziale der Bioökonomie nachhaltig zu nutzen ohne Nahrungssicherung zu torpedieren, ist es essenziel die Produktivität und Effizienz der Produktion und Nutzung von Biomasse zu erhöhen. Am Beispiel der Maisproduktion in Äthiopien versucht diese Thesis Strategien zu identifizieren, die zu einer höheren Produktivität und Nutzung von Biomasse in der entstehenden Bioökonomie beitragen. Diese Fallstudie bezieht sich auf Mais, einerseits, weil Mais ein wichtiges Grundnahrungsmittel in Afrika ist, andererseits, weil es das Potenzial hat, Biomasse für verschiedene Nutzungsarten in der Bioökonomie zu Verfügung zu stellen. Äthiopien eignet sich gut für eine Fallstudie, weil es gleichzeitig mit großen Herausforderungen mit Blick auf Ernährungssicherung konfrontiert ist und zudem große, unternutze Potenziale besitzt, die Produktion von Biomasse für die Bioökonomie zu erhöhen.

Die Thesis fokussiert sich auf zwei Themen: Eines ist die Analyse des Saatgutsystems, da die Bereitstellung von Maissaatgut als ein wesentlicher Engpass zur Steigerung der Produktivität von Biomasse identifiziert wurde. Äthiopiens Saatgut-Bereich ist gekennzeichnet durch Probleme mit Blick auf die Regulierung der Qualität von Saatgut, die Zertifizierung, die Dominanz von informeller Saatgutbeschaffung und die Ineffizienz des Verteilungssystems, neben anderen Governance Herausforderungen. Es gab große Reformbemühungen in den letzten Jahren, allerdings gibt es bislang nicht genügend empirische Beweise, inwiefern diese Reformen fortgeschritten sind. Das zweite Thema dieser Thesis ist die Nutzung von Biomasse aus Mais. Dieses Thema wurde gewählt, weil es eine Forschungslücke mit Blick auf die Nutzung von verschiedenen Maiskomponenten (z.B., Kolben, Stielen, Blättern etc.) gibt, sowie mit Blick auf die Frage, wie eine mögliche Nutzung auf die Ernährung von Haushalten auswirkt.

Vor diesem Hintergrund hat die Thesis drei Hauptziele: (1) die Analyse von institutionellen Arrangements zur Regulierung der Qualität von Maissaatgut, sowie die dazugehörigen Governance Herausforderungen; (2) das Identifizieren von Governance Herausforderungen im Hybrid-Mais-Saatgutsystems und die Analyse der Vorlieben von Landwirten hinsichtlich der Attribute für Hybrid-Saatgut-Verteilung; und (3) die Einschätzung der Nutzung von verschiedenen Komponenten von Maisbiomasse, sowie deren Implikationen auf Ernährungssicherung.

Diese Thesis basiert auf einem gemischten Methoden Ansatz. Daten wurden mit qualitativen und quantitativen Techniken gesammelt. Die Studie zu der Regulierung von Saatgutqualität wurde hauptsächlich mit qualitativen Datenerhebungsmethoden durchgeführt. Dazu zählen Prozess Net-Maps, Fokusgruppendiskussionen, Interviews mit Schlüsselinformanten sowie Direktbeobachtungen in drei Mais-anbauenden Distrikten. Für das zweite und dritte Ziel, wurden Daten mithilfe von Haushaltsbefragungen und einem „Choice Experiment” mit 325 Landwirten

gesammelt. Darüber hinaus wurden Prozess Net-Maps, Fokusgruppendiskussionen und Interviews mit Schlüsselinformanten verwendet. Es wurde ein latent class and endogenous switching regression Modell verwendet, um die Choice Experiment Daten zu den Präferenzen von den Landwirten zu den Verteilungsattributen sowie die Effekte von verschiedenen Biomassenutzungsentscheidungen von Landwirten auf Ernährungssicherung zu erforschen.

Die Thesis enthält 5 Kapitel: ein einleitendes Kapitel (Kapitel 1), drei empirische Kapitel (Kapitel 2-4), welche sich auf die drei oben genannten Forschungszielen beziehen, und einem abschließendes Kapitel (Kapitel 5).

Die Studie, welche in Kapitel 2 gezeigt wird, etabliert, dass die Qualitätskontrollsysteme für Mais-Saatgut durch verschiedene Governance Herausforderungen gekennzeichnet sind. Darunter fallen Korruption, mangelnde Rechenschaftspflichten, mangelnde Kapazitäten sowie fehlende Anreize Reformen vollständig zu implementieren. Die Studie empfiehlt verschiedene Wege, um diese Governance Herausforderungen zu lösen, etwa durch die Verbesserung von internen sowie externen Qualitätskontrollmechanismen, Neudefinierungen von Zertifizierungstandards und durch eine Erhöhung der Transparenz, Anteilhabe und Kosteneffizienz von Zertifizierungstandards. Die zweite Studie zu dem Mais-Saatgut-System, die in Kapitel 3 präsentiert wird, identifiziert potenzielle Einfallspunkte für Korruption und andere Governance Herausforderungen in dem reformierten Saatgut-Verteilungssystem. Die Studie betrachtet auch die Nachfrageseite der Reform, durch die Analyse von den Vorlieben von Landwirten für Attribute hinsichtlich von Saatgut-Verteilungsmechanismen wie Saatgutqualität, Anzahl von Ausgabestellen, Kredit als Zahlungsmethode, Saatgutquantität, Saatgutpreis und Gruppenformation. Basierend auf diesen Ergebnissen, werden verschiedene Wege gezeigt, die geeignet sind, die Governance Herausforderungen des Hybrid-Maissaatgut-Verteilungssystem in Äthiopien zu vermeiden.

Wie oben angemerkt, beschäftigt sich die Studie in Kapitel 4 mit der Nutzung von Biomasse. Die Studie identifiziert verschiedene Bereiche zur Nutzung von Biomasse, von denen die meisten unterentwickelt und unternutzt sind. Die Ergebnisse des The endogenous switching regression model zeigen, dass Haushalte, die ihre Nutzung von Biomasse diversifizieren, bessere Werte mit Blick auf Ernährungssicherung haben. Die Ergebnisse weisen darauf hin, dass, um Biomasse Produktion und Nutzung zu stimulieren, ein verbesserter Zugang zu landwirtschaftlicher Beratung, eine Förderung von Mehrzweck-Maisvarietäten und ein verbesserter Zugang zu Märkten und wertschöpfungssteigernden Technologien entscheidend ist.

Die Ergebnisse der Thesis tragen zu einer größeren Debatte zu den Governance und institutionellen Herausforderungen über die Sicherstellung von Ernährungssicherung durch die Entwicklung der Bioökonomie bei. Diese wird am Beispiel Mais, als eine wichtige Bioökonomie Pflanze, dargestellt. Indem die Rollen von verschiedenen Akteuren des Saatgutsystems erforscht werden, zeigt diese Studie, dass das System durch eine Reihe von Governance und institutionellen Herausforderungen geplagt wird. Darunter fallen Korruption, Implementierungslücken aufgrund von begrenzten Kapazitäten und ein mangelnder politische Willen den Privatsektor einzubeziehen. Die Studie zeigt Wege, um die Governance Herausforderungen zu lösen. Darunter fallen interne sowie externe Qualitätskontrollmechanismen, Neudefinierungen von

Zertifizierungstandards und eine Erhöhung deren Transparenz, Anteilhabe und Kosteneffizienz und ein starker politischer Willen diese Reformen durch die Förderung von Privatsektor-Akteuren zu implementieren. Darüber hinaus zeigen die positiven und homogenen Präferenzen für Attribute wie Saatgutsqualität, Arten von Verkaufsstellen und Zugang zu Krediten, welche die Mehrheit der befragten Haushalte teilen, inwiefern die Reformergebnisse von den Bedürfnissen von Landwirten abweichen. Die Studie identifiziert die Präferenzen von Landwirten mit Blick auf die Frage, wie sie gerne Zugang zu Hybrid-Saatgut hätten und schlägt Wege vor, um die Governance Herausforderungen im Saatgutsystem von Äthiopien zu lösen.

Zusätzlich zur Analyse hinsichtlich der Produktion, bestätigt diese Studie, dass die Nutzung von Mais Biomasse entscheidend für Ernährungssicherung und die Entwicklung der Bioökonomie ist. Die Ergebnisse zeigen, dass Mais-Biomasse, aufgrund von fehlenden Rahmenbedingungen wie dem Zugang zu landwirtschaftlicher Beratung und Information, zu Marketingkanälen, zu Mehrzweck-Maisvarietäten und zu wertschöpfungssteigernde Technologien, untergenutzt wird. Die Ergebnisse führen zu der Empfehlung das Politik-Innovationen essenziell sind, um den Zugang zu diesen Bedingungen zu verbessern und um Wachstum im Maissektor zu erreichen und somit die Ernährungssituation zu verbessern.

List of Abbreviations

AIC	Akaike Information Criteria
AKIS	Agricultural Knowledge and Information System
ASE	Amhara Seed Enterprise
ATA	Agricultural Transformation Agency
BIC	Bayesian Information Criteria
BOA	Bureau of Agriculture
CBD	Cooperative Based Seed Distribution
CSA	Central Statistical Agency
CE	Choice Experiment
DA	Development Agent
DI	Diversification Index
DOA/DAO	District Office of Agriculture
DSM	Direct Seed Marketing
EBA	Enabling the Business of Agriculture
ESR	Endogenous Switching Regression
ESE	Ethiopian Seed Enterprise
ETB	Ethiopian Birr
FCS	Food Consumption Score
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
HH	Household
ISSD	Integrated Seed Sector Development
KIIs	Key Informant Interviews
LCM	Latent Class Model

HHI	Hirschman Herfindahl Index
KII	Key Informant Interview
MOA	Ministry of Agriculture
MWTP	Marginal Willingness To Pay
NIAR	National Institute of Agricultural Research
OSE	Oromia Seed Enterprise
PAs	Peasant Association
PC	Primary Cooperative
PNM	Process Net-map
PSQCQA	Plant Seed Quality Control and Quarantine Authority
R&D	Research and Development
SEs	Seed Enterprises
SMMC	Seed Multiplying and Marketing Primary Cooperatives
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit
TVET	Technical Vocational Education and Training

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Chapter One: Introduction

1.1 Problem background

Achieving sustainable economic growth and at the same time ensuring food security of the growing population has become a global challenge. While fossil fuels have triggered economic growth for a long time in the past, these challenges have led countries to look for other alternative and reliable sources of growth. The bioeconomy or the bio-based economy has been argued to have the potential to sustain green growth, ensure sustainable and efficient use of resources to meet demands of the growing population and to ensure social and ecological sustainability (Börner, Kuhn, & Braun, 2017; Von Braun, 2014). While the definition of the bioeconomy has remained subject to debate, the German Bioeconomy Council (2015) defined it as an economy that comprises the knowledge based production and use of biological resources to provide products, processes and services in all economic sectors.

The bioeconomy is relevant for Africa, but the potential for food security issues is particularly relevant. There are two key challenges to developing the bioeconomy in the African context; increase in productivity of biomass and ensuring that biomass is used in a way that is compatible with food security (Mohr et al.,2015; Müller et al., 2015). However, there are essential knowledge gaps in this regard. This thesis is part of the larger collaborative research project "BiomassWeb'' which aims at improving food security in Africa through increased system productivity of biomass-based value webs. The project focuses on value-webs based on cassava, maize and banana plantain/enset in the productive Sudanian Savanna belt (Ghana, Nigeria) and east African Highlands (Ethiopia) (Biomassweb, 2013). To address the knowledge gap in this context, the thesis focuses on the seed system which has been identified as a major bottleneck for productivity increase and the food security implication of biomass uses as not much is known about this issue in the context of Africa. Therefore, the objectives of this thesis are to identify the bottlenecks in the seed system and the uses of biomass given its food security implications.

Yet, there are contested issues in the literature regarding the food security role of bioeconomy. On the one hand, trade-offs in the use of biological resources for the production of food, feed, and energy (biofuel or fuelwood) and for bio-based products in textiles and pharmaceutical industries exacerbate resources competition on land and aggravate development challenges (Kampman et al., 2008; Virchow et al., 2014). Environment and human right advocates argue that trade-offs in competing ends jeopardize food and nutrition security, if not governed appropriately (Heinimö & Junginger, 2009; Müller et al., 2015). Additionally, it is argued that inappropriate design of the bioeconomy may adversely affect food security while economic efficiency and sustainability may be increased (Von Braun, 2009). On the other hand, bioeconomy has been promoted to enhance efficient use of biomass through innovation in production, processing and marketing of biological resources. This is particularly the case in regions like SSA where there is high biomass potential and high yield gaps, but production, processing and utilization are inefficient. Sub-Saharan African has a high biomass potential, vast arable land and high cereal yield gaps. Despite the preponderance of high biomass potential, poverty and food insecurity are pervasive, that makes the region an island of undernourishment in the sea of enormous biomass potentials and vast agricultural land (Bruinsma, 2009; Fuglie, Wang, & Ball, 2012). Thus, development of bioeconomy is considered to be opening opportunity to make use of the untapped yield gaps and encourage efficient use of biomass and thereby enhance food security and growth of the region.

In response to the concerns of the environmental and human right advocates, it is argued that regulations and standards should ensure that biomass operators give priority to food (Mohr et al., 2015; Virchow et al., 2014). Thus would help farmers to generate additional income and employment and thereby enhance livelihoods by transforming agriculture sector from food supplying to biomass supplying (Abass, 2014; Mohr et al., 2015; Virchow et al., 2014). It also enhances efficiencies and synergies across biomass usages and sectors (Hoff, 2011). However, adequate institutional arrangements and appropriate governance structure are crucial to reap the optimum benefit of the bioeconomy without which food security of small-scale producers would be threatened (FAO, 2014; Müller et al., 2015; Priefer et al., 2017; Virchow et al., 2014). Adequate empirical evidence on institutional and policy environment required for the development of bioeconomy, and the challenges in relation to the emerging agro-biomass sectors is lacking. In Ethiopia, maize is considered as an important food security and bioeconomy crop because of its potentially diverse usages, from food to feed to fuel. This thesis uses maze as a model crop for analyzing the development of bioeconomy.

1.2 Rationale of the study

In this context of the bioeconomy, the objective of this thesis is to identify important governance challenges for several reasons. The focus is placed on two aspects of seed system on the part of production and the use of biomass in this whole context of the bioeconomy. The main reasons for this is that seed system has been identified as a major bottleneck to productivity increase and smallholder farming systems not much known about the uses of other aspects of the biomass and its link to food security. This study is thus a novel attempt to fill this knowledge gap and contribute to the current debates on bioeconomy and agricultural transformation by exploring the existing governance structure and the institutional terrain in the maize sector.

Maize is produced by more than nine million farm households in Ethiopia (Abate et al., 2015; CSA, 2014). The growth of the sector has stagnated with current yield which is about half of the estimated potential of six tons per hectare (Abate et al., 2015; Rashid et al., 2010). Several production and post production factors have curtailed the growth of the sector, such as the lack of access to good quality seeds, fertilizers, marketing outlets and extension services (Alemu, Rashid, & Tripp, 2010; Spielman, Kelemwork, & Alemu, 2011). Ensuring access to these factors, particularly high-quality seeds, for smallholder farmers has remained a challenge for long. The seed system has been controlled by the public sector, and there has been a lack of competition, information asymmetry, and high transaction costs in the maize seed systems (Alemu, 2011; Alemu et al., 2010; Benson, Spielman, & Kasa, 2014; Erenstein et al., 2011; Husmann, 2015; Spielman et al., 2011). The lack of access to improved seeds is worse in cereal dominated agrarian economies, such as Ethiopia (Diao, 2010; Taffesse et al., 2011). In Ethiopia, like many SSA countries, the seed sector is also plagued with problems of quality regulation, certification, distribution and marketing, among other governance challenges (Benson et al., 2014; USAID, 2013). Efficient seed system that allows farmers access to good quality maize seeds, it is argued, can enhance the potential of the maize sector (USAID, 2013).

In many SSA countries, public seed certification is more pronounced towards enforcement and control, which results into several challenges (ISSD, 2017; USAID, 2013). Setting up of unattainable quality standards, non-participatory process of certification, lack of transparency in the control system which encourages rent-seeking behaviors, are some of the main challenges in seed quality regulation (Louwaars, 2005). In the context of Ethiopia, the Ministry of Agriculture (MOA) had been in charge of developing seed laws, quality assurance procedures and also certifying all commercial seeds, until recently (Atilaw, 2010). The challenge to provide certification service to the increasing number of seed producers, both public and private, led to decentralization in seed quality regulation to respective regions since 2013. To what extent have these reforms enhanced seed quality control? And what are the major bottlenecks in the reformed system and how to overcome those? These are the main questions addressed in the following chapter of the thesis.

Apart from seed quality control, the distribution of high yielding variety of hybrid seeds is another major challenge in the seed sector in Ethiopia. Government control for a long time has resulted into inefficient seed production, distribution and marketing system, leading to the overall low productivity in the maize sector (Alemu et al., 2010). This drove a policy change from the state-sponsored cooperative-based distribution (CBD) approach to the direct seed marketing (DSM) program in 2011 in selected pilot districts. Yet, the liberalization of the seed system has not led to substantial decreases in transaction costs (Husmann, 2015). It is generally observed that even after the introduction of DSM, access to seeds in the desired quantity, quality and at competitive prices from multiple sales outlets is not happening. Moreover, the mode of payment in the new system is cash only. This limits the access to hybrid seeds for cash-constrained smallholders (Benson et al., 2014; Husmann, 2015). However, empirical studies on the post-reform governance challenges in seed distribution and marketing systems are lacking. In addition, we do not know which attributes of the hybrid seed distribution system are liked the most by the maize farmers. In other words, what are the preferences of Ethiopian maize farmers in terms of accessing hybrid seeds? Chapter 3 of the thesis addresses these questions.

Good quality seeds and efficient distribution system can increase overall productivity but does not necessarily translate into food security of farm households. Utilization of entire biomass is equally important for the development of bioeconomy. The usages of maize biomass for several purposes, and the food security implications of these usages are crucial factors but there is a dearth of empirical evidence on these. It is also true that the growth of the maize sector depends on production as well as post-production factors. Post-production factors would have the potential to reinforce or limit production and productivity. Despite that, past studies have paid less attention to decision behaviors of farm households' in terms of utilization of the entire biomass of particular crops. In this regard, Minot, (2013) and Rashid et al. (2010) have identified some of the post-production constraints and opportunities in the maize sector that affect maize farmers' decisions on the use of their maize crop. The lack of markets and downstream processing, and inconsistent export policy are among the major bottlenecks identified by the aforesaid studies. While Rashid et al. (2010) recommended creation of "demand sinks" in the poultry and livestock sectors for stimulating growth in the maize sector, others (e.g. Jaleta et al., 2015) have looked at the tradeoffs in maize crop residue utilization and have identified major usages, such as feed, fuel and soil enhancement. However, a consistent and an in-depth empirical study that documents the utilization of the different components of maize, the food security role of the diverse usages and its implications for the development of bioeconomy is lacking. Chapter 4 tries to address these issues.

1.3 Research objectives

The study has three general objectives addressed in three separate chapters. These objectives are as following:

- to analyze the institutional arrangements for maize seed quality regulation, and uncover the governance challenges therein;

- to identify the governance challenges in the hybrid maize seed distribution system and analyze farmers' preferences of the select attributes for hybrid seed distribution;
- to assess usages of the different components of maize biomass, and to examine its implications for farm household food security.

1.4 Research questions

Specific research questions in order to address the aforesaid three research objectives were formulated. The following three research questions address the first objective which looks at the institutional arrangements and governance challenges in hybrid maize seed quality control:

- What is the institutional arrangement for hybrid maize seed production and certification?
- To what extent has the decentralization of seed quality regulation improved efficiency of the system?
- What are the main governance challenges in the hybrid seed quality regulation? And how to overcome those?

In relation to the second objective, concerning the governance challenges in seed distribution system and farmers' preferences for the attributes of seed distribution, the following are the main guiding questions:

- What are the main governance challenges in the reformed hybrid maize seed distribution system? And how to overcome those?
- Which attributes of the hybrid maize seed distribution are valued the most by the farmers?
- What are the implications of farmers' choice of the distribution attributes for reforming the system further?

The third research objective deals with farm households' post-production decision on the usages of maize biomass. The following research questions address this objective:

- For what purposes do farmers use their maize biomass?
- How important are these decisions for farm households' food security? And what are the main challenges in relation to maize biomass use diversification?

1.5 Conceptual framework: maize value webs

The thesis follows a biomass-based value-web approach, based on a multidimensional framework that utilizes the 'web perspective' to understand the interrelations and linkages between several value chains and how they are governed (Virchow et al., 2014). The value-web approach challenges the classical Poter's value chain which looks at how inputs are changed to outputs. Because of the growing complexity, a systems approach that guides the integration of social, economic and environmental issues in production, processing and consumption of biomass is crucial (Mangoyana, Smith, & Simpson, 2013). Contrasted to the liner value chain approach, the web approach analyzes the complex systems (resembles a web) to identify inefficiencies in the sector, explore synergies and to improve access to markets for small-scale farmers. A diagrammatic representation of value-web framework is presented below:

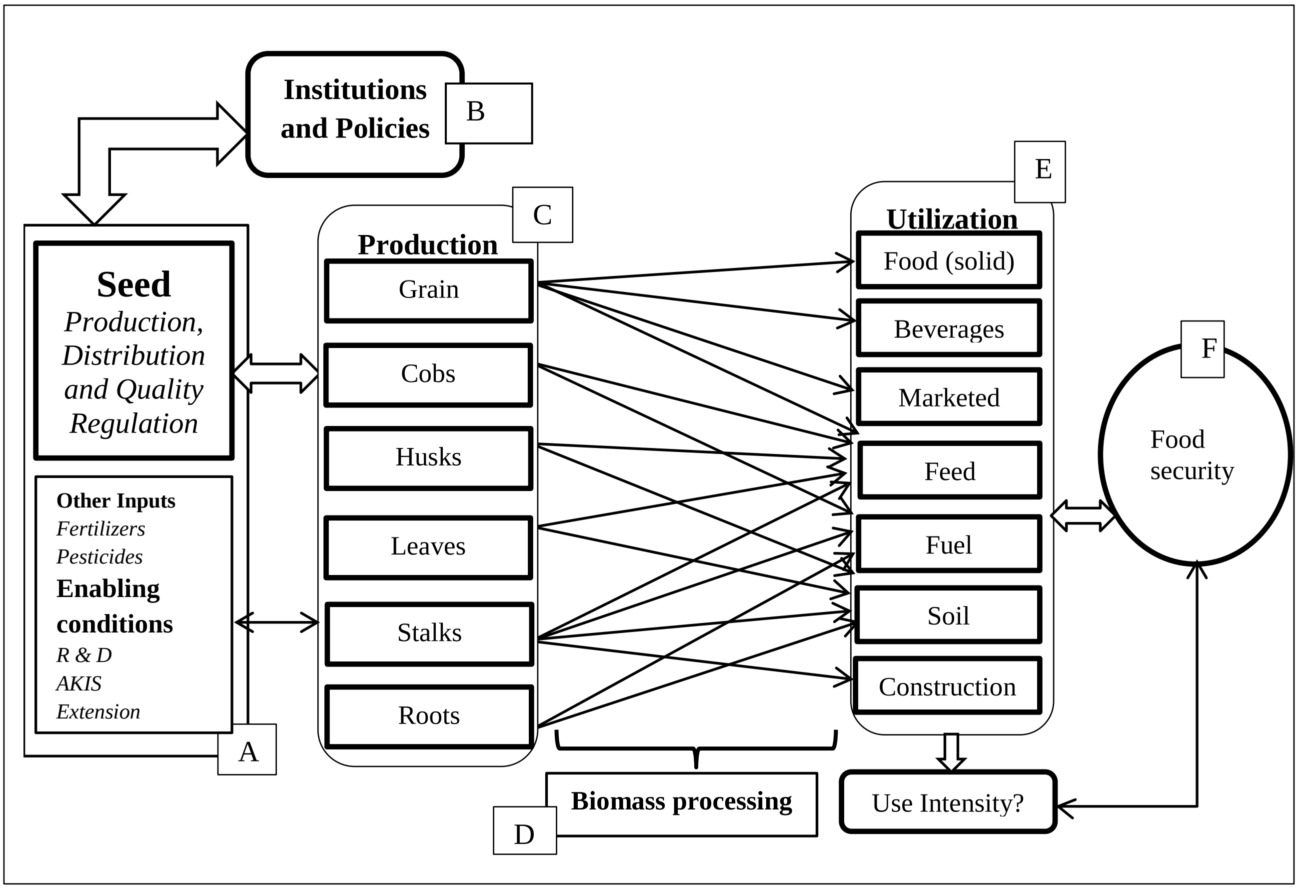

Figure 1. 1 A conceptual framework on household level maize biomass value-webs and food security

Source: Authors based on (Biomassweb, 2013; Virchow et al., 2014)

The conceptual framework in Figure 1.1 depicts production (C), processing (D) and consumption of biomass for numerous purposes (E). After biomass harvest, post-harvest handling activities and primary processing may or may not be performed before consumption. After biomass processing, it could be utilized at the household level by family members or pass onto consumers through wholesalers, retailers or by producers directly. This reflects the complex process on the flow of biomass and interaction among actors and activities. It is however argued that political and economic contexts are important to understand the challenges and opportunities in local and national biomass productions and consumption decisions (Müller et al., 2015). Thus, contextual factors such as inputs and enabling conditions (denoted by A) and the institutional arrangement and policy environment governing these contextual factors (denoted by B) are crucial to enhance biomass production. Of inputs, an efficient and well-functioning seed system that supplies good quality hybrid maize seeds is vital for production and effective utilization of biomass and to support the development of the bioeconomy. Biomass production further reinforces back and stimulates influences contextual factors in general and seed system in particular (denoted by A) and policies and institutions (denoted by B).

Biomass production increases availability of food but does not guarantee food security. It is evident that food security has got four pillars: availability, accessibility, utilization and stability of food (FAO, 2008). This expands our inquiry on the utilization of the different components of maize for several competing uses (denoted by E) and its implication for food security (F) through productivity or income effects. For instance, stalks can be used for feed, fuel, for farm and house fencing and part could also be left on the farm to enhance soil fertility. The same applies to other components as shown in Figure 1.1. In addition to use of components of maize for single purpose, intensity of use (use diversification) could influence food security outcome which the study seeks to explore. Thus, this study focuses on the pre-production factors, particularly on the hybrid maize seed quality regulation and seed distribution (Chapters 2 and 3, respectively), and the role of farm households' post-production decisions on the use of different components of maize for several purposes (C to E) and its implications on household food security (E to F) (Chapter 4).

1.6 Description of the study area

The study was conducted in the maize belt of Ethiopia. Oromia and the Amhara regions are the two largest maize growing regions. Of these two regions west Gojam and west Shewa zones are the leading producers of maize in the Amhara and Oromia regions, respectively (CSA, 2014; Warner et al., 2015). From the two zones, three districts were selected purposively. The two districts, Mecha and Wonberma are found in west Gojam. Mecha and Wonberma districts are within the administrative zone of West Gojam which administers 14 districts. Mecha and Wonberma are located 540 and 450 km north west of Addis Ababa, respectively (see the study map in Chapter 3 of the thesis). The total projected population of Mecha and Wonberma districts, respectively, is 334,789 and 116,229 (CSA, 2013). Bako Tibe is one of the twenty districts in West Shewa zone. It is located 250 km west of Addis Ababa, with a total population of 151,201, of which about 79 % live in rural areas (CSA, 2013). The first two districts, Bako and Mecha, are the leading maize growing districts in Oromia and Amhara regions, respectively (Warner et al., 2015). The third district, Wonberma, is model in terms of community based or cluster-based seed multiplication. These districts broadened the scope of our analysis as they better represent maize dominated production system and livelihoods and allowed the study to examine governance and institutional issues in the maize seed as well as grain production systems.

1.7 Methodology

The overall approach was a mixed method that combined qualitative methods with household survey. From the household survey, we got data for the second and third papers. This section only presents the overarching methods of the qualitative methods and the household survey, while the detailed explanation on the methods for each case study is presented in the subsequent chapters.

Qualitative approach

The qualitative approaches used for data collection includes Process Net-Maps (PNM), focus group discussions, key informant interviews and direct observation. PNM is a qualitative tool used to visualize consecutive steps of implementation process, and analyzes governance challenges (Birner et al., 2011). A total of nine PNMs were conducted based on focus group discussions and interviews with experts at federal to local levels in order to understand processes and uncover the governance challenges in hybrid maize seeds production, certification and distribution and marketing systems. Besides, eight focus group discussions (FGDs) with smallholder maize and seed producers in Mecha, Bako and Wonberma districts were conducted to understand process of hybrid maize seed production, certification and distribution and marketing systems. Additionally, key informant interviews with experts working for government, seed enterprises, researcher centers, poultry farms, feed and food processing firms were made to collect pertinent information about seed system and the use of components of maize and the challenges therein. Data collection was held in two rounds; the first round was held between July 2015 and January 2016 while the second round was conducted between February and March 2017.

Household survey

Quantitative data for the second and third case study were collected via household survey. The survey covered 325 randomly selected maize growers in two selected maize growing districts, Bako and Mecha. The purpose of the survey was to collect data on farmers' preferences for attributes of hybrid maize seed distribution system, production and uses of the different components of maize biomass and food security profile of households.

In the household survey, a choice experiment (CE) was conducted with same number of farmers to examine their preferences for attributes of the hybrid maize seeds distribution system. CE is a flexible tool for eliciting individual preferences by asking respondents to state their choice across different hypothetical alternatives, *ceteris paribus*, unlike revealed preferences which rely on actual conditions (Adamowicz, Louviere, & Swait, 1998; Mangham et al., 2009). Implementation of the CE however followed a series of procedures that required qualitative analysis, especially in identifying the choice attributes (Carlsson & Martinsson, 2003; Kløjgaard et al., 2012; Mangham et al., 2009). The household survey thus benefited a lot from the qualitative approach.

As a result, eleven attributes were identified using the FGDs with maize farmers. To have an optimum number of attributes for the CE, we ranked and selected only six attributes namely seed purity, quantity, group formation, sales outlet number, credit and price which scored at least half of the maximum score. The status quo levels were identified and defined in the FGDs, and the hypothetical levels were constructed with reference to the status quo levels and farmers' expectations on the direction of change in the levels the attribute. Having known the attributes and their levels, ten choice sets containing three alternatives including the status quo were generated by following the D-optimal design approach with the help of JMP software. The choice experiment data were then analyzed using the discreet choice model called Latent Class Model.

Yet data on maize biomass production and utilization were analyzed using composite techniques. The intensity of biomass use and the food security profile of households were measured using Hirschman Herfindahl index and food consumption score, respectively. The casual relationship between intensity of biomass use and food security was modeled using an endogenous switching regression technique.

1.8 Thesis layout

The thesis is divided into five chapters. Chapter one provides an introduction of the overall thesis. The second chapter deals with the institutional arrangements and the governance challenges in hybrid maize seed quality control. The third chapter deals with pertinent issues of hybrid maize seed distribution. More importantly, it presents findings on the governance and institutional challenges in hybrid maize seed distribution and identify which attributes of the seed distribution system matter the most to maize farmers. Chapter four presents results on farm households' post-production decision on the diverse usages of maize biomass and its relationship with household food security. The last chapter summarizes the main findings of the thesis and lessons drawn from this empirical work. The thesis identifies areas of bottleneck in enhancing maize sector productivity and for the development of bioeconomy in Ethiopia.

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Chapter Two: Institutional arrangements and governance challenges in regulating seed quality in Ethiopia

Abstract

Ensuring access to good quality hybrid seeds remains a major challenge to cereal production in Sub-Saharan Africa (SSA). In Ethiopia, like many SSA countries, the seed sector is plagued with the problems of quality regulation, certification and dominance of informal seed sourcing, among other governance challenges. Since 2013, seed quality regulatory role has been decentralized in Ethiopia in order to enhance access to good quality seeds, particularly of major cereal crops such as maize. However, there is dearth of empirical evidence on how this measure has improved efficiency of the regulatory system and in turn, helped in better quality seed production. This study examines the institutional arrangement and regulatory framework for hybrid seed production and certification. It maps the processes of seed multiplication and certification for both public and private enterprises, identifies the various actors involved in these processes, and uncovers the governance challenges therein. Data were collected through Process Net-Maps, key informant interviews and focus group discussions in three purposively selected districts. While there is some evidence to believe that the decentralized seed regulatory system has led to improvements in seed certification services, there are several governance challenges that continue to affect the seed system negatively. The hybrid seed production is largely dominated by public seed enterprises, which lacks the incentive to maintain robust internal seed quality control. The certification agency is deprived of both human and physical resources. Moreover, the study found that seed inspectors, laboratory analysts and samplers often compromise on seed quality standards. The seed testing process is influenced by vested interests and seed enterprises are often able to circumvent the system. Farmers' participation and interest is neglected and there is an overall lack of accountability in the seed certification and quality control processes. By investigating the roles of different actors in the seed system, the study suggests ways to improve the system through enhancing internal as well as external quality control mechanisms, redefining certification standards, and by making the certification services transparent, participatory and cost-effective.

Keywords: *hybrid maize seeds; seed quality; seed certification; agricultural transformation; Ethiopia*

2.1 Introduction

Ensuring access to good quality hybrid seeds is crucial for bridging the yield gap in cereal production in Sub-Saharan Africa (SSA), and in turn enhancing food security as well as in development of bioeconomy. A bioeconomy comprises the knowledge-based production and use of biological resources to provide products, procedures and services varied economic sectors (Börner, Kuhn, & Braun, 2017). In Ethiopia, the growth in the maize sector, one of the most important bioeconomy crops is stagnated with current yields falling below three tons per hectare, when the potential is estimated to be about six tons per hectare (Abate et al., 2015; Rashid et al., 2010). Hybrid maize seeds, it is argued, can bridge this gap and enhance the potential of the maize sector (Alemu et al., 2010; Rashid et al., 2010). However, maintaining good quality standards from seed sourcing to multiplication and certification stages remains a challenge (Alemu et al., 2010). In the last two decades, many SSA countries have promulgated seed laws and have developed regulatory mechanisms for seed quality control and certification.Yet, vast majority of farmers are dependent on informal seed sourcing, which is often poor quality and low yielding (Erenstein et al., 2011). The reforms in seed quality regulation thus far are not so encouraging and have not translated into substantial productivity gains (ISSD, 2017). How to ensure quality control in hybrid seed system remains a major governance challenge as far as agricultural transformation in SSA is concerned.

Seed quality regulation supports the supply of certified seeds to farmers. A well-functioning seed system encourages quality assurances by seed producers themselves internally and by external certification agency (ISSD, 2017). Internal quality assurance practice consists a set of activities undertaken by seed producers to meet certain internally crafted standards. Whereas the external quality assurance mechanism possesses packages of services provided by an external certification agency against stipulated standards and procedures. Seed certification activities by external include field inspections, laboratory analysis and labeling and packaging (EBA, 2016). The final seed users, farmers, rely on this service as they cannot visually inspect seed quality, and their productivity is largely dependent on the quality of certified seeds received. In many SSA countries, certification is run by the public and characterized as less responsive to the demands of service recipients, and the service is more oriented towards enforcement and control (ISSD, 2017; USAID, 2013). Another challenge in such certification modality arise from setting up of unattainable seed quality standards, the extent in which the system allows participation of other actors such as seed producers, community organizations and seed users (farmers), and lack of transparency in the control system which encourages rent-seeking, especially where inspections are predominantly undertaken by under-paid public servants (Louwaars, 2005). In the context of Ethiopia, there is a dearth of empirical evidence on the governance challenges in the seed quality control mechanisms, which is the main subject matter of this study.

The debates on seed quality regulation are largely dominated by two conflicting views points. The rights group argue that seed laws and regulations criminalize farmers and rather protect breeders and seed enterprises (GRAIN, 2015). Transaction cost economists, on the other hand argue that seed laws protect farmers from buying sub-standard seeds as they do not have perfect information about the inherent quality of the seed unlike seed sellers (Josling, Roberts, & Orden, 2008). Furthermore, seed laws have the potential to set rules of the market for seed suppliers and create a ‘level playing field’ (Louwaars, 2005). A related contestation in the literature within the external quality control via certification has been as to whether certification ought to be voluntary- “truth-in-labeling” or compulsory. The former has been the case in most advanced countries like the USA where seed companies label the truth for own reputation unlike seed companies in the developing world. Beyond these mainly ideologically driven arguments ‘for’ or ‘against’ seed regulation, in countries such as Ethiopia, there are insufficient empirical studies on the issues of seed quality control. This study aims to fill this gap and suggest ways to enhance quality in hybrid maize seed multiplication and certification.

The Ministry of Agriculture has been responsible for developing seed laws and quality assurance procedures and also effecting them in all commercial seeds (Atilaw, 2010). Since 2013, because of the increasing number of seed producers and size of seed land, the responsibility of seed quality control has been decentralized[1]to respective regions.

[1]New proclamation Proc. No. 782/2013(FDRE, 2013)

In a bid to have an efficient regulatory system which not only offers quality certification services to seed producers but also protects farmers from accessing sub-standards seeds, regional governments have undertaken reforms which constitute establishing of seed quality control and quarantine authorities under the regional law. To what extent have these reforms enhanced seed quality control? And what are the major bottlenecks in the reformed system and how to overcome those? These are the main questions addressed in this study.

The study attempts to examine the institutional arrangements in seed quality control and analyzes the governance challenges therein. The study mainly relies on qualitative data collected using Process Net-Maps, key informant interviews and focus group discussions in three purposively selected major maize growing districts in the Amhara and Oromia regions. While there is some evidence to believe that the reformed seed control system has led to improvements in seed certification services, there are several governance challenges that continue to affect the seed system negatively. The hybrid seed production is largely dominated by public seed enterprises, which lack the incentive to maintain robust internal seed quality control. The certification agency is deprived of resources both human and physical to provide full ranges of seed certification services. Moreover, the study found that seed inspectors, laboratory analysts and samplers often compromise on seed quality standards in exchange of own benefits. The seed testing process is influenced by vested interests and seed enterprises are often able to circumvent the system. Farmers' participation and interest is neglected and there is an overall lack of accountability in seed certification and quality control processes. By investigating the roles of different actors in the seed system, the study suggests ways to improve the system through enhancing internal as well as external quality control mechanisms, redefining certification standards, and by making the certification services transparent, participatory and cost-effective.

The rest of the paper is structured as follows. Section 2.2 outlines the seed quality control systems in selected developing countries, followed by the seed quality regulatory system in the contexts of Ethiopia. The later section presents a timeline of the key milestones in the Ethiopian formal seed system in general and the seed quality control in particular. Section 2.3 discusses the methodology and data collection. Main results and significant findings are presented in section 2.4 and the key analytical points are discussed in section 2.5. Following that, important conclusions from the study and policy recommendations are suggested in the last section.

2.2 Seed regulatory system: Selected country experiences and challenges

This section is divided into three parts. It begins with an overview of literature on seed quality control experiences in select countries. The second section provides review of major governance challenges in seed regulatory systems of select countries. The third section presents an overview on key milestones in Ethiopia's seed system and the governance challenges, more importantly, in seed quality regulation.

2.2.1 Lessons learned from selected countries: seed certification

Sub-Saharan African countries cereal productivity is by far lower than any other part of the world. The region also performs the lowest overall in the EBA seed indicators that looked at the performance of the seed variety registration, plant breeding and seed quality control (EBA, 2017). Experience of countries on seed quality control has shown different levels of government involvement (Louwaars, 2005). In the USA certification is often a voluntary service. This reflects general confidence in the regulatory effects of the market. In the European member countries, seed certification is voluntary for vegetables but required for field crops (USAID, 2013). The world banks survey result in its enabling the business for agriculture research team showed that out of the 40 countries surveyed, 31 established a mandatory government-run seed certification system for cereal seed (EBA, 2016). Public institutions have thus developed the mandate and legal backings for 'policing' seed quality (Louwaars, 2005). In the context of Africa, there is a mixed approach as far as certification is concerned. Kenya has the third largest seed industry in SSA next to South Africa and Nigeria (Sikinyi, 2010; USAID, 2013). Seed certification is required for field crops but not for vegetables. The Kenya Seed Company, a parastatal, dominates field crops but has been giving ground to new entrants, especially for hybrid maize (Sikinyi, 2010; USAID, 2013). In South Africa, seed certification is voluntary for all crops. South Africa's seed industry is linked to international breeding compared to other African countries. This provides the system to introduce more new varieties each year, and has the largest domestic market

(USAID, 2013).In Burkina Faso, seed certification is mandated to the government and inspectors from the National Seed Service. Seed farms are inspected less frequently (maximum of three times) than expected (four times) due to shortages of material and human resources. The peculiar aspect in the certification process is that seed producers responsibility to transport the entire seed to a common regional central warehouse for certification at their own cost (ISSD, 2017). In South Sudan, the type of seed quality assurance mechanism is called self or own-control. This means that seed producers in the formal seed system have to engage seed inspectors for field and seed inspection. Additionally, they have to send seed samples to the research center for laboratory testing on pay basis, which about 3 USD for a sample and 16 USD for the certificate (ISSD, 2017).

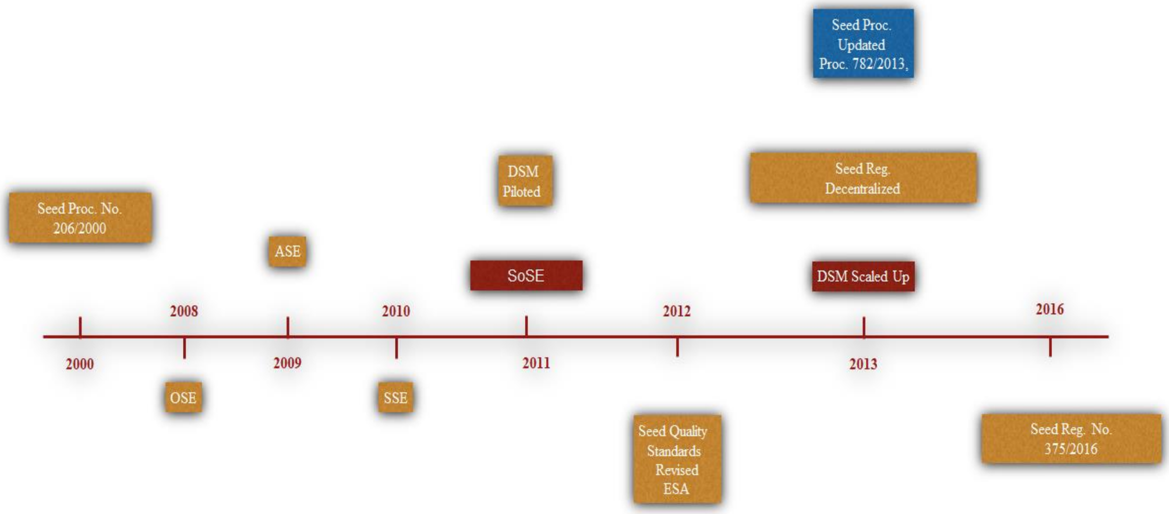
2.2.2 Governance challenges in seed regulatory system: from the lens of "good governance"

Regulations can be designed to resolve challenges in a particular system. It is argued that regulation could be designed to overcome governance challenges and ensure "good governance" in a particular system (Birner & Linacre, 2008). It is clear however that there is no universal and consistent definition of good governance. For instance, Kaufmann (2009) defined good governance by taking several dimensions such as voice and accountability, rule of law, political stability and absence of violence, government effectiveness, regulatory quality and control of corruption. Similarly, the British and Irish Ombudsman Association (2009) defined using the principles of good governance such as independence, openness and transparency, accountability, integrity, clarity of purpose and effectiveness. These definitions to some extent share some elements. In the context of seed quality control, independence refers to the power of seed certification agencies to make decisions without the influence of external body in the process of seed certification. Openness and accountability designates the nature of the process of seed regulation as to how clear the procedures and standards are, and as to how the process provides scope for stakeholder participation. Integrity demonstrates impartiality in regulatory services to service recipients. Control of corruption in regulatory system refers to the ability of the regulatory system in closing all entry points or incentives for corruption, and safeguards service receipts against misconduct of implementers (Birner & Linacre, 2008). It is argued that seed regulatory system, particularly in SSA including Ethiopia, is inherited from advanced countries where farmers' interest is represented (Louwaars, 2005). As the systems are copied without considering local context of countries, voice representation and farmers participation in seed quality control are ignored as farmers are excluded in the process (Lawrans, 2005). However, there is a critique that standards and procedures of seed certification should consider country contexts if lack of access to good quality seeds to farmers is to be resolved (Wattnem, 2016).

Moreover, it is argued that "best-fit" in the capacity of service providers and service recipients is crucial to ensure meaningful agricultural advisory services (Birner et al., 2009). In this regard, past studies (Alemu et al., 2010; EBA, 2016; Sahlu et al et al., 2012) indicate seed certification agency is limited in terms of number of field inspectors, laboratory analysts and physical resources. Another governance dimension in seed quality control is transparency. In SSA seed quality control lacks transparency, most countries as a result do not have official fee schedules for certification activities that the government performs where third-party certification is not permitted (EBA, 2017). This exacerbates the problem of supply of substandard seeds to farmers. Another good example on the problem of transparency had happened in Uganda where test completed and sold as hybrid maize in local markets in 2015 were often not as advertised (EBA, 2017). Similarly, Gorfu et al. (2012) in the context of Ethiopia underscored that standards of seed certification lack clarity and some quality attributes such as seed health are not sufficiently addressed.

2.2.3 Ethiopian context: A snapshot on timeline of key milestones in the seed system

The key milestones in the Ethiopian seed system can be summarized under the themes of seed production, distribution and quality laws and regulations. With regards to seed production, the bulk of the country's cereal seed production including maize was in the hands of the public seed enterprises, predominantly the Ethiopian Seed Enterprise (ESE) until recently. Following the decentralization of seed production to regional governments in 2008, the system has shown significant increments in the number of seed enterprises. Reginal governments established their own public seed enterprise within their respective jurisdiction. For instance, Oromia Seed Enterprise (OSE), Amhara Seed Enterprise (ASE), South Seed Enterprise (SSE) and Somalia Seed Enterprise (SoSE) were established in Oromia, Amhara, southern and Somalia regions, respectively as cascaded on the figure 2.1. This makes the current number of private and public SEs to be more than 30.



Source: Authors based on Alemeu et al, 2010, Benson et al, 2014 and MOA, 2017

Figure 2. 1 Timeline of key milestones

The second important milestone in the seed system is the distribution and marketing of seeds. Until 2011, distribution of hybrid maize seeds regardless of private or public seeds was channeled through state-sponsored cooperatives. Inefficacies in the monopoly of seed distribution triggered a policy shift towards a new marketing approach called the direct seed marketing (DSM) which has been piloted since 2011 and scaled-up to over 30 districts in 2013 (Benson, Spielman, & Kasa, 2014). DSM allows direct interaction of seed producers with farmers through multiple channels including primary cooperative or private dealers. The third important milestone happened in the seed quality regulatory system. There exist are two seed quality control mechanisms in Ethiopia; own or self-control or internal carried out by seed producers themselves and certification by the external certification agency. Regarding seed certification, until 2013, the ministry of agriculture was the sole entity to prepare as well as effect seeds laws through centrally administered seed laboratories and field inspectors. In 2012, the Ethiopian standards authority revised seed quality standards.

And in 2013 the seed proclamation was updated, and seed quality control system was decentralized to regions. This reform has thus transferred central government's role to regional governments to regulate all seeds produced within their territory.

How these millstones have been unflooded and what quality related challenges have so far been empirically identified? These are very essential questions to explore deeper having seen such millstones in seed quality control system. Benson et al.(2014) identified two seed quality related challenges based on a survey of seed sellers and maize farmers. The first challenge which is streamed from the survey of seed sellers is the marketing of carryover stocks of seeds of two or three years old. Control of such seeds remains a challenge. The second quality problem obtained from the survey of farmers is that farmers complained to seed producers about problems of germination, insect damages and quality of packaging. As a result, competition among producers on seed quality by allowing direct interaction with farmers via the direct seed marketing (DSM) program was expected to overcome the challenge. Despite the DSM, a transaction cost economics based study by Husmann (2015) found multiples of quality deteriorating factors such as shortage of basic seeds, lack of support for own breeding efforts, lack of capital for private seed enterprises to invest on quality attributes, high transaction cost of breeding as breeding has often been done in remote areas and isolated plots of land, dominance of the public in setting seed price.

Seed quality possesses multiple dimensions. In this regard, it is argued that seed quality constitutes five dimensions; genetic content, physical purity, purity of the variety (mixture), vigor and seed health (Minot et al., 2007). In view of this, a pre-reform qualitative assessment by Gorfu et al. (2012) argue that despite seed health is central to ensure seed quality, the seed system paid less attention to it. In addition, Sahlu et al.(2012) and Alemu, et al. (2010) identified imbalances in terms of capacity of seed testing laboratories and personnel contrasted with demands for certification as the diversity of the seed system is growing, and seed production and conditioning have been increasingly taking place in more dispersed locations. However, in-depth post-reform empirical account on the institutional arrangement and the governance challenges in seed quality regulation is lacking. This study fills the gap in knowledge by examining the seed production and quality control systems and governance and institutional challenges.

2.3 Methods and data

This is a qualitative case study in which data were collected using qualitative techniques such as Process Net-Maps, focus group discussions, key informant interviews and direct observation of seed farms, seed processing plants and quality testing facilities. Data were collected from three purposively selected districts, Bako, Mecha and Wonberma. The two, Bako and Mecha, are leading maize growing districts in Oromia and Amhara regions, respectively (Warner et al, 2015). The third district, Wonberma in the Amhara region, is a model in smallholder-based seed multiplication. Data collection was held in two rounds: the first round between July 2015 and January 2016 and second round between February and March 2017.

Process Net-Map is a qualitative tool that visualizes consecutive steps of implementation process, identifies actors involved and analyzes governance challenges (Birner et al., 2011). The PNMs were conducted sequentially. In the first phase, the respondents were asked to describe the implementation process step by step, and to identify the actors involved in each step. The actors are written on stickers and pinned on a large flipchart. The implementation steps are drawn by arrows between the actor cards. The arrows are marked with numbers and the implementation steps that correspond to every number are explained at the bottom of the Net-map. In the second phase, the respondents were asked to indicate where potentially bottleneck such as corruption in the implementation process can occur. Finally, individual PNMs were aggregated with the identified actors, paths of the process and potential areas for governance challenges to occur explained in the individual PNM's to depict the complete picture of the process of implementation of seed production and certification. A total of nine PNMs were conducted; seven based on expert interviews with experts at the Ministry of Agriculture (MOA), BOA and plant seed quality control and quarantine authority (hereafter, PSQCQA) and seed enterprises (SEs, hereafter) to understand the process and governance challenges in seed certification. Two PNMs were conducted based on focus group discussion with maize seed farmers in Wonberma district to understand process of cluster-based seed multiplication and identify the bottlenecks.

A total of eight FGDs with smallholder maize growers and seed farmers were conducted in the three study districts. Of these, six FGDs were with smallholder maize farmers in Mecha and Bako, and two with smallholder maize seed producers in Wonberma to understand the process of smallholder-based seed production. Additionally, experts at the federal, regional and district government offices and experts, heads of SEs and farmers were consulted to understand the governance challenges in relation to hybrid maize seed production and certification system.

2.4 Results

This section first provides highlights the menses of seed production and the governance structure. The second section presents the results on the governance challenges in seed production and quality control mechanisms followed a section on process of certification and the governance challenges therein.

2.4.1 Diversity of actors and challenges in hybrid maize seed production

Currently, the Ethiopian seed system entertains four types of actors involved in certified seeds multiplication. These include public, private, cooperative unions and transnational seed companies all these four types together form the formal seed system which supplies only less than 10% while the remaining is obtained from the informal seed sourcing, which is local, saved and exchanged by farmers (MOA, 2017). Of this the share of production of certified seeds by the public is above 85% although varies by crop which is between 65-70% for hybrid maize seed. The challenges in relation to access to land and source of basic seeds are analyzed by seed enterprises types are examined if these factors contributed for the low participation of the private. Access to basic seeds is an important input to increase production of certified seed and ensure quality. In the current seed system, all types of seed enterprises, except transnational companies, obtain basic seed largely from the national research system. Whereas transnational seed companies such as Pioneer rely on imported parental lines. Except transnational seed companies, all SEs are agents of public as obtain basic seed from the

National Institute of Agricultural Research (NIAR) and solely rely on public maize varieties.

In our qualitative assessment we found that there are about five ways to access to land; own land, state farms, TVET college farms, land of smallholders and large-scale investors. Public seed enterprises have been using all forms of arrangements of land for certified seed multiplication. Compared to public, other SEs; private, cooperative unions and transnational seed companies have a limited access to land for seed production as elucidated in diagram 2.2. Access to state and TVET farms is limited to public seed enterprises. The two options, land of smallholders and large-scale investors, are the dominant and commonly used means of access to land for all types of SEs. This has an implication on production and transaction costs. Outsourcing to smallholders or large-scale investors requires engagement and negotiation between the two parties on a series of issues which increase the transaction cost for registered seed enterprises. Besides, it has implications on seed quality control efforts as seed farms are fragmented.

IV. Transnational SEs A. Access to land i. *Large-scale investors* B. Source of basic seeds: imported	**I. Public SEs** A. Access to land i. *Own* *ii. State farms* *iii. Large-scale investors* *IV. Clustered smallholders* *V. TVET* College farms B. Source of basic seeds: NIAR
III. Cooperative Unions A. Access to land i. *Clustered smallholders* B. Source of basic seeds: NIAR	**II. Private SEs** A. Access to land i. Own ii. *Clustered smallholders* B. Source of basic seeds: NIAR

Source: Authors based on key informant interviews

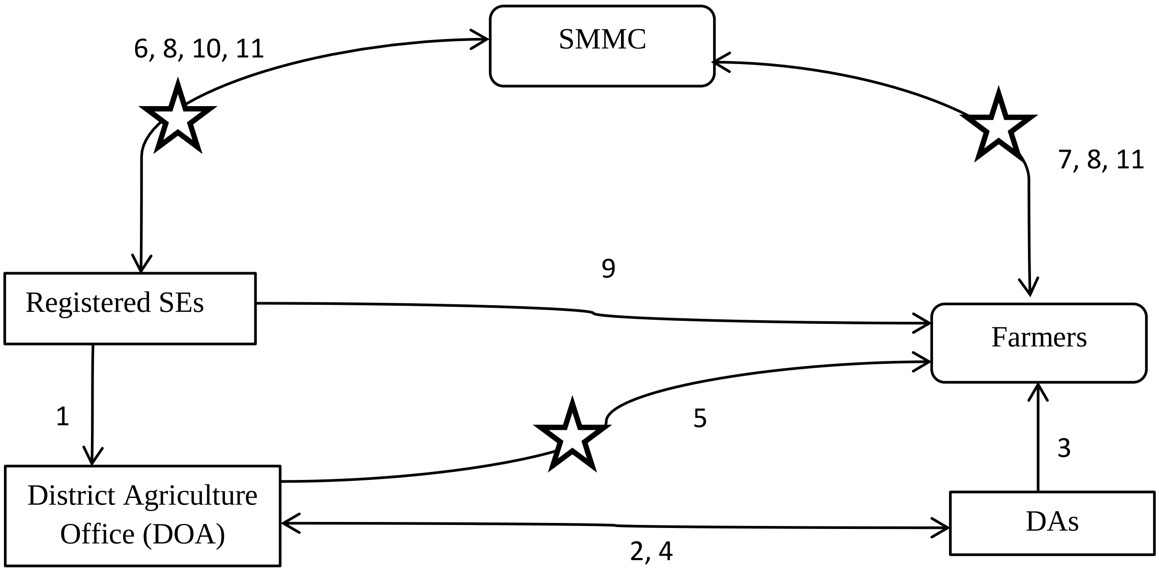
Figure 2. 2 Diversity of actors in seed multiplication in Ethiopia

For instance, one of our key informants who is a manager of one of the seed enterprises in Ethiopia explained that:

> As far as production is concerned, we don't have our own farm. But we outsource after carefully identifying farmers and investors who own land with size of 50 hectares and above and have capital equipment's and technical experts in the area of seed production and multiplication. Once we settle these issues and signed the contract, we provide them our parental lines which we import from abroad for free. For instance, this year we have more than 2000 ha of hybrid maize seed from a total of 19 farmers in Oromia .[2]

Thus, except transnational companies, all SEs (quadrant I, II and III) have been using the cluster-based approach for seed multiplication. This has been taken as a way not only to bypass access to land criteria for newly entering SEs while applying for competence license but also serves as an alternative mode of seed multiplication for already registered land scare SEs. This approach also creates a new market opportunity for maize growing farmers facing problems of access to maize market. This has a bigger implication on the seed regulatory system and deriving insights on how it functions, and how it supports or challenges seed quality control efforts. Using the PNM, the processes of implementation of the cluster-based seed multiplication in Wonberma district is depicted on Figure 3 are explained. First, new or registered SEs interested in this way of seed multiplication, contact district office of agriculture (DOA) (step 1). The DOA assigns DAs to work on clustering of farmers (step 2), and DAs cluster farmers (step 3). DAs report the total land size and number of smallholder farmers clustered for seed multiplication to the DOA (step 4). DOA assigns SEs to the different clusters (step 5).

[2]Interview with manger of a seed enterprise, December 4, 2015



1. SEs request the DOA for clustering of farmers
2. The DOA assigns DAs to this purpose
3. DA's mobilize and cluster farmers
4. DAs report number and site of clusters to the DOA
5. DOA assigns SEs to different clusters
6. SMMC signs a contractual agreement with SEs

7. SMMC signs a contract with farmers
8. SEs supply basic seed to farmers via SMMC
9. SEs provide technical support via their own agronomists since planting stage
10. SEs collect all seeds (delays)
11. SEs effect payment to SMMC (delays)

☆ -Denotes bottleneck areas

Source: Authors' aggregation of PNMs

Figure 2. 3 Process of clustered based hybrid maize seed production

Following assignments of SEs to the different clusters, a formal contractual agreement is signed between the SE and SMMC on behalf of the clustered farmers (step 6). The SMMC, then signs a contractual agreement with individual farmers in line with the provisions of the agreement with the SE (step 7). SEs then supply basic seeds to SMMC (step 8). Clustered farmers plant the seeds according to the working rules and norms set by members of the cluster (step 9). Agreed upon rules and norms govern interactions and guide seed production activities like land preparation, planting, weeding, de-tasseling[3], harvesting, cob-selection and cleaning. All members of the cluster are supposed to abide by the rules and regulations, and violations are subjected to punishments. If for instance one member fails to de-tassel on the date scheduled for de-tasseling and harvesting of seed, others do the job and the one who fails to do so faces

[3]It is the stage in which flowers are removed from the female parent line

punishments accordingly. After harvest, farmers handover the seed to the SMMC, and SEs collect all seeds and effect payment to SMMMC accordingly (step 10 and 11).

In this form of arrangement, two issues that have implications on the sustainability of the approach and also on the quality of seed come out of our focus group discussion with maize seed farmers; seed selling price and choice of what variety and to which SEs to multiply for. With regards to seed price, there are two pricing strategies. The first pricing mechanism, common in case of maize seeds, is an agreed up on price per quintal at the time of contracting with SEs before commencement of seed production. The second pricing mechanism, often the case for wheat seeds, is by adding percentage premium (often ranges between 10 to 20%) on current grain price. The second important element in this kind of arrangement is farmers' variety and SEs choice. Framers choice of seed variety and SEs are not considered in this mode of seed multiplication. The DOA is in charge of clustering of farmers and assigning of SEs to different clusters regardless of farmers choice.

2.4.2 Challenges in cluster-based hybrid maize seed production

The results of our focus group discussion held with maize seed farmers in Wonberma district indicate that farmers in the cluster have better opportunity to sale maize seed with a higher price than grain maize. The current agreed upon farmers' seed price per quintal is 950 Ethiopian Birr, which is almost three-fold of the price of grain maize. As a result, it reduces farmers transaction cost of selling of grain maize to consumers. However, seed farmers have been experiencing some challenges. The first constraint that could negate the possibility of expanding this mode of seed multiplication by engaging large number of farmers is the shortage of the basic seed in the right quantity and type, and the high cost of basic seeds. One key informant explained the challenge as follows:

> The problems we have are many. The most pressing ones are the high cost of basic seeds and fertilizer. The cost of basic seeds we are paying for the SE is very high, and price of fertilizer is increasing every year for the reason

> we do not know. The price of our seed we are getting from the SE however remains fixed and decided during the contractual agreement.[4]

The continued engagement of seed farmers in this mode of multiplication apart from income obtained depends on the degree of autonomy in choosing the type of hybrid variety and the seed enterprises to whom to multiply for. However, it is noted from the words of the key informant that variety and SE choice are decided by the district. The district extension officers who do the clustering assign of seed farmers assign SEs to the different clusters. One key informant explains:

> I would have been very happy if I had the chance to multiply Limmu hybrid seed variety [local name of Pioneer variety] since it has higher yield than what I am multiplying now.[5]

Nevertheless, when it comes to production risks and uncertainties, seed farmers are liable to all cost of production failures caused either by natural factors or rejections by seed inspectors. Another governance related challenge that comes out during our focus group discussion with seed farmers is that the cluster-based mode of production is not inclusive as it only allows few farmers. Imbalances between demand and supply of basic seeds exclude other smallholders' farmers who are willing to participate in the cluster-based seed multiplication. Another challenge for participating farmers is that SEs delay collecting of seeds and effecting payments to the respective clusters in time. In addition to this, lack of access to seed production supporting infrastructures is another challenge. One of our key informants, a management committee of SMMC explained:

> … The regional government in recognition for our contribution in seed multiplication has awarded us this seed processing machine. However, we are not using it because of power shortage. It has been idle for long as you see. Another challenge we have now is lack of access to combiner harvester. So far we rent from private owners. We sometimes face difficulties in accessing the machine when we need it.[6]

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[4]Interview with a seed multiplying farmer, Wonberma district, March 9, 2017
[5]Interview with a seed multiplying farmer, Wonberma district, March 9, 2017
[6] Interview with member of management committee of SMMC, Wonberma, March 10, 2017

Seed quality assurance efforts in the due course of multiplication and primary processing at the farm level, problems such as power cut for instance hinders seed cooperative from doing so. Seed enterprises capacity to collect the seeds multiplied by cooperatives is very limited and this delay contributes for quality deterioration.

2.4.3 Seed quality control

Seed quality control consist internal quality control by seed producers and certification by the certification agency. This section first presents internal quality control mechanisms and challenges. The second sub-section presents the process of seed certification by the "external" certification agency and the governance challenges.

State of the art and constraints in internal seed quality control

Maintaining seed quality maximizes profit and marketability of seeds. Quality of seeds can be maintained or deteriorated along production process. Experience of SEs in seed quality control internally includes field inspection and lab test. Field inspection and demands SEs to hire inspectors, and lab testing also needs recruitment of lab analysts and establishment of lab facilities. Thus, the strength of SEs internal seed quality control largely depends on these factors. In view of this, Table 2.1 presents different seed enterprises, and their access to these factors to effect internal seed quality control. In case of seed multipliers producing for a particular SE, quality inspection is carried out by office-based inspectors of the contractor SE and experts of out growers as shown in table 2.1. This is a customary practice by both public and private SEs. Quality control during routine seed growth stages such as de-tasseling, weeding, fertilization and harvest are contracted to out growers. Some SEs (Anno for instance), however, do field inspection using own farm-based agronomists. Frequency of farm inspection particularly during de-tasseling stage contributes for seed quality which is a function of distance. This is where the office vs farm-based inspection idea comes in. One of our key informants, from the sides of private seed enterprise, explained that they are aware of the impact of proper de-tasseling, which they believe that it makes a substantial difference in seed quality."[7]

Table 2. 1 Internal seed quality control experience by seed enterprise type

[7] Interview with a farm manager August 3, 2015

No	SEs contacted	Type of SE	Own laboratory	Field Inspection
1	ESE	Public	Yes	Out growers +office-based inspectors
2	ASE	Public	No	Out growers +office-based inspectors
3	OSE	Public	No	Out growers +office-based inspectors
4	Anno	Private	No	Farm-based agronomists
5	Yimam Tesema	Private	No	Out growers +office-based inspectors
6	Merkeb	Coop. Uni	No	Out growers +office-based inspectors
7	Gibe-Dedesa	Coop.Uni	No	Out growers +office-based inspectors
8	Pioneer	Transnati.	No	Out growers +office-based inspectors

Source: authors based on key informant interviews

In addition to field inspection, laboratory-based quality testing is an integral part of the internal quality assurance system. Thus, SEs take samples and test quality using own labs. The reality on the ground however indicates that only few public seed enterprises (e.g. ESE) own seed testing labs. Majority of SEs, both private and public, mainly depend on field inspection because of challenges to establish facilities. One of our key informants explained:

> We know that quality is important, and we remain in the business and retain customers if we can produce quality seeds. However, ensuring quality requires many things such as own processing and cleaning plant, proper storage facilities and quality testing labs. However, all of these require capital and access to land but are unable to afford them so far.[8]

It is drawn from the above key informant that the main reasons why SEs, particularly the private, stick to apply only field inspection to maintain quality is due to lack of capital and land to establish lab facilities. As a result, the larger share of responsibility to control seed quality and protect farmers from accessing substandard seeds is mandated to the certification agency.

[8]Interview with manger of a private seed enterprise, Bahirdar, October 25, 2015

Seed Certification

Following the new seed law, regional governments shall undertake seed quality control within their respective boundary for domestic markets (FDRE, 2013). Generally, three things are crucial in seed certification; setting certification standards, field inspection and lab tests. All seeds produced for commercial purposes must qualify certain standards stipulated by the ESA in collaboration with the MOA. Seed certifying body thus relies on these standards that include field level and laboratory standards.

Certification standards

Standards are the bases to effect seed certification. Different generation (pre-basic, basic and certified seeds) have dissimilar standards shown in table 2.2. The standards comprise field level and laboratory standards. The field standards comprise issues such as isolation of seed farm from adjacent farms and crop rotation. For certified seed production, isolation must be isolated minimum of 300 meters from adjacent farms to minimize possible contamination caused by wind or insects. Furthermore, a minimum of a one-year crop rotation is required.

Table 2. 2 Minimum requirements for hybrid maize seed certification

Characteristics	**Breeder, Pre-basic seed**	**Basic seed**	**Certified Seed**
Field standards			
Rotation (minimum year)	2	1	1
Isolation (minimum meters)	400	400	300
Off type & type & another cultivar (max. %)	0.1	0.1	0.1
Pollen shedding heads in seed parent at flowering (max %)	0.2	0.2	0.2
Laboratory standards			
Pure seed (min. %)	99	99	98
Weed seed (max. %)	N. S	0.2	0.3

Infested/infested/ Seed (max. %)	N. S	0.2	0.5
Inert mater (max. %)	0.5	1	2
Germination (min. %)	90	85	85
Moisture content (max. %)	13	13	13

Note: "N.S" not specified

Source: ESA, 2012

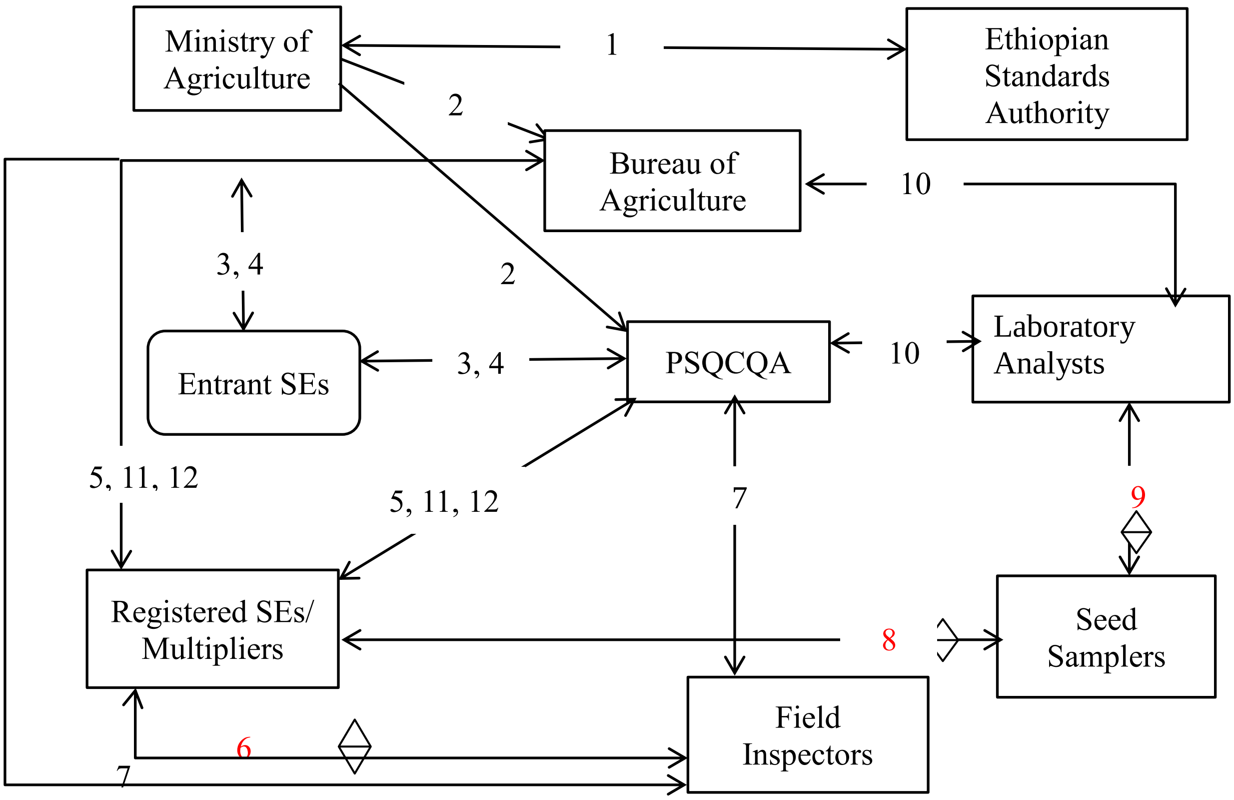
Laboratory standards address germination rate, purity and moisture content of the seed. As per the stipulated standards in table 2.2, the minimum germination rate, minimum purity level and maximum moisture content for certified seeds are 85%, 98% and 13%, respectively. There is a clear deviation in terms of the perceived level of seed quality and the minimum quality standards stipulated. Results of the focus group discussion in the case study districts of Bako and Mecha show that seed quality has been a major concern for farmers, and the perceived level of quality of seed distributed in terms of germination, yield potential, defects and mix-ups with off-types does not exceed 75%. This begs the question of what attributed to this deviation which leads to examine the processes of seed certification and the capacity of the certifying body.

Seed certification implementing bodies have established seed testing centers in different location within their region. At the national level, a total of 16 seed quality testing centers are available; four in Oromia and Amhara each, three in South, two in Tigray, one in Gambelia, Benishangul and Addis Ababa each. These centers are administered by either the regional Bureaus of agriculture or the regional certification agency. For instance, the Amhara regional state has established a semi-autonomous entity called PSQCQA. This authority has established four centers in Bahirdar, Debre-Markos, Dessie and Gonder. Yet in Oromia region, Bureau of Agriculture (BOA) is mandated to administer the four centers[9]; Ambo, Assela, Shashemene and Nekemte.

[9] Only Ambo and Assela laboratory centers are fully functional so far

Process of seed certification

Figure 2.4 demonstrates the process of seed certification. The process has two levels. The first level constitutes law making and standard setting bodies. The ESA in collaboration with the MOA develops certification standards and directed to implementing bodies (step 1 and 2). The second stage elucidates the law enforcing actors and the process that goes along implementation. This phase can be sub-divided into three phases; pre-certification assessments, field inspection and lab testing and certification. First, the BOA (in case of Oromia region) and the regional PSQCQA (in case of Amhara region) certify and issue competence license to entrant SEs (step 3 and 4) according to regional standards. The second level (steps 5) enters when the registered SEs request the BOA or PSQCQA to conduct an early field level inspection. With this request, the BOA/PSQCQA conducts early inspection through field inspectors. At this stage, inspectors check the validity of competence license, sources of basic seeds, land isolation and crop rotation standards and provide feedback to SEs (step 6). Furthermore, inspectors provide inspection report to the BOA/PSQCQA (step 7). Three to five times of field inspections during pre-flowering, flowering, pre-harvest, harvest and post-harvest periods is expected to be done. Inspections over these growth stages are done to make sure that quality deteriorating factors are controlled adequately. For instance, field inspectors during flowering stage aims to check whether de-tasseling is done properly or not to avoid seed contamination. And during pre-harvest inspection crop estimation of the seed farm is done. Feedback of field inspectors could reach up part or total rejection of the seed farm if it fails to conform to stated standards. Field level inspection results of seeds of SEs determine whether lab test should be done or not.



1. MOA cooperate with the ESA and develop standards 2. MOA provides standards to regional authority (BOA or PSQCQA) 3. Entrant SEs apply for competence license 4. Review and approval and registration by the BOA /PSQCQA 5. Registered SEs request the BOA/PSQCQA early inspection 6. Field inspectors in the BOA/PSQCQA inspect seed farms and provide feedback to SEs 7. Field inspectors report inspection result to the BOA and PQQCA irrespective of result 8. Samplers take samples from stores of SEs	9. Samplers code, decode and register the sample seeds on the seed registry book/ledger and give it to lab analysts 10. Lab analysts code samples, and test purity, moisture and germination, and report test results to center head 11. BOA/ PSQCQA registers lab result on the registry book and announce to respective SEs and issue tag based on crop estimation 12. Dissatisfied SEs appeal to the BOA/PSQCQA for retest ◇ Entry point for governance challenge

Source: Authors' aggregation of PNMs

Figure 2. 4 Process of hybrid maize seed certification

The third phase of implementation process (steps 8 to 11) goes to lab for seeds which qualify the field inspection. During this phase, field inspection qualified SEs request the centers for lab testing. With this request, certification bodies send seed samplers to draw samples from seed stores of SEs. Samplers take samples according to recommended sampling techniques to ensure representativeness. Size of samples taken can vary by crops while it is one kilogram per lot[10] for maize (step 8). Samplers then code, decode and register drawn sample seeds on seed registry book/ledger of the center and handover sample seeds to laboratory analysts for testing (step 9). Seed laboratory analysts' code and register samples received and conduct lab testing and report results to center head (step10). Center heads after registering test results in the seed test result registry book announce test results to respective SEs and issue the required number of tags as per results of crop estimation (step 11). SEs whose seeds fail to comply with standards and fail to pass laboratory and dissatisfied with test results can request the BOA/PSQCQA for retest (step 12).

Governance challenges in seed certification

Along the implementation process of certification, several governance challenges occur. Triple areas in implementation process are identified for governance challenge such as corruption to occur. The first area where corruption can occur is at the field inspection phase by field inspectors. During this phase, inspectors can compromise stated standards in exchange of financial or other forms of incentives provided by SEs. For instance, the number of certification tags issued to SEs is decided based on crop estimation carried out by field inspectors. Field inspectors can compromise estimations which entitle SEs to obtain excess number of tags from the certification agency. This encourages SEs to sale seeds produced from rejected farms or adulterated seeds. The second area for governance challenge to occur is during sample taking by seed samplers. Seed samplers, though are expected to draw samples according to sampling strategies to ensure representativeness, can compromise for own benefit from SEs. The third area for governance challenge occurs because of lack of confidentiality of certification process. Lab testing for instance is carried out in labs of the centers which host samplers, laboratory analysts and field inspectors. This erodes anonymity of the process and encourages compromise of overall results for joint gains. Besides, the lack of full autonomy of certification centers to exercise full power is very limited. As public funded certification agency, there is a tendency of seeing public seed enterprises as partners which has the notion of that- "All fingers are not equal."

[10] One lot is equals to 400 quintals for maize across crops

These governance challenges are not the results of poor implementation of certification standards rather combined with other effects of hardware related constraints.

Profiling capacity of quality testing centers: what constraints?

"Best-fit" between capacity of seed certification agency and standards, at the field and lab levels, determines performance of certification service. Of course, it is argued that both the capacity of service providers and service recipients in demanding quality service from service providers are equally important to ensure service good governance and quality service. With this background, we took two seed quality testing centers, Ambo and Bahirdar, to make a case with a focus on their working set-ups in terms of human and physical resources, scope of the services (area of land and number of SEs) and compare changes resulted because of the reform.

Table 2. 3 Seed production attributes and resource profile of seed quality testing centers

No	Avenues	Bahirdar (2 zones)			Ambo (11 zones +[11])		
		3 yrs. before	Now	%Δ	3yrs. before	Now	% Δ
1	Seed multipliers (No)	10	17	41	5	15	66
2	Seed production sites	5	10	50	5	11+	55
3	Seed land size (ha) aprox.	1200	3200	62.5	2000	7000 +	72
4	Field inspectors (No)	2	4	50	1	3	66
5	Lab analysts (No)	2	2	0	1	2	50
6	Number of samplers (No)	1	1	0	1	1	0
7	Total staff (No)	6	18	66	3	18	83
8	Avrg. salary/month in ETB	3000	3900	30	3000	4000	33
9	On job training freq.(max/yr)	1	2	50	1	2	50
10	Mean distance to seed farms	-	80km	-	-	120km	-
11	Number of vehicles	1	1	0	1	1	0
12	ESA accredited?	-	No	-	-	No	
13	Certification fee	-	No	-	-	No	-

Source: Authors based on expert interviews between February and March 2017

For the purposes of analysis, we grouped the avenues listed in table 2.3 into four; scope certification, resources profile, cost of certification and accreditation status of quality

[11]Some SEs, (e.g.OSE and Pioneer), multiply seed in Benishangul region while lab testing is mandated to Ambo center

testing centers. Scope of certification covers issues about number of seed multipliers, seed production sites and size of seed land to be inspected within the command area of the centers before and after reform. In three years' time, the number of seed multipliers demanding certification service increased by 41% and 66% in Bahirdar and Ambo centers, respectively. Seed production site also increased by 50% and 55% and size of seed land increased by 63% and 72% in Bahirdar and Ambo centers, respectively. The second crucial element is the resource profile of the centers; both human and logistical resources available to discharge certification services. Currently, there are four and three field inspectors in Bahirdar and Ambo centers, respectively. These inspectors are expected to inspect all seed farms. This number was even less than by 50% and 66% three years ago. Compared to increments in the scope of certification, increments in the number of inspectors and lab analysts are incomparable. In fact, it is not the number that matter but also quality of personnel's. In this regard, attempt was made to enhance capacity of field inspectors and thereby support inspection process by assisting it with GPS technologies to map seed farms and estimate crop yield. However, the required expertise to use GPS by staffs is very limited among the staffs. This has been explained by one of our key informant that:

> Since last year we have been assisting our field inspection with GPS system after receiving training by ATA. It helps us identify and locate seed farms although we are struggling to properly use it as we do not have GPS expert in our center.[12]

The number of laboratory analysts increased by 50% in Ambo and remained same in Bahirdar center. The number of samplers remains constant in both centers. The total number of staffs increased by 66% and 83% in Bahirdar and Ambo centers, respectively. Currently, the average frequency of on job training offered to field inspectors, lab analysts and samplers is twice a year. Additionally, physical or logistical resources such as vehicles support mobility of certification experts (inspectors, samplers) in discharging certification service. Mobility is a function of distance and costs of fuel. The mean distance from Bahiradar and Ambo centers to seed production sites is about 80 and 120 km, respectively. The two centers own one vehicle each to support mobility to seed

[12]Interview with center head, Bahirdar center, March 5, 2017

farms, seed processing and storage sites. The lack of access to means of transportation negates timely provision of certification service which in turn delays timely distribution of seed. One beneficiary of certification service explained:

> In earlier times, they were named as seed agency. We inform the center about our land size and whereabouts so that they come and inspect our land. They do not often come during vegetative stage rather come during flowering stage and measure isolation and count flowering randomly on our farm. Maximum they perhaps visit us two times a year.[13]

Technically, laboratory test focuses on seed germination, purity and moisture attributes. The centers have not yet developed the capacity to adequately diagnose seed health related problems which can damage seed quality. One of our key informants explained that;

> Capacity of seed quality testing centers in diagnosing seed health problems, for instance the recently emerging seed virus threat, is very much limited. The surprising part is the decision to reject seeds as a solution regardless of quality because suspicion without developing the capacity to test.[14]

The last important avenue with regards to certification services is cost of certification and accreditation status of the centers. So far, certification service has been given for free and there is no clear indication about fee rates and schedules to share costs with service recipients. On top of this the two quality testing centers are not certified yet by ESA, which is in charge of setting standards and certifying of laboratories.

[13] Interview with manager of a seed enterprise, December 24, 2015
[14] Interview with manager of a seed enterprise, December 24, 2015

2.5 Discussion

The discussion section has two parts. The first part discusses important findings on seed quality related attributes in hybrid maize seed production. The second part discusses Seed quality assurance mechanisms and the challenges.

2.5.1 Seed production: quality incentives and limiting factors

In Ethiopia, hybrid maize seed production happen happens at various scales by both private and public seed producers. The two key, if not the only, production factors influencing production of quality seed supplied are access to land and basic seeds.

Seed multipliers obtain basic seeds from the national research system. The public sector, except for few transnational seed companies, is the sole supplier of basic seeds. This shows high degree of dependence on public as far as access to basic seed is concerned. On the other hand, transnational companies have multiple sources as they import from various sources at the international markets. The single source of basic seeds limits variety choice of SEs which in turn diminishes the possibility of supplying of good quality seeds to the market. According to Langyintuo et al. (2010) following liberalization of seed sectors in eastern and southern Africa, the number of seed companies increased four-fold while quantity of seed barely doubled between 1997 and 2007. The limited and inefficient transfer of genetic materials from the public to the private sectors has been argued one of the factors behind this disparity. Overreliance on the single source of basic seeds further jeopardizes research and development efforts of SEs which curtail supply of good quality seeds to farmers.

Regarding access to land, there appears a significant different between private and public SEs. Public SEs have multiple ways to secure access to land including use of state farms, farms of TVET colleges, land of large-scale investors and smallholder farmers. SEs other than the public have a limited access to land hence predominantly rely on smallholders'. The increased use of such form of arrangement to access land for seed production undeniable raises the degree of dispersion of land and in turn the cost of seed quality control. Furthermore, this has implication on cost of production and the competitiveness of seed producers, particularly for the private sector.

2.5.2 Seed quality assurance mechanisms

This section first discusses challenge related to internal seed quality control, followed by a section on the governance challenges in seed certification.

Internal seed quality control (self-control)

Own or self-control mechanism is a seed quality assurance mechanism carried out by SEs internally. Self-control mechanisms include field inspection and quality testing laboratories of SEs. The main factors driving SEs towards enforcing strong internal quality assurance mechanism via own field inspectors and laboratories are available incentives in the market; price incentives and market shares. However, in Ethiopia's seed sector, market incentives have been paralyzed as seed pricing has been largely determined by public SEs forum, and SEs overwhelmingly depend on varieties of the public. This has the potential to crowd out private seed producers and discourages SEs from applying effective internal quality control strategies. Additionally, most SEs do not have quality testing laboratories but rather solely rely on field inspection. This strategy however is very costly particularly in case of dispersed and smallholder-based seed production system. Current experiences show that SEs hire agronomists (often one to two agronomists), who are based in the office, to assist seed producers. The frequency of assistance by office-based agronomists is a function of distance and access to means of transportation. In this regard, farm-based agronomists would provide relatively better support as observed in the case of Anno around Bako area. Weak internal quality control practices further add a burden on the certification agency. In this regard, the position of internal quality control in the overall regulatory system either complementary or substitute to seed certification has not been clearly stated.

Seed certification: governance challenges

Certification is the second level of quality assurance mechanism in the Ethiopian seed system. Following the seed laws, institutional frameworks, standards and procedures have been put in place to provide certification services. As a result, this body has been responsible for bridging the information gap between seed producers and seed clients. Quality and performance of the certification services provided by this body however depends on the clarity of certification standards, capacity of the certification, and political incentives to materialize stipulated standards (Kjær, 2017; Poulton, 2014). Besides, the degree of independence of the certifying body to exercise full authority, its ability to control corruption, degree of transparency of certification process and scope for stakeholder participation. In addition, quality of the certification service requires capacity of final service recipients (maize growers) in demanding the service.

In light of these parameters, the certification process does provide opportunities for several governance challenges to occur. The first and foremost challenge is the lack of clarity of procedures and inspection standards. As stated in certification standards for certified seeds production, frequency and times of field inspections are not clearly stated. Thus, there is no consistent understanding as to when and how often seed farms should be inspected by field inspectors. This creates a disincentive for SEs to invest on seed quality and would rather opt for rooms to bypass inspection. The second governance challenge emanates during sample taking. Samplers while taking samples compromises standards and commit biases for own benefits and thus samples lack representativeness which in turn affects test results. This indicates that the system provides the opportunity for inspectors and samplers to compromise stated standards for own benefit. Additionally, there is lack of anonymity in the process of testing seed quality as samplers, laboratory analysts and field inspectors are both employees of the same center who even might even share office. This provides them to develop a rent-seeking behavior by compromising quality standards. This indicates that the reform in seed quality regulation fail to capture corruption.

Interventions pursued to overcome governance challenges in field inspection are made. For instance, use of GPS assisted inspections for mapping seed farm sites, estimating crop yield. This however, has been a subject of quality of staffs in applying of GPS and GIS knowledge, which remained a bottleneck in the seed quality testing centers. Another governance challenge regarding seed certification is the lack of independence of the certifying body that excludes private and civil society organizations. Samplers, inspectors and laboratory analysts undertaking certification are employees of the public and hence autonomy can be easily eroded by appointees of public institutions. Furthermore, cost ineffectiveness of the service is another challenge as certification service is provided for free which exacerbate public burden.

Capacity of seed certifiers

Capacity of seed certifiers is crucial to ensure good governance in seed quality assurance system. It is argued that best marriage between the software (institutions) and the hardware (capacity of the regulatory institutions) determines quality of seed certification service being provided (Birner et al.,2009). Inspection service covers wide ranges of activities including checking the authenticity and validity of SEs competence license, inspection from planting, de-tasseling, harvesting, point of sale and post distribution. Our results, however, indicate a clear implementation gap by the certifying body, as the centers are under resourced and have not developed the full capacity yet to inspect all farms and aspects of seed during seed production and distribution. The number as well as quality of inspectors, samplers and lab analysts is very low. The continuous learning opportunity to acquire new skills and new knowledge via training is also very limited. Previous study by Sahlu et al., (2012) and Alemu et al. (2010) found a similar capacity related challenges such as shortage of human and physical resources to effect seed certification. Thus, limited capacity of certifiers delays timely certification and in turn timely distribution of seeds. Additionally, we found that the scope of lab testing is limited to purity, moisture and germination rate of the seed. Yet seed health issues are unaddressed though remain important as researchers (e.g. Gorfu et al.(2012)) consistently found. Inadequate field inspection and monitoring service such as point of sale, post-distribution and seed health aspects, remain uninspected and thus create a condition for seed adulteration and black markets. Alemuet et al. (2010) argue that most seed production plots are visited less frequently than stipulated.

Voices and accountability in seed certification

It has been argued that ensuring quality of certification services need requires participation and capacity of both parties (Birner et al., 2009; Birner & Linacre, 2008). The prime responsibility of the certifying body is to be voice of farmers and thereby safeguard them from substandard seeds. As discussed in section 5.2, the process of certification is non-inclusive as it excludes farmers. Moreover, it is argued that it is not only the capacity of the certifying body that determines the quality of seed supplied but also the capacity of maize seed users in demanding this service. Thus, farmers' awareness about seed certification is important to hold seed certifying body accountable. However, farmers' awareness about certification is low and hence ensuring accountability in the seed certification remained a challenge. The level of education of farmers in understanding and distinguishing of certification tags and seed labels is very limited. On top of this, the paper tags can be spoiled, duplicated easily and they are found very rarely which is consistent to earlier findings of Alemu et al. (2010).

2.6 Conclusion and policy implications

SSA seed system has been dominated by the informal seed sourcing that supply low yielding varieties. Enhancing cereal productivity using high quality seed varieties has thus been taken as a priority to boost cereal productivity. In Ethiopia, several measures have been taken at the policy level since 2008 to improve maize seed production, distribution and quality regulation. Nevertheless, the fruits of these measures in ensuring access to high quality seeds for farmers are not ripened for several reasons. The effectiveness and efficiency of the seed quality regulatory mechanisms, internal and certification, aimed at safeguarding seed quality have been questioned, and requires a thorough examination on what challenges debarred the systems from delivering quality seed. This is the objective of this study which explores the institutional arrangements and the governance challenges in the maize seed production and regulatory system.

The findings of this study highlight the governance challenges in seed quality regulation. Seed quality attributes cannot be ensured through certification. Availability of incentives and driving factors for seed enterprises to compete on quality are equally important though eliminated in the Ethiopian seed system. The hybrid seed production is largely dominated by public seed enterprises, which lack the incentive to maintain robust internal seed quality control. The certification agency is deprived of resources both human and physical. Moreover, the study found that seed inspectors, laboratory analysts and samplers often compromise on seed quality standards. The seed testing process is influenced by vested interests and seed enterprises are often able to circumvent the system. Farmers' participation and interest are neglected and there is an overall lack of accountability in the seed certification and quality control processes. By investigating the roles of different actors in the seed system, the study suggests ways to improve the system through enhancing internal as well as external quality control mechanisms, redefining certification standards, and by making the certification services transparent, participatory and cost-effective. The study further suggests the importance of assisting of GIS and GPS technologies by hiring skilled experts to assist inspection and as a check and balance for field inspection. Overcoming of these governance challenges would help to not only to ensure access to quality seeds and enhance yield at the national level but also fosters harmonization of regional seed law and facilitate transfer of spillovers of seed varieties and the development of bioeconomy.

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Chapter Three: Seed Distribution Reform and Farmers' Choice: Implications for Agricultural Development in Ethiopia

Abstract

Inefficiencies in the state-controlled hybrid seed distribution system have for long been identified as one of the main reasons for the lack of growth in Ethiopia's maize sector. Important changes in the seed distribution policy introduced in 2011 ended the monopoly of state-sponsored cooperatives and made direct seed marketing by both public and private enterprises possible. As farmers can now choose between different seed providers, the question arises as to which attributes of the seed distribution system do farmers prefer, and to what extent the constituents of the reform and farmers' preference for the distribution attributes converge. And what are the governance challenges in the new seed distribution system? The paper addresses these questions with a mixed methods approach including, focus group discussions, Process Net-Map, and choice experiment with 325 randomly selected farmers in two locations. Farmers' preference for six attributes, namely seed purity, quantity, group formation, sales outlet number, credit and price were modeled using the Latent Class Model (LCM). Based on qualitative analysis, our study identifies potential entry points for corruption and other governance challenges in the reformed distribution system. Our model result shows homogenous and positive preference for attributes like seed quality, sales outlet and credit by the majority of farmers, while preference for attributes like seed quantity, price and group formation is heterogeneous and context specific. The study identifies farmers' preferences in terms of how they would like to access hybrid seeds and recommends ways to overcome the governance challenges in seed distribution in Ethiopia.

Keywords: *Hybrid maize seed distribution; governance challenges; reforms; Process Net-Map; choice experiments; latent class model; Ethiopia*

3.1 Introduction

Global experiences have taught us that agricultural transformation is possible through the use of modern inputs, such as improved seeds. In spite of this, ensuring access to high-quality seeds for smallholder farmers has remained a challenge in many African countries (Erenstein et al., 2011; Langyintuo et al.,2010). The dominance of the public sector, lack of competition, information asymmetry, and high transaction costs have been identified as the main causes for inefficiencies in the seed systems (Alemu et al., 2010; Benson et al., 2014; Erenstein et al., 2011; Husmann, 2015; Langyintuo et al., 2010). The situation is even worse in cereal dominated agrarian economies, such as Ethiopia, where cereals contribute to about 65% of the agricultural GDP and about 70% of crop land (Diao, 2010; Taffesse et al., 2011). Maize is one of the most important cereal crops in the country, both for food security and livelihoods. The maize production in the country is largely dominated by smallholder farming, and contributes to about 95% of the total maize area and production (Abate et al., 2015). Studies show that it is the leading cereal crop in terms of production, area of land-coverage (more than two million hectares), and supports about nine million farm households (Abate et al., 2015; CSA, 2014). However, the growth in the maize sector is stagnated with current yields falling below three tons per hectare, when the potential is estimated about six tons per hectare if farmers use proper agronomic practices (Abate et al., 2015; Rashid et al., 2010). Hybrid maize seeds, it is argued, can bridge this gap and enhance the potential of the maize sector (Alemu et al., 2010; Rashid et al., 2010).

In spite of the significance of increasing yields through hybrid seeds, the maize area covered by improved varieties grew from 14% in 2004 to 40% in 2013 (Abate et al., 2015). Currently, however, only about 16% of maize planted area is covered with hybrid maize varieties (Benson et al., 2014). The reasons for the low uptake of hybrid maize seeds are the dominance of the public enterprises and state-controlled cooperatives, and lack of competition, which results into inefficient seed production, distribution and marketing system. This is particularly the case in the distribution and marketing of hybrid maize, leading to the overall low productivity in the maize sector (Alemu et al., 2010). This drove a policy change from the state-sponsored cooperative based distribution (hereafter, CBD) to the direct seed marketing (hereafter, DSM) program in 2011 and 2012 in pilot districts of the Amhara and Oromia regions, respectively. The DSM program was scaled up to 31 districts in 2013, and its coverage has been increasing since then. Nationwide transition from a state sponsored CBD system to the DSM, however, has not happened yet. The DSM allows seed enterprises (hereafter, SEs) to compete and directly interact with farmers through multiple channels, including private traders, primary cooperatives or development agents (agricultural extension workers). The DSM has been experimented through two modalities. The first modality has been instrumented in the Amhara region and exclusively authorizes primary cooperatives to distribute seeds of all SEs within their respective district. Contrastingly, the second modality, which has been experimented in Bako district of the Oromia region, licenses only private traders to distribute seed of SEs.

Yet, the liberalization of the seed system has not led to substantial decreases in transaction costs (Husmann, 2015). It is generally observed that even after the introduction of DSM, access to seeds in the desired quantity, quality and at competitive prices from multiple sales outlets is yet happening. Moreover, the mode of payment in the new system is cash only. This limits the access to hybrid seeds for cash-constrained smallholders (Benson et al., 2014; Husmann, 2015). There are some recent qualitative assessments about farmers' preference for maize varieties focusing on the physical attributes of the seed, such as yield potential, drought tolerance or cob size (e.g. (Tadesse et al., 2014). However, empirical studies on the governance challenges in the reformed seed distribution and marketing system are yet to emerge. In addition, we do not know which attributes of the hybrid seed distribution system matter the most to the farmers. In other words, what are the preferences of Ethiopian maize farmers in accessing hybrid seeds? This study aims to address these questions. The objectives of the study are to identify the bottlenecks in the seed distribution system under the DSM; to explain why the reforms have not been able to resolve distribution and marketing problems; to identify the attributes of the distribution systems that farmers value most; and to recommend on this basis what future reforms in the seed distribution system need to focus on in order to establish a more vibrant and efficient seed distribution system that accelerates productivity gains of the maize in Ethiopia.

The study applies a mixed methods approach to address the aforesaid problems. Qualitative techniques, such as, focus group discussions (hereafter, FGD), expert interviews and Process Net-Map (a method further explained in section 4 of the paper) were used to identify the bottlenecks in the distribution and marketing system. These methods also assisted us to select the attributes of the distribution system for conducting a choice experiment [15](hereafter, CE) with randomly selected households in Bako and Mecha districts, which are found in the maize-belt of Ethiopia. A total of six attributes of the distribution system, namely seed purity distributed by SEs, quantity accessed, group formation, sales outlet number, mode of payment and price were used for the CE and farmers' preferences for these attributes were modeled using the Latent Class Model (hereafter, LCM). The study finds that the DSM reform has only been partially implemented with substantial regional differences. The paper also identifies areas where governance challenges occur along the process of distribution which, in turn, impede reform outcomes. The LCM results demonstrate positive and homogeneous preferences for suppliers of higher quality seed, credit as an alternative mode of payment, and attributes of the sales outlets. The findings of the paper provide insights to policy makers in their endeavor to reform the hybrid seed distribution system. By focusing on the farmers' perspectives on seed distribution and marketing, the study also bridges the gap between farmers' needs and reform outcomes.

The paper is structured as follows: the following section reviews the literature on seed distribution and marketing in Ethiopia. Section 3.3 provides a brief description of the study areas. Section 3.4 describes research methodology and techniques of data collection. Section 3.5 presents the results of the qualitative assessment of governance challenges in the new system and the findings of the CE. A discussion and analysis of results is presented in section 3.6, followed by conclusions and policy recommendations in the last section of the paper.

3.2 Seed distribution and marketing in Ethiopia: issues and challenges

Access to good quality hybrid seeds remains a challenge in most Sub-Saharan African countries. Qualitative studies in eastern and southern Africa identified the major

[15] Synonymous to discrete or stated choice experiments or controlled experiment

challenges in the seed system. According to these studies, lack of credit for seed enterprises, inefficient transfer of foundation seeds, shortage of land for private seed enterprises, high transaction costs and dominance of the public sector are the main reasons for inefficiencies in the seed system (Erenstein et al., 2011; Langyintuo et al., 2010). In Ethiopia, the situation is not much different; seed system suffers from most of these deficiencies (Alemu et al., 2010; Husmann, 2015).

For decades, Ethiopia's commercial seed system, and the marketing and distribution of hybrid maize seed had been monopolized by the state and state-sponsored cooperatives. The CBD system required farmers to register at a district agriculture office or with agricultural extension workers (referred as 'development agents') for the next cropping season and receive the seeds from either primary cooperatives or the district agriculture office through development agents, usually after four to six months of registration (Alemu et al., 2010; Husmann, 2015). Critics argue that the CBD system limits farmers' opportunity of changing what they had requested earlier and leads to higher transaction costs of traveling back and forth to outlets of the sole distributors. The cooperative unions had the sole responsibility of procuring the seeds from seed enterprises and transporting them to the primary cooperatives, who distributed the seeds to farmers. While the capacity of primary cooperatives has been limited, it has also been observed that the CBD system was skewed in favor of big farmers and investors, as they were more likely to influence the primary cooperatives in accessing hybrid seeds. Overall, this system has resulted in the slow growth of the Ethiopian maize sector over decades (Alemu et al., 2008; 2010).

Taking a cue from the inefficient functioning of the CBD system, the Ethiopian government in 2011 promulgated reforms in seed distribution and marketing (Benson et al., 2014; Husmann, 2015). It was believed that a vibrant seed system that provides quality seeds to meet the demands of farmers was key to boosting agricultural productivity (Alemu et al., 2008; 2010). Further, the reforms were based on the logic that through liberalization and increasing private sector participation, some inefficiencies in a fully state-controlled seed system could be minimized (ibid).

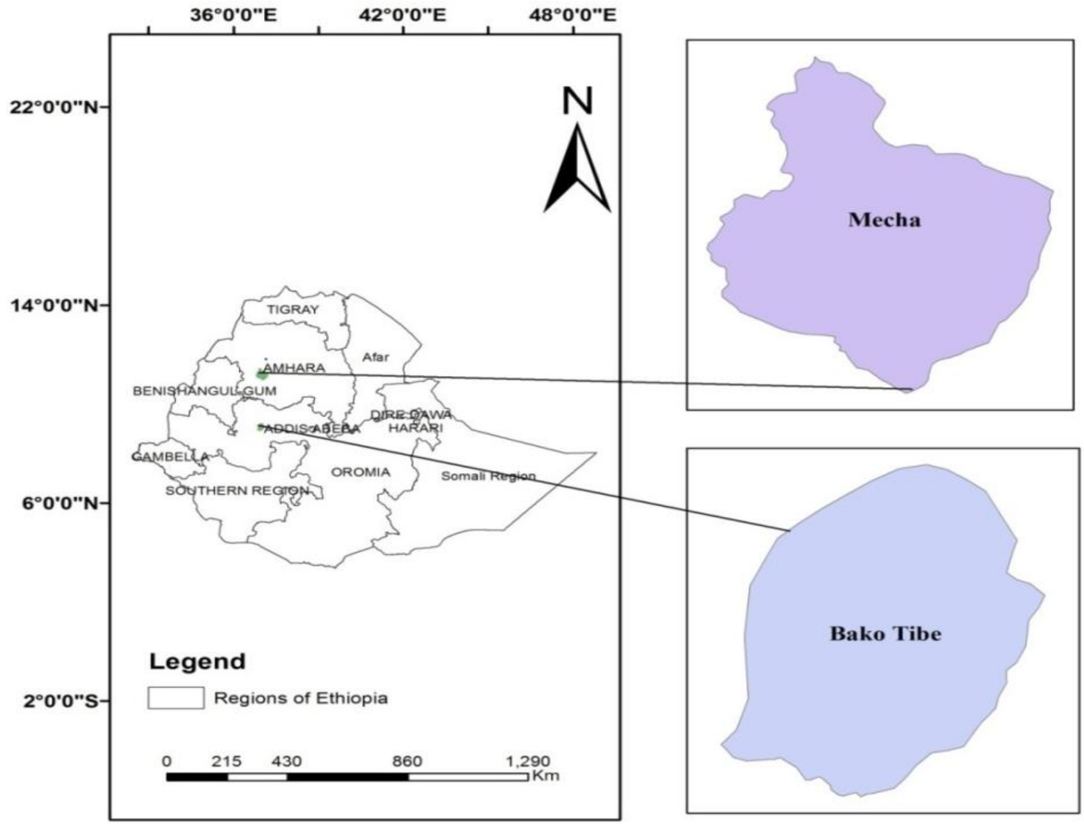
A new distribution system called DSM program was piloted in 2011 in Amhara, and in 2012 in the Oromia and Southern Nations, Nationalities and Peoples regions, respectively. In 2013, it was scaled up across 31 selected districts of the three regions where pilot projects were implemented and expanding every year since then. Under the DSM program, seed enterprises (public, private, transnational and cooperative unions) were authorized to sell hybrid maize seeds directly to farmers through several channels, including private traders serving as agents for the producers, local primary cooperatives, and government extension agents at the sub-district or the district levels (Benson et al., 2014). Conceptually, the DSM program is rooted with the belief that fostering seed sales in a well-regulated and competitive market would improve varietal characteristics and make available the desired quantity at competitive prices. In addition, it was anticipated that the DSM would improve the spatial density of seed selling points, timeliness of provision of seeds, and payment modalities for smallholders (Benson et al., 2014).

Husmann (2015) conducted a study of the Ethiopian formal seed system based on the theoretical framework of institutional economics. Expert interviews were used for data collection. She found some positive outcomes of the DSM such as, better traceability and quality maintenance, and improved trust between farmers and seed providers. Despite these positive signs, the study also identifies some of the challenges in the new system. In 2012, when the data was collected, sales prices were determined by the government. Companies were not allowed to add transportation costs and agro-dealer commissions. This resulted in diminished profit margins for the seed suppliers. Also, the lack of storage facilities and dearth of well-trained agro-dealers contributed to high transaction costs. There has not been any systematic assessment of the overall governance challenges in the new seed distribution system, nor any evaluation of entry points for leakages along the delivery chain. Additionally, we do not know the fate of the DSM since its scaling-up in 2013. This study attempts to fill that gap in our understanding of the functioning of the DSM by combining qualitative and quantitative research methods in an innovative way, as further explained in Section 4.

Which physical attributes of the seed are preferred by farmers? Several studies have attempted to address this question in the context of Ethiopia. A qualitative study by Tadesse et al. (2014), conducted in 2012 and 2013, using a participatory variety selection trials in north western Ethiopia found that attributes such as maturity period, drought tolerance, grain yield, husk cover, cob size, grain color or grain size affect farmers' preference. Similarly, Abera et al. (2013), with 240 randomly selected farmers, found that yield, disease resistance, pest resistance and lodging resistances are the leading criteria farmers consider when selecting a particular variety. Wale (2012) conducted a CE with farmers in northern Ethiopia on factors that trigger farmers to abandon certain traditional varieties of crops. Likewise, Asrat et al. (2010) investigated farmers' teff and sorghum crops variety preferences, using a CE which focused on attributes of producers' price, environmental adaptability and yield stability. The study found that environmental adaptability and yield stability attributes are important from the farmers' perspective when selecting a particular seed variety. What remains unaddressed is the farmers' preference in the attributes of the seed distribution and marketing system. This study is a novel attempt to address this unresolved issue. In addition to farmers' variety preference as analyzed by some of the studies mentioned, governance of the distribution systems and farmers' preferences for the distribution attributes need to be explored. This is done by combining CE, qualitative and quantitative techniques in order to deepen our understanding of the policy reforms and identify factors that may improve the maize seed distribution system.

3.3 Description of study areas

The study was conducted in two maize belt regions of the country, namely Oromia and Amhara, by taking one case study districts, Bako and Mecha, respectively. Bako district is one of the twenty districts in West Shewa zone. It is located 250 km west of Addis Ababa, with a total population of 151,201, of which about 79 % live in rural areas(CSA, 2013). Mecha district is one of the fourteen districts of West Gojam zone located 540 km north west of the country. The total projected population of the district is 334,789, of which 301,182 live in rural areas (CSA, 2013).



Source: Drafted by authors

Figure 3. 1 Map of study sites

3.4 Methodology

As pointed out above, this study uses a mixed methods approach that combines qualitative, choice experiment (hereafter, CE) and quantitative techniques. This section first describes qualitative techniques, followed by the design and implementation of the CE. The last sub-section presents the econometric approach employed to analyze the quantitative data.

3.4.1 Qualitative techniques

The study employed qualitative techniques consisting of FGDs, expert interviews and Process Net-Map to understand. Process Net-Map is a tool used to identify and analyse governance challenges that arise during the process of implementing agricultural and rural development programs (Birner et al., 2011).Thus, six Process Net-Maps based on expert interviews at the Ministry of Agriculture (MOA), Bureaus of Agriculture (BOA) and offices of different SEs were conducted to understand the process of hybrid maize seeds distribution. We asked our interviewees to describe the seed distribution process step by step, and identify the actors involved in each step. The actors are written on varied coloured stickers and placed on a large flipchart. The implementation is then indicated by arrows between actors. The arrows are indicated by numbers to show the implementation step. Then we asked our interviews to pinpoint where bottlenecks, such as leakages, may occur along the process. Finally, individual Process Net-Maps were aggregated with the identified actors, routes of the process and potential entry points explained by each of the interviewees but overlooked by others to have a full-fledged picture of governance in the seed distribution system. In addition, four FGDs (two in each district) with four to five farmers each, and two FGDs (one in each district) with nine participants were conducted. The purpose of the first four FGDs was to prepare lists of attributes that define an efficient and a well-functioning distribution system from farmers' perspective. In the last two FGDs, nine farmers participated in each discussion to rank the attributes identified in the previous four FGDs.

3.4.2 CE design and survey preparation

The CE was conducted through a household survey to understand farmers' preferences to the attributes of the distribution system. CE is a flexible tool for eliciting individual preference by asking respondents to state their choice across different hypothetical alternatives, *ceteris paribus,* unlike revealed preferences which rely on actual conditions (Adamowicz & Louviere, 1998; Mangham et al., 2009). To this effect, a semi-structured survey questionnaire was developed and used. Implementation of the CE followed a series of procedures that required qualitative analysis, especially in identifying the attributes as outlined below.

3.4.2.1 Identification, ranking and selection of attributes

The clearer the survey questions, the better the quality and amount of information collected in a CE (Carlsson& Martinsson, 2003). And the validity and success of a discrete CE depends on the quality of the qualitative processes used for attributes identification, selection and formulation of choice sets (Kløjgaard et al., 2012; Mangham et al., 2009). As a result, the CE utilized results of the six FGDs conducted in identifying and selecting distribution-related attributes. Using the first four FGDs (two in each district), we identified 11 attributes. To have an optimum number of attributes for the CE, we conducted two additional FGDs (one from each district) with nine participating farmers to rank the attributes based on their degree of importance. In the ranking process, all participants of the FGDs were given 10 Ethiopian Birr (ETB)[16] to value each attribute out of 10 based on its importance and degree of urgency in the distribution system. Hence, the maximum value of an attribute is 90 if all participants give 10 ETB, and 0 if all gives nothing. Participants value the attribute and put the value in the ballot box prepared to maintain their confidence and to not be influenced by other participants. Finally, the total value of the attribute is the sum of values given to that attribute by all participants. Finally, we took the average value of the attribute in the two FGDs and ranked the attributes accordingly. In order to draw optimum number of attributes, a selection criterion was imposed. Accordingly, attributes which scored at least half of the maximum value were selected, i.e. 45 ETB.

Table 3. 1 Distribution Attributes and Levels Used to Explain Choice Alternatives

No	Attributes	Description of attributes	Status Quo Level	Hypothetical Levels
1	Sales outlet	Number of seed sales outlet or shops where a farmer can visit or consider while planning to buy hybrid maize	1	2,3,4
2	Seed purity	Perceived level of SEs quality of hybrid maize seed distributed in terms	Supply 75%	SE with 80% SE with 95%

[16] On average, one USD was equals to 20.5 ETB during data collection

		of germination, yield potential, defects and mix-ups with off- types		SE with 99%
3	Seed quantity	Amount of hybrid maize seed a farmer can buy at a time	Limited	Half increment Double increment
4	Group formation	A precondition to partner with another farmer to buy a seed less than the minimum package size of 12.5 kg	Individual/ Group	Individual Group
5	Mode of payment	Percentage of seeds a farmer can buy on credit basis	0%	50%, 100%
6	Price of seed	Average price of one packet, 12.5 kg, of hybrid maize seed in Ethiopian Birr (ETB)	600 (350)[17]	500, 525, 575

Source: Authors

Table 3.1 presents a list of the six selected attributes, their description and context and levels. Accordingly, sales outlet number represents number of shops where a farmer buys hybrid maize seeds. SE's seed quality level represents farmers perceived purity levels of hybrid seeds in terms of yield potential, defects and mix-ups with other off types. Seed quantity refers to an amount of hybrid maize seed a farmer can buy at one time from sales centers. Group formation is a precondition imposed when farmers want to buy seeds below the minimum package size of 12.5 kg for all SEs. This requires a farmer to partner with another farmer who demands the same amount or is willing to buy and share the 12.5 kg packet. Credit mode of payment attribute represents percentage of seeds that farmers can buy on a credit basis. Price attribute represents average price of the 12.5 kg hybrid maize seed. The status quo levels were identified during the FGDs, and the hypothetical levels were constructed with reference to the status quo levels and farmers' expectations on the direction of change in the attribute levels.

[17] Average price of a 12.5 kg of hybrid maize seed of transnational and other SEs (private, public and cooperative unions) is 600 and 350 Ethiopian Birr, respectively

3.4.2.2 Formulation of choice sets

A choice set, or a choice card is a list of alternatives or choices presented to respondents during the choice experiment. The classical full-factorial design is the most efficient technique in designing discrete CEs as it makes it possible to include all choice sets and to estimate the main and interaction effects, independently of one another (Hoyos, 2010). Nevertheless, putting all choice sets in the experiment makes the implementation of the experiment infeasible, technically and economically (Carlsson & Martinsson, 2003; Hoyos, 2010). To make it feasible and to keep the interest of respondents when answering repeated choice sets, the experiment drew few sample choice sets. The D-optimal design approach was implemented to formulate choice sets with the help of JMP software. As presented in table 3.1, there are three 2-leveled and three 3-leveled attributes, making a total of 15 levels. To decide the number of choice sets, we followed the rule of thumb where the minimum optimum number of choice sets is the sum of the number of levels of the attributes plus one minus the number of attributes, which is equals to 10. The choice set contains the status quo and two alternatives derived from the hypothetical levels of attributes. Three in total, are presented as shown in the sample choice card in table 3.2. The full list of the 10 choice cards is enclosed (Appendix 3.4).

The following question was asked to respondents: *If the following are the hypothetical settings and your only choices or alternatives through which seed is distributed, which one would you prefer?*

Table 3. 2 Sample Choice Card

Attributes	**Choice 1**	**Choice 2**	**Choice 3**
Sales outlet number	4	2	**Neither Choice 1, nor Choice 2. I would remain with the current status quo**
Seed purity level	SE with 95%	SE with 80%	
Seed quantity	Half increment	Double increment	
Group formation	Individual	Group	
Credit mode of payment	50%	100%	
Price	500 Birr	575Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 ☐ please tick one option (✓)

3.4.2.3 Sampling and sample size

The study purposively selected Mecha and Bako districts in the Amhara and Oromia regions, respectively. These districts were chosen because both are in the high maize-belts of the two respective regions. In addition, based on crop production rankings, Mecha and Bako stood first and third in maize production, respectively (Warner et al., 2015). After identifying the two districts, three and four peasant associations (PAs) from Bako and Mecha were selected, respectively. The selection of PAs in the Mecha district was based on PA's irrigation potential. In this district, there is an irrigation scheme called 'Koga Irrigation Project'. Some PAs are beneficiaries of it, whereas others are not. As a result, we randomly selected two PAs within and two from this scheme. The purpose of doing so was to account for possible differences in terms of challenges that farmers experience and preference for the distribution attributes. In Bako, unlike Mecha, there was no large-scale irrigation scheme and hence we randomly selected three PAs. Finally, we selected 325 maize farmers randomly (137 and 188 in Bako and Mecha, respectively).

3.4.2.4 Survey and data management

The survey questionnaire was tested at the pre and field levels. Data enumerators were used to conduct pre-field testing where one enumerator interviewed another enumerator acting as a farmer and vice versa. This enabled data enumerator to have be on the same page about the questions. Feedbacks from pre-field level testing were collected, and necessary amendments were made. Furthermore, field level testing was done where all five data enumerators in each district interviewed two farmers within their enumeration area (a total of 20 from both districts). We incorporated feedbacks and produced the final survey questionnaire.

To make the choice process easily understandable for farmers, we prepared and used colored cards through which data enumerators explained and represented each alternative in a choice situation. Farmers were then asked to choose one during the survey which was held between July 2015 and January 2016. The program STATA 12 was used to manage the data. With regards to data structure, the sales outlet and price attributes were entered in cardinal-linear forms. The remaining four attributes have qualitative levels, and hence were coded using dummy coding procedure, which assigns zero to the status quo level of attributes (see Appendix 3.1). This procedure generates L-1 number of variables to all qualitative attributes, where L is the number of levels of each attribute (Bech & Gyrd-Hansen, 2005; Hasan-Basri & Karim, 2013).

3.4.3 Econometric approach

Despite its wider use in valuation of environmental goods and services, the use of CE technique has been growing in areas of consumer goods and services (Hanley et al., 1998). The underlying assumption that popularizes this technique is the possibility of defining demand for goods and services, according to the characteristics of the good or the service, rather than by the good or services themselves. The prime reasons and advantages that drove us to implement the CE technique are twofold. First, the technique permits us define seed delivery service, which is reformed, by the characteristics and drivers of the service. Furthermore, putting farmers in an experiment helps us to probe elements relevant for the system, but overlooked in the reform. The technique, thus, assists us examine convergence and divergence between reform constituents (reform menu) and farmers' preference for the distribution attributes, and thereby derive some policy insights. The most prominent model in analyzing discrete CE data is the conditional logit mode (McFadden, 1974). This model assumes that random terms are independence of irrelevant alternatives (IIA). This assumption anticipates that the ratio of the choice probabilities of any pair of alternatives is independent of the presence or absence of any other alternatives in the choice set. This helps to further assume that respondents' preference largely depends on 'observable characteristics.'

Mixed logit and latent class models challenge the IIA on accounts of preference heterogeneities. A comparative study by Shen (2009) indicates that the LCM accounts for the heterogeneity of preferences better than the mixed logit. Furthermore, LCM specifies the random parameters to follow a continuous joint distribution and assumes that discrete numbers of classes are sufficient to account for preference heterogeneity. Therefore, it helps to capture agents observed and unobserved preference heterogeneity in the population. It also specifies the discretion to approximate the true parameter distribution, instead of assuming normal mixing distribution. It was estimated through expectation maximization algorithm (Pacifico &Yoo, 2012; Shen, 2009). Given this background, the study uses the LCM. Following Adamowicz & Louviere (1998), who noted that data generated from CE are analyzed using utility maximization framework, we thus assume that utility of respondent *n* choosing alternative *i* over option *j* in choice set *C* is given by the utility function:

$$U_{in} = g(\gamma_s, z_n) + \varepsilon(\gamma_s, z_n) \tag{1}$$

g (γ_s, z_n) is the deterministic component explained by the distribution attributes (γ) and the observed socio-demographic characteristics (z) of smallholders, whereas $\varepsilon(\gamma_s, z_n)$ represents unobserved attributes and socioeconomic factors of farmers. Assume $P_n(i|\beta)$ is the probability of respondent *n* choosing alternative *i* conditional on a vector of taste coefficients β, in the general logit form is expressed as:

$$P_n(i|\beta) = \frac{e^{Z_{ni}}}{\sum_{j=1}^{J} e^{Z_{nj}}} \tag{2}$$

Where j is the total number of alternatives, and the observed utility Z_{ni} is given by $f(x_{ni}, \beta)$, which is a function of the attributes of alternative *i* faced by farmer *n* and the vector of taste coefficients β.

In the LCM, heterogeneity in tastes across farmers is accommodated by the use of separate class with different values for the vector of taste coefficients β. The LCM, to which the specification of this study relies on, uses probabilistic class allocation[18] in which attributes are assumed to stay constant across alternatives while the parameters vary across classes, unlike the choice models (Hess & Ben-Akiva, 2011). Probabilistically, farmer *n* belongs to class *s* with a probability of π_{ns} where $0 \leq \pi_{ns} \leq 1$ and $\sum_{s=1}^{S} \pi_{ns} = 1$. As a result, the general logit form of equation 2 needs to be redefined. Suppose that $P_n(i|\beta_s)$ gives the probability of maize farmer *n* choosing alternative *i* conditional on farmer *n* falling into class *s*. The unconditional (on *s*) choice

[18]In a class allocation model, attributes normally stay constant across classes while parameters vary across classes. In a choice model, attributes vary across alternatives while the estimated coefficients stay constant across alternatives.

probability for alternative *i* for farmer n is the weighted sum of choice probabilities across *s* classes, with class allocation probabilities being used as weights, given by equation 3:

$$\mathrm{P}_n(i|\beta_1, \dots \beta_s) = \sum_{s=1}^{s} \pi_{ns}\, \mathrm{P}_n(i|\beta_s) \tag{3}$$

Following (Hess & Ben-Akiva, 2011) and (Hynes et al., 2011), in cases where a respondent responds a series of multiple choice sets in a CE, specification of equation 3 above is extended in the form of equation 4 below:

$$\mathrm{L}_n(j_{n1} \dots . j_{nTn}|\beta_1 \dots . \beta_s) = \sum_{s=1}^{s} \pi_{ns} \,(\prod_{t=1}^{Tn} \mathrm{P}_n\,(j_{nt}|\beta_s)\,) \tag{4}$$

The beauty of the LCM specification, which utilizes the probabilistic class allocation model instead of the choice model, however, arises when class allocation probabilities are not uniform across all farmers and varies according to their socioeconomic characteristics as a class membership factor. Therefore, the probability function is further re-specified in the form of equation 5 by incorporating socioeconomic and demographic factors (Hynes et al., 2011). With z_n giving vectors of characteristics for farmer *n*, and with the class allocation model taking on a logit form, the probability of farmer *n* falling into class *s* by:

$$\pi_{ns} = \frac{e^{\delta_s + g(\gamma_s, z_n)}}{\sum_{l=1}^{S} e^{\delta_l + g(\gamma_l, z_n)}} \tag{5}$$

δ_s is a class-specific constant, γ_s is a vector of parameters to be estimated and $\mathrm{g}\,(\gamma_s, \mathrm{z_n})$ gives the functional form of utility for the class allocation model specified in equation 3. This allows the model to probabilistically cluster respondents into several classes based on the pattern of choice to the distribution attributes. Ensuing to the class allocation probability, deciding the number of latent classes is essential. The common approaches of doing so are the Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC) (Pacifico & Yoo, 2012).

Mathematically;

$$\mathrm{AIC} = -2\ln\mathrm{L} + 2\mathrm{m} \tag{6}$$

$$\text{BIC} = -2\ln\text{L} + m\ln\text{N} \quad (7)$$

Where lnL is the maximized sample log likelihood, *m* is the total number of estimated model parameters and N is the number of observations. The least value of BIC or AIC is considered as break-even point that leaves the required number of classes for analysis (Jaeck & Lifran, 2014). We therefore initially tested with six class specification and found the minimum BIC at the fourth class leaving three classes for analysis (see appendix 3.2).

Once the preference of farmers for the distribution attributes is examined, the question that follows is farmers willing to pay for changes in the level of attributes. Conventionally, the marginal willingness to pay (MWTP) is the ratio of estimated model coefficients of attribute to the coefficient of the monetary attribute as defined by equation 8. MWTP, in a CE unlike the contingent valuation technique, is an indirect method of exploring respondents' willingness to pay. However, respondents have to trade cost for improvements in the positively valued attribute or for a decrease in negatively valued attributes (Kjær, 2005). Mathematically it is defined as;

$$MWTP = -\frac{\beta_{attributes}}{\beta_{monetary\ attribute}} \quad (8)$$

The price attribute in this choice task is used not to represent overall cost of the package rather measures price of a 12.5 kg or one package of hybrid maize seed. While computing the MWTP, the value follows the sign of attributes and only the magnitude of price coefficient is used as a proxy indictor.

3.5 Results

This section first presents the qualitative results, followed by results of the CE.

3.5.1 Results of the qualitative assessment

The qualitative assessment section first presents a menu which contains lists of attributes relevant as per farmers' perspective. The second sub-section describes the features and governance of the seed distribution systems and the challenges therein.

3.5.1.1 Seed distribution system: "Reform menu" and "Local litmus" nexus

As discussed in section 2, the promises of the seed distribution reform (hereafter the reform menu), were improvements of quantity of improved seeds, seed quality guarantees, enhance quality and quantity of information on seed performance, increase the spatial density of seed selling points, improve timeline of provision of seed, provide alternative payment modality and make the price of seed affordable (Benson et al., 2014; Husmann, 2015). Contents of demand driven reforms are believed to originate from reform triggering local contexts (Grindle, 2007). As a result, reforms which fully constitute local contexts succeed better than those that do not. With this background, we have explored the perspectives of smallholders based on the contents of the menu of the distribution system using FGDs. We found eleven seed distribution related attributes which farmers believe are very important, with various degrees, in the distribution system. These can be considered as "local litmus" for they carry farmers' parameters in defining a better serving distribution system. As a result, an ideal distribution system is system that best fits and intersects farmers' contexts or local litmus. The ideal distribution system can be explained as a system that gives farmers access to high quality seeds from multiple outlets with all the required information and extension service, without quantity restriction, at affordable prices, without partnering with someone, with multiple modes of payment, including credit, time availability and without long queue at sales centers.

Table 3. 3 Attributes Mean Value and Rank

S. No	Attribute name	Mecha FGD	Bako FGD	Mean value	Rank
1	Sales outlet	90	64	77	2
2	Information-extension support	20	16	18	10
3	Time spent to access seed	55.5	45	50.25	8
4	Seed available timing	44	34	39	9
5	Yield potential	49	58	53.5	7
6	Seed quantity	69	62	65.5	4
7	Seed purity	69.5	78.5	74	3

8	Credit provision	54	65	59.5	5
9	Group formation	69	52	55.5	6
10	Relation to seed providers	15	25	17.5	11
11	Seed price	90	84	87	1

Source: FGDs, 2015

The study assumes that farmers pursue utility maximization. Utility is maximized when farmers have an efficient seed distribution system. The content of this attributes menu is established based on farmers' free imagination and aspirations on what the seed distribution system should look like, *ceteris paribus*. Any distribution reform that inscribes these issues can best fit and meet the preferences of farmers and alleviates existing challenges in the system. Pragmatically, the assumption of keeping other factors as constant is infeasible and demands us to re-explore farmers' preference for the distribution attributes when farmers are subjected to constraints in the course of their utility maximization. Cognizant of this, we conducted the CE to further evaluate farmers' preferences by imposing choice constraints (see section 4.2 above).

3.5.1.2 Features of seed distribution and marketing systems

The study compares the attributes of the traditional CBD and the DSM systems. Table 3.4 presents summary of operational similarities and differences of the CBD and DSM systems under the themes of dealership, seed transportation, handling of unsold seeds, mode of payments and pricing. In the traditional CBD, the features of the system were uniform across the country regardless of regions. Therefore, it is worth comparing these features between systems (the traditional CBD where the reform has not been in place yet, and the DSM implemented via two modalities, DSM-private and DSM-Cooperative).

Table 3. 4 Features of Seed Distribution Systems

No	Features	CBD (Conventional)	DSM Since 2011/3	
			Bako (Amhara)	Mecha (Oromia)
1	Dealers type	Cooperatives/DAs/District Agriculture Office (DOA)	Private	Primary Cooperatives
2	Dealership agreement	No	Yes	Yes
3	Dealers incentives	No/unclear	Commission	Commission
4	Dealers authorization	BOA	BOA/DOA/SEs	PSQCQA
5	Number of dealers	One	One dealer per SE	
6	Pricing power	Central	Public SEs' forum + market	Public SEs' forum + market
7	Seed transporters	Cooperative Unions	SEs	SEs
8	Mode of payment	Cash/credit	Cash	Cash
9	Liability to unsold seeds	Cooperatives and Districts	SEs	SEs

Source: Authors compilation based on in-depth expert interviews, 2015

Dealership role in the traditional CBD system was fully mandated to cooperative unions regardless of regions. In the DSM system, the type of dealers varies across regions. In the Mecha district of the Amhara region, primary cooperatives remained the sole distributor representing one implementation modality. The peculiar feature compared to the traditional CBD is that primary cooperatives have been licensed to do so by the regional Plant Seed Quality Control and Quarantine Authority (PSQCA). In contrast, in the Bako district of the Oromia region, dealership role has been transferred to private actors who are screened and authorized by the district agriculture office (DAO) or SEs or BOA. The DOA and the district input committee (DIC) have been using education status, farming experience, acceptance by the local community, and indisputably financial position or resource endowments, which might serve as collaterals and as a criterion while screening. However, the decision to accept or reject the recommended dealers or to choose own dealer is in the hands of SEs.

Unlike the traditional CBD, dealers in the DSM system, regardless of regions, enter a formal contractual agreement with SEs to act as a dealer on a commission basis, which habitually ranges from 30 to 50 ETB/quintals. Nevertheless, dealers' incentives in the traditional CBD system were unclear. SEs in the DSM program, unlike the CBD system, transport their seeds to shops of primary cooperatives and stores of private dealers. In the traditional CBD, this was the full responsibility of primary cooperatives. Private dealers in Oromia, upon receiving the seeds, select their own agents at various clusters and allocate the seeds to these agents on a sub-commission basis. As to the number of dealers in the DSM, 'one dealer per SE' has been implemented in Bako whereas in the Mecha district it remained the same as the traditional CBD. Unsold seeds in the traditional CBD system were counted as a loss of primary cooperatives, which finally become a default transferred to the district's fiscal budget. Regional governments, as a result, deduct an equivalent amount from the district's annual budget. This was completely changed in the DSM system where SEs are fully liable for the unsold seeds.

The rationale of moving towards DSM was to foster competition among SEs with the hope of enhancing farmers' access to high quality seeds with a fair price. This study finds that the public SEs forum still holds the power to decide the prices of seeds of all public SEs. It is observed that the public SEs usually set a relatively low price, and the non-public, except transnational, follow the price already set by the public SEs. Additionally, except for transnational seed companies, all SEs in Ethiopia multiply and distribute almost similar types of hybrid varieties developed by the national research institute. This also diminishes the scope for competition on seed quality and price. It has also been observed that only transnational seed companies are using their own parental lines, imported from abroad, and distribute differentiated varieties. Operationally, table 3.4 presents some changes on attributes of agreed upon commission, management and liability of unsold seeds between the CBD and DSM. However, the exclusive dealership role given to primary cooperatives and private actors in the Amhara and Oromia regions, respectively, indicates partial implementation of the reform and resulted in significant variations of some of the constituents of the reform between the two districts. This demonstrates the paradox of free competition and the shift from CBD to DSM.

Table 3. 5 Mean Comparison of Selected Attributes across Distribution Modalities

No	Attributes and features	DSM (Mecha) (n=188)	DSM (Bako) (n=137)	Mean difference
		Mean	**Mean**	
1	Distance to seed shops (walking minutes)	62.87	37.79	25.07***
2	Frequency of extension contact/year	2.40	3.59	-1.19**
3	Share of maize land	0.53	0.71	-0.18***
4	Number of hybrids farmers often plant	1.93	2.73	-0.80***

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.0, respectively.

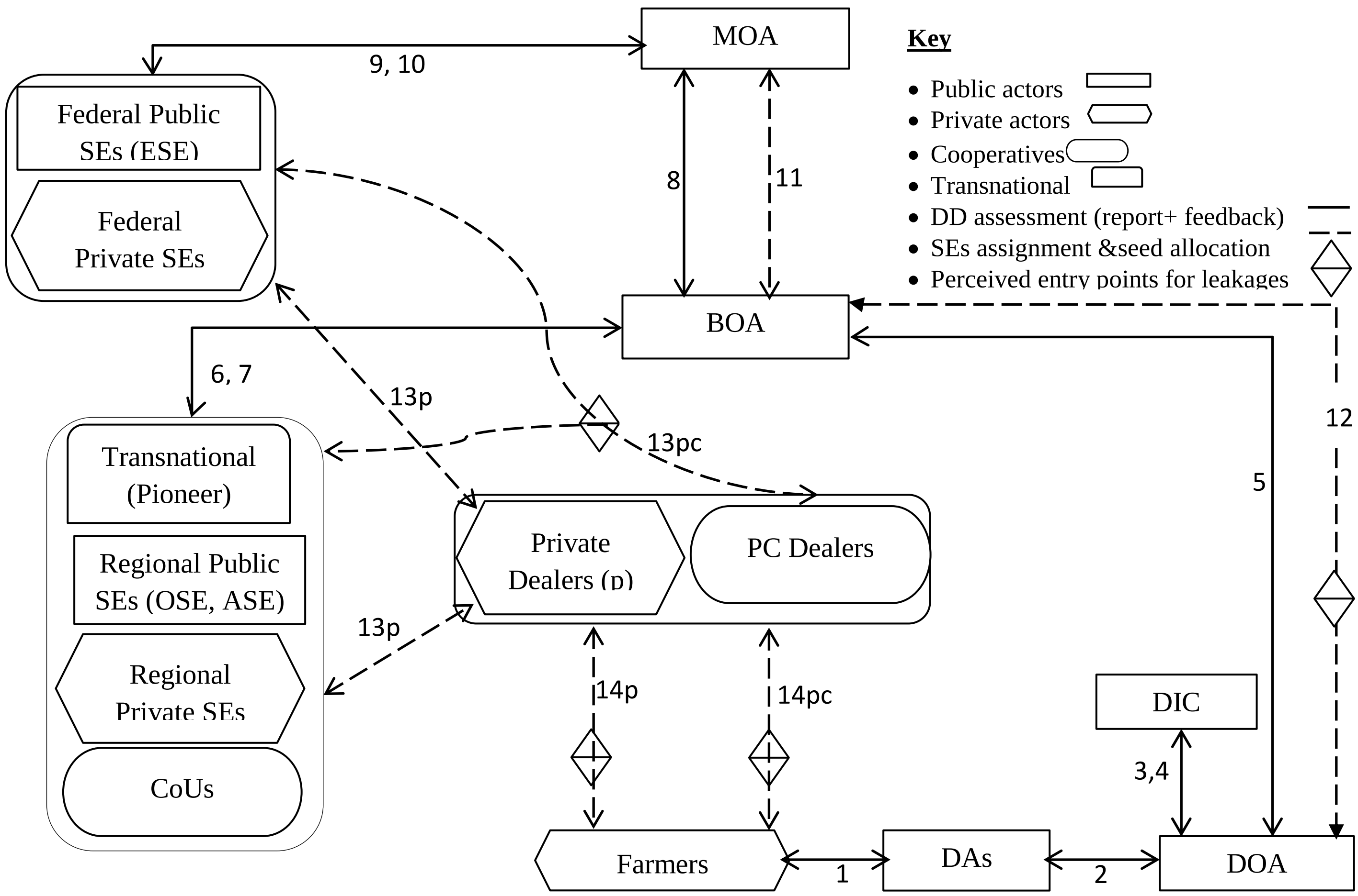
Source: Authors analysis using the survey data.

Table 3.5 reports the mean differences in the number of seed sales shops, frequency of extension contacts, share of land allocated for maize and number of hybrid maize varieties often preferred. Despite both districts falling within the DSM program, differences in the type of actors effecting the actual seed distribution led to significant differences on some of the attributes. We found a significant mean difference in terms of the number of seed sales centers between the two modalities where it is higher in the case of the DSM-private of Bako district than the DSM-cooperative of Mecha district. Regarding the frequency of extension contact, we found a significant mean difference between the two modalities where it is higher in the case of DSM-private of Bako district than in the DSM-cooperative of Mecha district. Similarly, we found that the share of maize land and number of hybrid maize varieties often planted have significant mean differences between the two modalities with higher means in the DSM-private.

3.5.1.3 Process of seed distribution

Actual seed distribution in DSM system passes through numerous steps before it reaches the farmers. The aggregated PNM displayed in Figure 3. 2 shows this process. It involves two main paths:(1) the bottom-up demand assessment(steps1-10), and (2) the top-down assignment of SEs and allocation of seeds to districts (steps 11-14).The non-broken and the doted lines connecting various actors represent the demand assessment path, and the allocation of SEs and seeds to districts, respectively. As already explained in table 3.4 of the previous section, PCs dealers in the PNM represent distribution system in Mecha, whereas private dealers represent the case of Bako.

As shown in the aggregated PNM (see Figure 3.2), the DAO initiates the process by conducting seed demand assessment through development agents (DAs) at the peasant association (PA) level. DAs assess farmers demand by the type and amount of seeds for the next cropping season. The result of the demand assessment is reported to the DAO, which totals all the PAs demands and proposes to the DIC, where the head of the DAO is a member for approval. The approved district seed demand is then reported to the regional BOA. The BOA distributes this information to SEs to be aware of the districts' seed demand. SEs, in turn, report their seed stock to the BOA. The BOA also requests the MOA for an additional amount of seed from the federal level SEs, if the BOA foresees deficit. After knowing the region's seed potential, the second course of the process is commenced by assigning SEs to districts across the region by the BOA. SEs, then transport seed to their respective districts and handover to dealers. Finally, the dealers distribute seed to farmers.



1. DAs assess seed demand in every PAs	8. BOA requests the MOA to fill regional seed deficit, if any
2. DAs report the demand assessment to DOA	9. MOA shares regions seed DD to federal SEs
3. DOA reports to the DIC	10. Federal SEs report their certified seeds to the MOA
4. DIC approves	11. MOA allocates seed to the BOAs per request
5. DOA sends approved seed DD to BOA	12. BOA assigns SEs to districts
6. BOA shares demand assessment report to SEs	13. SEs supply seed to dealers
7. SEs report back total certified seed they produced	14. Dealers distribute to farmers

Source: Authors' aggregation of Process Net-Maps, 2015

Figure 3. 2 Process of hybrid maize seed distribution

Along the demand assessment path, this study identifies demand related challenges. Despite seed demand assessment done by the DAO before actual distribution is made, seed distributers, at the time of distribution, do not correspond to earlier seed requests. This creates surplus of one type of seed variety in one particular area, and deficit in another. In addition, this complicates the monitoring of seed distribution activities. Undeniably, uncertainties perpetuate from the side of farmers, as farmers often change their mind and request a different quantity and type of seed induced by weather or other reasons. Sticking to earlier requested types and quantity of seeds or allowing farmers to buy what they want at the time of purchase creates deficiencies in one area and surplus in another. As a result, SEs are sometimes unsure of which variety and what quantities to supply to farmers within their operational districts.

Despite reforms of the distribution system, we identified three areas where governance challenges occur along the process of distribution. First, assignment of SEs into different districts by the BOA (step 12) lacks objective criteria and restricts SEs from freely competing and selling seeds in all districts of the region. Moreover, dealership type has also been identified as one factor that contributes to governance challenges in the distribution system. This is particularly the case in cooperative-based dealership (13pc). Cooperative dealers, in the case of Mecha that are selling seeds of all SEs in the same shop, could sell seeds of a SE that not only pays a higher commission, but also provides (informal) incentives to sales persons, first. Furthermore, the limited capacity of PCs further increases farmers' transaction costs. One key informant expressed the challenges he has experienced as follows:

> "When we go to the sales center on the date scheduled for our PA, we find them busy with farmers scheduled before us. We spend the whole day doing nothing and return home empty handed at the expense of our on-farm activities.''[19]

Another bottleneck in this cooperative-based dealership is that sales persons, due to lack of checks and balances, can sell seeds either to large-scale investors or smallholders (step14) whom they favor the most, because of kinship or any form of benefits. This limits smallholder's access to the type and quantity of seed in the district. One farmer in Mecha district expressed this concern as follows:

> "When we sometimes go and request first [Pioneer hybrid varieties] seed, they do not let us buy it. Instead, they give us second [BH 660, BH661, BH540] seed which we do not need at that time and vice versa.

[19] Interview with farmer, Mecha, September 24, 2015

They argue that it is delayed by the SE. As a result, we have to travel to neighboring districts."[20]

Furthermore, absenteeism of sales persons also increases the transaction costs for farmers. These challenges, indeed, are important bottlenecks in the distribution system. They jeopardize the attributes of the "reform menu", as well as the "local litmus".

3.5.2 Results of the CE

This section first presents the descriptive statistics of the sample respondents, followed by results of the CE on the preferences of farmers for the distribution attributes and their marginal willingness to pay.

3.5.2.1 Descriptive statistics

Table 3.6 presents the socio-demographic and economic characteristics of sampled farmers. For instance, 96% of respondents are male headed households, and the mean family size is about six. The average landholding and frequency of extension contact per year is 1.6 and 2.9, respectively.

Table 3. 6 Descriptive Statistics for Variables Used in the Regression

Variables	**Variable description**	**Mean**	**SD**
Gender (1=male)	Sex of the household head	0.96	0.19
Age	Age of household head in years	43.60	11.44
Education	Education of household head in years of schooling	3.69	2.63
District (1=Bako)	Name of the district	0.42	0.49
Family size	Number of family members living in the same house	5.94	1.93
Land size	Average land size a household owns in hectares	1.60	2.04
TLU	Total tropical livestock unit	5.04	2.63
Farm experience	Farming experience of the household head in years	20.74	9.87
Training freq.	Number of times a farmer receives training/year	2.65	1.77
Outlet distance	One-way distance to seed shops in walking minutes	52.30	36.74

[20] Interview with farmer, Mecha, September 24, 2015

Irrigation (1=yes)	Irrigation orientation of land, partly or fully	0.53	0.49
Coop. member (1=yes)	Household head's membership to cooperatives	0.80	0.39
Farm income[21]	Annual average farm income in ETB in 20014/15	12475	8362
Market access (1=yes)	Access to grain markets	0.61	0.48
Extension freq.	Frequency of extension contact in a year	2.90	3.31

Source: Authors analysis using the survey data.

3.5.2.2 Empirical model results: latent class model estimates

Overall, the CE results demonstrate that only 2% of farmers sampled prefer the status quo option. This overwhelming preference for alternatives of the hypothetical settings indicates farmers' desire for changes in the distribution attribute levels.

The LCM identifies three classes to further disaggregate farmers' preferences for the distribution attributes. The assumption of this class-oriented analysis is that farmers in the same class exhibit homogeneous preferences for the distribution attributes. Thus, the predicted class membership probability for the first, second and third classes is 0.272, 0.465 and 0.263, respectively. Moreover, we estimated individual class membership probability to further examine district wise heterogeneities. Hence, from the predicted individual class membership probability, about 79% of farmers in Bako fall in the second class. Conversely, it is observed that three-fourth of farmers in the Mecha district fall in first and third classes (see Appendix 3.3).

[21] Computed based on total annual expenditures, i.e (Farm income=Total expenditure +saving- (off farm and non-farm income))

Table 3. 7 Latent Class Model Estimation Results

Variables	**Class 1**	**Class 2**	**Class 3**
Sales outlet	-0.23	0.49***	0.75***
	(0.24)	(0.07)	(0.10)
Seed purity			
SE with 80%	6.83***	3.36***	1.03***
	(1.51)	(0.80)	(0.27)
SE with 95%	7. 30***	4.91***	-0.99**
	(1.48)	(0.81)	(0.37)
SE with 99%	5. 45***	4.02***	0.23
	(1.48)	(0.82)	(0.36)
Quantity (+50%)	-0.25	-1.01***	0.72***
	(0.29)	(0.09)	(0.12)
Group	2.82***	-0.33***	0.57***
	(0.34)	(0.07)	(0.11)
Credit (50%)	-0.03	0.55***	0.00
	(0.34)	(0.07)	(0.11)
Price	-0.04***	0.02***	-0.01***
	(0.01)	(0.002)	(0.002)
Class membership variables			
Constant	2.82	-3.49	
	(3.42)	(3.40)	
Gender	0.98	1.42	
	(1.04)	(1.30)	
Education	0.14	0.16**	
	(0.08)	(0.08)	
Family Size	-0.06	-0.13	
	(0.11)	(0.10)	
Irrigation access	0.09	0.79**	
	(0.41)	(0.38)	
Landln	0.25	0.18	
	(0.37)	(0.36)	

Outlet distance	0.04 ***	0.02**	
	(0.01)	(0.01)	
Market access	-0.83 *	-0.52	
	(0.42)	(0.41)	
District	-1.33**	-2.81***	
	(0.43)	(0.47)	
Coop_memb.	-0.76*	0.56	
	(0.44)	(0.46)	
Extension freq.	-0.06	0.02	
	(0.07)	(0.05)	
TLU	-0.11	-0.22**	
	(0.08)	(0.09)	
Class share (%)	27.2	46.5	26.3
Number of observation	9750	9750	9750
Number of respondents	325	325	325
Log-likelihood	-1882.43	-1882.43	-1882.43

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.01, respectively. Standard errors in parentheses. Only selected class membership variables reported.

Source: Authors analysis using the survey data.

Overall, the results reported in table 3.7 show that improvements in seed sales outlet, quality of seed supplied by SEs and credit mode of payments are homogeneously preferred by the majority of farmers. On the other hand, seed quantity, group formation and price are context specific, as preferences for these attributes are heterogeneous across classes.

In the first class (27.2% of the sample respondents), we found that the utility of farmers has been significantly affected by seed quality of SEs, group formation and price attributes. In this class, farmers value SEs with quality seed and group formation positively. In other words, farmers would like to have access to seed of SEs supplying better quality and buy seeds in groups. The possible justification for the positive preference for group formation is associated with land ownership and land use decision of farm households. This means farmers who own or allocate less than half a hectare of land demand seeds less than the minimum package of 12.5 kg. Thus, buying this independently will require them to pay for the full amount even though they do not need it. It also avoids such costs and risk of failing to plant maize. As a consequence, they value grouping positively, but it is not an inherent choice. Moreover, farmers value the price attributes negatively implying their demand in reduction in the price of seeds.

The second class consists of 46.5% of farmers sampled. In this class, all attributes significantly affect the utility of farmers. A 50% increase in quantity and group formation affect utility negatively. This means that farmers prefer to buy seeds independently without forming a group and are not interested in increasing the amounts of seeds they buy by half. This study finds a positive preference for improvements in outlet number, SEs with quality seed, a 50% credit sales and price attributes. This entails that improvements in the quality of seeds, increased number of sales shops and credit mode of payment are valued positively. The possible reasons for the positive preference for price attributes could be the farmers' perceived linear association between price and quality. Moreover, the nature of the current seed market price scenario could create a divide between farmers. It is observed that two prices scenarios dominate the systems which are price of seeds of transnational companies (Pioneer) and other SEs. The price of the former is almost double the price of the latter. This might demonstrate that farmers seem to be reluctant in using either type of seed, which results into heterogeneous preference for this attribute.

The utility of farmers in the third class, which encompasses 26.3% of farmers, is affected by all distribution attributes, except the credit mode of payment. Farmers prefer a higher number of seed sales outlet, improvements in quality of seed supplied to 80%, half increments in seed quantity and buy seed in group. Essentially, increased numbers of sales outlets where farmers can buy seeds affect utility positively. At the same time, farmers prefer to buy seeds in group. The surprising result in this class is the negative preference to the SE supplying 95% seed purity level. Three possible interpretations may justify this. First, the level of quality may make farmers expect a price hike in seeds and perceive it as unaffordable. Similarly, farmers might have apprehensions about the availability of such high-quality seeds in the market. Furthermore, the current purity level being supplied by SEs might not be lower compared to the other two classes of farmers.

Socio-demographic and economic factors such as education level, cooperative membership, market access, access to irrigation, TLU, distance to seed sales centers and district have contributed significantly in predicting class membership probabilities (see table 3.7). District, for instance, significantly highlights the presence of preference heterogeneity between districts. We thus calculated the probabilities of district level class membership (see Appendix 3.3).

3.5.2.3 Willingness to pay estimates

Overall, farmers have varied MWTP for the same attributes across the three classes. It is evident that the willingness to pay for seed quality attributes enormously exceeded others, as reported in the last column of table 3.8.

Table 3. 8 MWTP for the Distribution Attributes

No	Attributes	Class 1	Class 2	Class 3	Mean MWTP
1	Sales outlet number	-6.3	25.73***	83.00***	34.14
2	SE's seed purity				
2.1	SE with 80%	189.66***	176.73***	114.77***	160.38
2.2	SE with 95%	202.86***	258.47***	-110.33***	117.09
2.3	SE with 99%	151.25***	211.53***	25.88	129.55
3	Group formation	78.44***	-17.10***	63.22***	41.52
4	Credit (50%)	-0.75	29.21***	0.44	9.63
5	Quantity (50%)	-6.92	-52.94***	80.44***	6.86

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.01, respectively.

Source: Authors analysis using the survey data.

We found that farmers in the first and second class are willing to pay, respectively, about 202 (42.5%) and 258 (54.3%) extra ETB for a 12.5 kg hybrid seed if the perceived quality of seed distributed by a SE is raised to 95%. Besides, the mean MWTP for a unit change in the number of shops where farmers can buy seeds is about 34 ETB. The other figures can be interpreted in the same way. The result overwhelmingly indicates farmers' willing to pay for improvements in the quality of hybrid seeds.

3.6 Discussion

This paper analyzes the governance challenges in reformed hybrid maize seed distribution system and examines farmers' preferences for the distribution attributes. The main driver of the reforms initiated in 2011 was the inefficiencies in the previous system arising from the monopoly of state-sponsored cooperatives, coupled with high transaction costs of accessing seeds, limited capacities of the cooperatives and lack of competition (Alemu et al., 2010; Benson et al., 2014; Langyintuo et al., 2010). It is argued that reform outcomes are largely dependent upon convergences and crossovers between the contents of reform menu and the interests of reform beneficiaries (Birner et al., 2009; Grindle, 2007). This paper suggests that the interests of the beneficiaries, i.e. smallholder maize growers in Ethiopia have not been adequately considered in the reformed seed distributions system. Yet, as shown in the results section, the reforms have removed some of the deficiencies of the previous CBD system. Firstly, it guarantees commission to dealers, and avoids their liability to unsold seeds. Secondly, the DSM partly allows private sector engagement in seed distribution system. We find that the reformed system has replaced primary cooperatives by private actors in Oromia, but not in the Amhara region, where cooperatives remain the sole distributors. Inevitably, this phenomenon exterminates SEs' incentive to compete on the basic constituents of the reform menu pertaining to the seed distribution system; for example, seed quality, time of delivery, quantity, price and information-extension support. This is consistent with the findings of Jayne et al. (2002), where during the structural adjustment reforms of the 1980s and 1990s in Sub-Saharan Africa, the most fundamental elements of reform either remain unimplemented, reversed or were implemented in such a way that jeopardize private sectors participation.

The qualitative assessment of the seed distribution system with the help of Process Net-Maps highlights major governance challenges in the reformed system. We identified three potential entry points for corruption along the process of distribution. The first entry point is the assignment given to SEs by BOA for distributing hybrid seeds to different districts. The lack of clear and objective standards to this effect creates opportunities for SEs to influence the assignment process and select their preferred districts where competition and transaction costs are low. The second entry point relates to disparities in the amount of commissions paid to dealers that might drive dealers to always sell seeds of a SE which pays higher commission, regardless of seed quality or farmers' preference. The third entry point is the autonomy given to the cooperative-based dealerships to sell seeds of all SEs under the same roof. This, in turn, enables them to misguide or influence farmers' purchase decisions and use discretionary power to decide whom to sell, in what quantity and when. The backward linkage (between salespersons and SEs) and forward incentives (personal relationships between salespersons and buyers) dictate and influence farmers' seed purchase decisions-quantity and variety choice. Additionally, the problem of absenteeism on the part of salespersons exacerbates transaction costs for farmers. This is consistent with the finding of Husmann (2015). She found that shops of cooperatives distributing seeds were open usually only for two afternoons in a week, due to lack of fulltime employees. These governance challenges, relating to the particular entry points as explained above, eventually affect the outcomes of the reform and reproduce the deficiencies of the previous distribution system.

The results of the LCM show farmers' overwhelming preference for SEs supplying quality seeds, increased number of sales shops and credit mode of payments. This is consistent with earlier studies by Abera et al.(2013) and Wale (2012) which have shown that seed quality has been the farmers' primary criterion when selecting one variety over another. This begs the question as to what has been the outcome of the distribution system reform which promised to enhance access to high quality seeds. Our findings, despite significant mean differences in terms of distance to seed shops between the two modalities, indicate that the issue of seed quality and spatial density of seed selling points have largely remained demanded still in the reformed distribution system. The exclusion of one actor and authorization of another restricts competition among SEs on the spatial density of seed selling points. Furthermore, in fact all SEs except transnational, rely on the parental lines developed and supplied by the national research system. This has the potential to limit competition on seed quality and number of SEs distributing quality seeds in the system which is manifested in our CE result. Further, the current distribution system does not provide smallholders with credit as an alternative mode of payment inhibiting cash-constrained farmers from planting hybrid maize. This provides evidence of the mismatch between reform outcomes and farmers' preference.

The results of the LCM also show that farmers' preference for seed quantity, price and group formation are heterogeneous among the three classes and are context specific. Differences in reform implementation have contributed to preference heterogeneity for the distribution attributes among classes and between regions. Given the 25 kg/hectare recommended rate of hybrid maize seeds, the current 12.5 kg packaging size does not allow farmers to buy seeds in quantities less than that. The negative preference for the group formation is due to the potential risk of not planting any maize in one cropping season if farmers fail to find someone willing to buy and share the 12.5 kg hybrid seed packages. Undeniably, changing the packaging size has its own cost implication for government and SEs. Nevertheless, providing small packages will be beneficial for a large number of smallholder maize growers in Ethiopia.

Heterogeneity of preference to the price attribute shows farmers' mixed response to seed pricing. The positive preference for high-priced seeds challenges government's reluctance of opening up the seed market to protect the smallholders from a price hike in seeds. Disparities in production scale coupled with non-market-based pricing of seeds divide public and non-public SEs as price leaders and followers, respectively. This is consistent with the evaluation by Benson et al. (2014) disproving government's suspicion about exposing the farmers to private players in seed market. Our findings show that despite incentives and entry of non-public SEs in the seed business, irregularities in operation (e.g. non-market-based pricing or restrictions in terms of operational areas) and lack of alternative sources of parental lines create disincentives for private sector. Consequently, the reforms have failed to trigger competition and innovation. The fate of the reforms so far can be summarized in terms of Gresham's Law of 'bad money driving good money out' (Sullivan, 2005) as incentives for private actors have been eroded and diminished. The information asymmetry between buyers and sellers as we see in the hybrid maize seed market post-reforms negate competition resulting into the crowding out of quality products or services out of the market.

3.7 Conclusions and policy implications

Despite the crucial role of agriculture in food security and livelihoods for smallholders, the sluggish growth of the sector remains a challenge due to poor access to inputs, most notably, high quality hybrid seeds. In Ethiopia, until recently, cereal seeds and hybrid maize seeds were distributed solely through a state-sponsored cooperative dealership system. However, as several studies confirm (e.g. Alemu et al., 2010; Benson et al., 2014; Erenstein et al., 2011; Husmann, 2015),this centralized system has resulted into the lack of growth and productivity in the maize sector. This led to a policy shift towards DSMin2011, which was scaled-up in the following years. This paper, evaluates what has (or hasn't) changed in terms of seed distribution, identifies the governance challenges that persist, and most importantly, taking recourse to a CE, examines the attributes of seed distribution system that matter the most to farmers.

The study finds that reform of the distribution system has brought some advances particularly in terms of dealers' incentives and handling of unsold seeds. The discrimination against one actor and preferential right given to another in the two regions, however, indicates the partial implementation of the DSM. Thus, dealership in the DSM program is dictated and not fully left to the market. Our analysis suggests that several governance challenges that existed in the past CBD have been carried over into the new system. The study identifies entry points for governance challenges along the distribution chain, which require attention by policy makers to make the hybrid seed distribution system efficient and dynamic.

The results of the CE, despite context specific heterogeneity to attributes of seed quantity, group formation and price, show that preference for seed quality and sales outlet number improvement, and credit as an alternative mode of payment are homogenously preferred by the majority of respondents. This shows that smallholders in Ethiopia favor the promises made in the reformed system, although the reform has unfolded thus far leave them dissatisfied as manifested in the CE exercise. This calls for the need to undertake a separate and exhaustive study that addresses the supply side issues of seed quality. We find compelling evidence that identified governance challenges further hamper the translation of good intentions behind the distribution system reform into better outcomes from the perspective of smallholders. Therefore, government needs to ensure that a viable check and balance mechanism exists to curtail the discretionary powers of the Bureau of Agriculture (in allocation of distribution area for particular SEs); of seed SEs (in terms of commission and sale priority regardless of the preference of farmers); and that of and cooperative-based dealers (in deciding whom to sale, in what quantity and when). Overall, the study suggests that the private sector involvement (both domestic and multinational) has so far been very limited in the hybrid seed market in Ethiopia, although there are not sufficient reasons to believe that competition within the sector would be detrimental to smallholder maize growers.

3.8 References

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Appendix

3.1 Coding attribute levels

Attributes with qualitative levels	Number of levels	levels	V1	V2	V3
Sales outlet	Entered as 1*, 2, 3, 4				
SE's seed quality level	4				
SE with 75%*		1	0	0	0
SE with 80%		2	1	0	0
SE with 95%		3	0	1	0
SE with 99%		4	0	0	1
Seed quantity	3				
Limited*		1	0	0	
Half increment		2	1	0	
Double increment		3	0	1	
Group formation	2				
Yes*		1	0	0	
No		2	1	0	
Credit provision	3				
0% *		1	0	0	
50%		2	1	0	
100%		3	0	1	
Price	Entered as 475*, 500, 525 and 575				

Note: *represents attribute levels for the base alternative (status quo) and V-stands for generated variables

3.2 Information criteria's: AIC and BIC

Classes	LL	AIC	BIC
2	-2115.709	4440.79	4409.7
3	-1882.426	4131.179	4077.179
4	-1689.923	3902.2	3825.2
5	-1652.97	3982.323	3882.478

6	-1631.88	4097.186	3974.901

3.3 Predicted class membership probability

Class	Districts				Total observations
	Mecha		Bako		
	Observations	Share (%)	Observations	Share (%)	
1	2340	41.5	300	7.1	2640
2	1350	24.9	3240	78.8	4590
3	1950	34.6	570	13.8	2520
Total	5640	100	4110	100	9750

Chapter Four: Analysis of maize biomass use and its implication on food security and Ethiopian bioeconomy

Abstract

Ethiopia's agricultural productivity growth is driven by cereal production. Despite high cereal biomass and yield potential, achieving food security remains a challenge. The focus of previous studies was on grain productivity, while less attention was paid to the production and utilization of the entire biomass of the plants. This study examines the uses of maize biomass, one of the bioeconomy crops, and its implication for household food security and the challenges therein based on cross-sectional annual maize biomass production data. The study follows a mixed methods approach that involves a household survey covering 322 randomly selected farmers, key informant interviews and focus group discussions. Both qualitative and quantitative approaches were used to explore biomass production and utilization. We examined the implication of intensity of biomass use on farm household food security using an endogenous switching regression model. The study finds that more than half of the total biomass production has been allocated for non-direct food purposes. Our result indicates a positive correlation between biomass production and farm household food security. The model result further shows a positive and significant effect of biomass use diversification on farm household food security. Yet, a broad set of factors such as lack of market access, limited information and extension support on biomass uses, and a lack of biomass value adding technologies have curtailed the full biomass utilization potential. Therefore, the study highlights the importance of provision of these factors in order to unlock the full potential of biomass for food security.

***Key words**: biomass production; biomass use; food security; endogenous switching regression; challenges; markets and extensions; institutional innovation*

4.1 Introduction

Achieving sustainable economic growth has become a global challenge. This challenge triggers shifts from an entirely fossil-based economy to a bio-based economy[22] (Börner, Kuhn, & Braun, 2017). Despite differences in the stages of development and characterization, every country in the world has a bioeconomy. The agricultural sector is the main source of economic growth and the base of bioeconomy in Sub-Saharan Africa (SSA). Despite high preponderance of biomass potential and availability of vast arable land, there exists a high incidence of food insecurity in SSA. The use of biomass has been advocated for reducing household food insecurity while at the same time enhancing sustainable livelihoods of smallholders (Abass, 2014; Mohr et al., 2015; Virchow et al., 2014). In Ethiopia, the growth in the maize sector, one of the most important bioeconomy crops, has stagnated with current yield falling below three tons while the estimated potential is about six tons per hectare (Abate et al., 2015; Rashid et al., 2010). Increasing productivity in the maize sector and effective utilization of maize biomass (grain and non-grain complements) has the potential to boost the bioeconomy of the country. Robust bioeconomy, in turn, could reduce food insecurity in Ethiopia, one of the poorest countries in the world with very high biomass potential.

Ethiopia's agricultural productivity growth is driven by cereal productivity. Despite high cereal biomass and yield potential, achieving food security remains a challenge. The focus of previous studies is more tilted towards grain productivity, while less attention was paid to the production and utilization of the entire biomass of crops. Sample survey results by the Central Statistics Agency (CSA) for instance show the various usages of the disaggregated grain maize, where about three-fourths go to direct food consumption(CSA, 2011, 2014). In this regard, for instance, Minot (2013) and Rashid et al., (2010) identified some of the constraints contributed to this, and indicated some opportunities in the maize sector. The lack of markets and down-stream processing and inconsistent export policies are among the major bottlenecks. While the "demand sinks" in the poultry and livestock sectors are recommended as potential market opportunities for stimulating growth of the maize sector. On the other hand, others (e.g. (Jaleta et al.,2015; Mekonnen et al., 2017), Baudron et al. (2014) and Jaleta et al.(2013) looked at the tradeoffs in crop residue utilization in the context of Ethiopia, Kenya and SSA, respectively in

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[22] Bi-based economy, bioeconomy or the knowledge-based bioeconomy synonymously used

view of conservation agriculture. Jaleta et al. (2015) for instance assessed the determinants of crop residue management, and identified major crop Stover uses as feed, fuel and soil enhancement. Mekonnen et al. (2017) looked at the tradeoffs between the domestic and productive uses of biomass energy sources. However, a consistent and an in-depth empirical study that examines the utilization of the entire maize biomass and its impact on farm households' food security and implications for the development of bi-economy is lacking, which is the main subject of this study.

The objective of this study is to assess farm households' decision on the entire maize biomass utilization and examine its implications for food security. The study uses a mixed methods approach and data was collected using a household survey covering 325 randomly selected farmers, key informant interviewees, and focus group discussions (hereafter, FGDs) in two maize belt districts, Mecha and Bako. Collected data was analyzed using both descriptive statistics and econometric model. The study finds that more than half of maize biomass produced has been allocated for non-direct food purposes. The findings also suggest that quantity of biomass production provides farm households the opportunity to allocate larger quantity of biomass for the various uses and thereby enhance food security. The model results further indicate a positive and significant effect of biomass use diversification on farm household food security. Yet a wide range of factors such as poor access to markets, lack of access to information, extension and biomass processing and value adding technologies have curtailed the full biomass utilization potential. This study highlights the importance of strengthening conditions that foster biomass utilization through institutional innovation, particularly, in the research, extension and marketing systems.

The rest of the paper is organized as follows: the next section describes the conceptual framework and review of literature on the uses of biomass components. Section 4.3 provides a brief description on data collection and analysis techniques. Section 4.4 presents results on the uses of components of biomass, food security profiles of sampled farm households and the empirical model results on impact of intensity of biomass utilization on food security. Discussions on major findings of the study are presented in section 4.5. The last section provides conclusions and policy implications.

4.2 Conceptual framework and review of literature

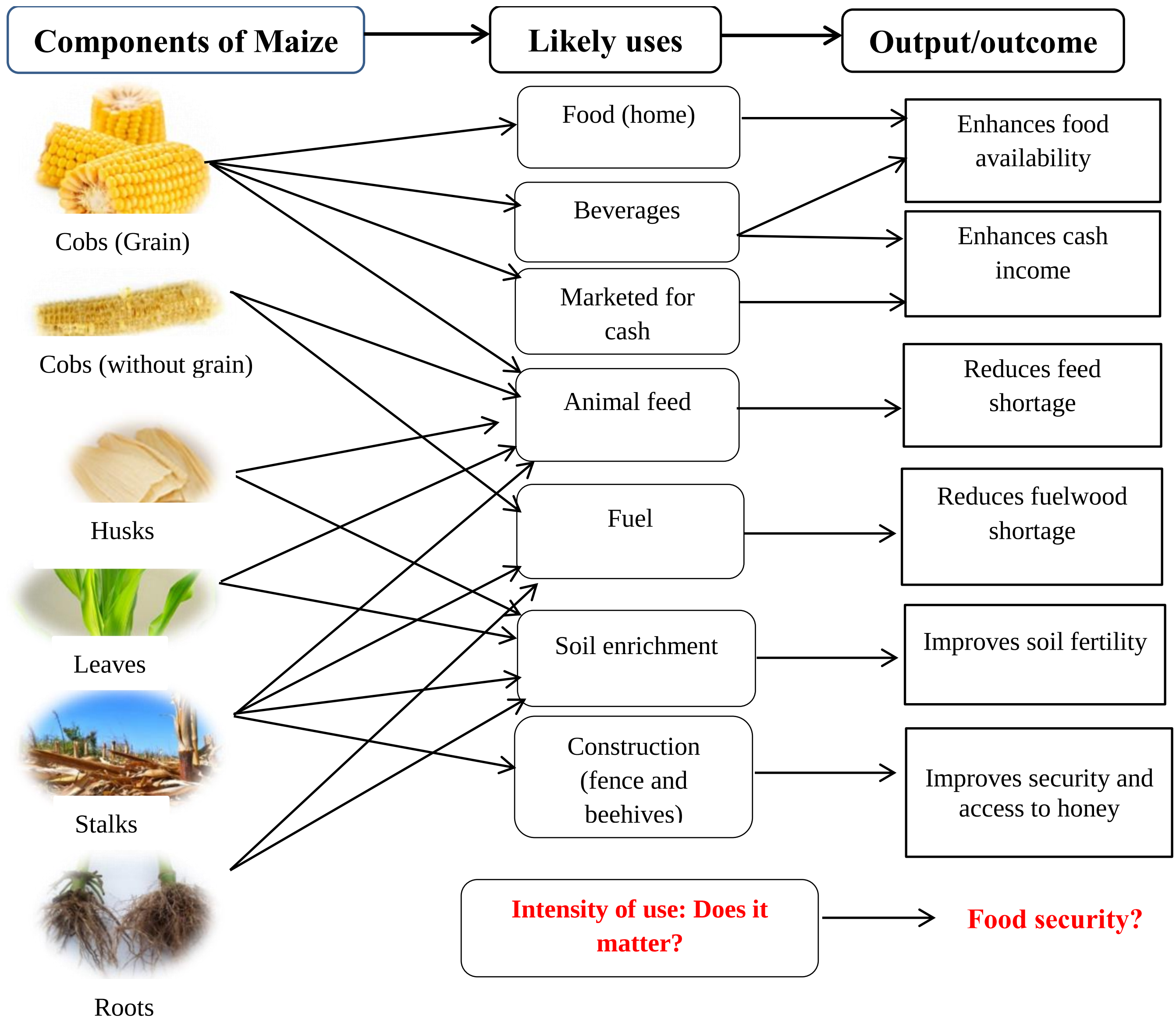
Maize is an important cash and food crop with high biomass potential. Like many sub-Saharan African (SSA) countries, food insecurity and poverty are pervasive in Ethiopia. Cereals, more importantly maize, have been seen as potential crops to alleviate poverty and food insecurity. Previous studies (e.g. Abate et al., 2015; Alemu et al., 2010; Rashid et al., 2010; Taffesse et al., 2011) examined supply side factors with a focus on determinants of maize grain production and productivity successes and the challenges. A study by Taffesse et al. (2011), based on national survey data, argues that the increased production of cereals including maize in the last decade has been attributed to the increased area cultivated. While Abate et al. (2015) based on data of the central statistics agency (CSA) argue the increased use of extension service, improved seeds and fertilizers, and increased number of researchers and budget are drivers of production and productivity success in the last two decades. Additionally, others (e. g. Asfaw et al., 2012; Teklewold et al., 2013) studied the welfare impact of maize technology adoption. All agree on the importance of institutional supports: extension service and improved seeds and fertilizers. However, post production issues are not included in the equation.

Overall growth of the maize sector depends however not only on supply factors but also on demand. Post-production decisions on the uses of maize biomass are equally important. In this regard, very few (e.g. CSA, 2011, 2014) looked at the allocation of grain maize while others (e.g. Jaleta et al., 2015, 2013; Mekonnen et al., 2017; Tegegne et al., 2013) have looked at the uses of non-grain maize biomass. The agricultural sample survey report on crop utilization by the CSA, (2011; 2014) indicate that about three-fourths of grain maize prior to the survey was consumed as food at the household level followed by sale and seed, accounting for 11% and 10%, respectively. Total maize consumption in Ethiopia is high in the eastern Africa, 3.9 million metric tons compared to Kenya, at 3.2 million metric tons. However, the estimated annual per-capital maize consumption is low, 162.5kg compared to Kenya which is 296 kg and the regional average is 289 kg (MOA, 2017). One of the reasons for low share other than food use is the lack of markets. A diagnosis study authored by Rashid et al.(2010) identified marketing challenges such as volatility of price, absence of year-round markets and inconsistent export policy[23]. The study suggested the livestock and poultry sectors as potential 'demand sinks'. The recommendation was based on the fact that Ethiopia has the largest livestock population in Africa with an estimated size of 80 million cattle, sheep, goats and camels, and a 50 million poultry population (CSA, 2013; Tegegne et al., 2013). The study estimated 800,000 tons of cereal for downstream processing as food and 450,000 tons of maize for feed. A qualitative assessment commisioned by the International Livetock Research Institute (ILRI), consistently, supported that feed shortage remained a challenge in the dairy production and marketing systems (Tegegne et al., 2013). However, the challenges in utilizing demand sinks are unknown and no sufficient evidence on the reason is available.

On the other hand, non-grain maize biomass can serve many purposes. For instance, Jaleta et al.(2015) based on cross-sectional survey data collected from 1430 farm households in 2011 studied the uses of maize Stover and its determinants in Ethiopia using a seemingly unrelated regression model. The study finds that 56% and 31% of maize Stover has been used for feed and fuel, respectively. The study identified cropping patterns, farm size and production of maize Stover as main determinates of tradeoffs in crop residue utilization. Mekonnen et al.(2017) based on survey data covering 930 randomly selected households in Ethiopia indicate that on farm production of fuelwood enhances the value of crop output and saves labor by making fuelwood collection convenient.

However, neither of the previous studies has shown the utilization of the entire maize biomass components, and the challenges therein, and the food security effects of farm households individual or diverse use decisions on food security. With this rationale, this study conceptualizes that the entire biomass components presented in the first column (see Fig 1 below) could be used for varied purposes (column 2). These single or diverse likely uses in turn led to several outcomes which directly or indirectly affect food security (column 3).

[23]Banning of export of maize was taken with the objective of market stabilization following the 2007/8 food crises. However, the banning of export of maize resulted in a net cost to the national economy as the gain to consumers is less than the loss to maize growers (Minot, 2013)



Source: authors

Figure 4. 1 Conceptual framework: maize biomass components, likely uses and outcomes

For instance, farm households' decision to use grain cobs for direct food consumption enhances availability and utilization of food at the household level. And the decision to allocate biomass for markets increases farm income, which in turn contributes to food security. Furthermore, farm households' decision to leave parts of the biomass (leaves, stalks, husks) on farm enhances fertility of the soil and crop productivity gains, which in turn fosters food security. In addition to individual use decisions, the study hypothesizes that intensity of use (use diversification) influences food security outcome.

4.3 Methods and data

The study uses a mixed methods approach and involves a composite of data collection and analysis techniques. This helps to quantify maize biomass production and utilization, and thereby to examine the implications of biomass use on household food security. Beyond quantification, the qualitative approach complements and deepens our understanding about biomass utilization and helps us further explore the factors and challenges influencing biomass utilization decisions. Qualitative data was collected using key informant interviews (hereafter, KIIs) and FGDs. Our key informants include maize growers, experts at the district agriculture office, researchers at the national maize research center, experts at the food and feed processing industries and poultry farm managers and owners. Four FGDs, two in each district, with four to five farmer participants each, and two FGDs (one from each district) with nine participants were conducted. Cross-sectional data was collected from a randomly selected sample of 325 farm households between July 2015 and January 2016 in the maize growing regions, Amhara and Oromia. A multi-stage random sampling technique was employed to draw sample households. Firstly, Mecha district in the Amhara region and Bako district in Oromia region were selected purposively. Mecha and Bako, respectively, are the first and third top maize producing districts in the country (Warner et al., 2015). Secondly, three and four peasant associations, from the Bako and Mecha districts, respectively, were randomly selected. Finally, a total of 325 maize farmers, 188 and 137 from Mecha and Bako, respectively, were selected randomly. Of the total sampled farm households, only data from the 322 farmers was used for analysis as the remaining contained incomplete information on the allocation of maize biomass for the various uses.

The study involves composite data analysis techniques tenable to biomass use, intensity of use, food security and implication of intensity of use on food security. The following sub-section, therefore, first describes techniques used to examine the type and intensity of biomass use. The second sub-section presents the instrument applied to measure farm households' food security. The last sub-section outlines the implications of intensity of biomass use on food security, and the challenges as far as biomass utilization is concerned.

4.3.1 Intensity of biomass use

The use of maize biomass was explored using a simple descriptive approach by asking sample farmers how much biomass they produced in the last cropping season and how much was allocated for which use. It is also assumed that farm households had produced approximately similar amounts of maize at least in the last two to three years. Then, intensity of biomass use is measured using a proxy indicator called the Herfindahl-Hirschman Index (HHI). HHI is a commonly used method in measuring market concentration where its inverse measures the degree of diversification. It is defined as the sum of the squares of market shares of individual firms operating in the market (Calkins, 1983; Clarke & Davies, 1984; Feeny & Rogers, 1999; Jacquemin & Berry, 1979). The study therefore contextualizes the HHI to measure the degree of maize biomass use diversification. Mathematically, if farmer *n* (where n=1, 2…m) produces Q_n amount of maize in one cropping season, and uses for *i* (i=1, 2…j) purposes with a share of q,

$$\mathrm{HHI} = \sum_{i=1}^{j} \left(\frac{\mathrm{q}_{ni}}{Q_n}\right)^2 \tag{1}$$

The diversification index (DI), HHI is given by equation 2

$$\mathrm{DI} = 1 - \mathrm{HHI} \tag{2}$$

Q_n is the total annual maize production of farm household n, q_{nj} is n farm household's annual maize production allocated for j purposes, and m is the total number of sample farm households. The closer the index values to one the greater the degree of the diverse use of maize and vice-versa. Thus, no diversification (i.e. maximum concentration) happens when the entire maize goes to a single purpose making the index value to zero and vice versa.

4.3.2 Household food security

The food security profile of sampled households was measured using a standard method called food consumption score (FCS) developed by the world food program (WFP, 2008). FCS contains eight food groups including cereals with seven days recall period. Each food group has weight ($\mathrm{w_i}$) attached to it as demonstrated in table 4.1.

Table 4. 1 Standard food groups and weights attached

No	Food groups (f_i)	Examples	Weight (w_i)
1	Main staples	Maize, maize porridge, rice, sorghum, wheat, teff injera, bread and other cereals	2
2	Pulses	Beans, peas, groundnuts and cashew nuts	3
3	Vegetables	Vegetables, leaves	1
4	Fruit	Banana, papaya, orange, apple	1
5	Meat and fish	Beef, goat, poultry, pork, eggs and fish	4
6	Milk	Milk yogurt and other dairy products	4
7	Sugar	Sugar and sugar products, honey	0.5
8	Oils	Oils, fats and butter	0.5

Source: WFP, 2008

Based on frequency of consumption of the food groups within the recall period and weight of each food group, consumption score is computed using equation 3 below;

$$FCS_n = \sum_{i=1}^{j} f_i w_i \qquad (3)$$

FCS_n denotes the food consumption score of individual n, f_i is the frequency of food group *i (i=1,2…j)* consumed during the recall period, w_i is the respective weight attached to food group *i*. Households with FCS of less than 21, between 21.5 and 35, and above 35 as called poor, borderline and acceptable food consumption profile holders, respectively[24]. The seven days recall period assumption has been relaxed changed to 4 weeks to overcome possible inclusion and exclusion of few food groups consumed within the recall period for reasons of fasting, seasonal availability or unavailability of the food. This instrument however is not a full-proof measure of food security due to recall biases and complexity of the food security concept.

[24] The maximum score (FCS=112) is achieved when a household consumes all food groups in all recall days and the minimum score is 0 nothing is consumed (For detail see WFP, 2008).

4.3.3 Econometric approach

The simplest technique in studying the impact of a decision or an intervention on a certain outcome variable is a simple OLS. This however does not provide sufficient evidence to believe that the impact is attributed to the intervention only as other controlled and uncontrolled variables could have influenced an outcome variable. This requires the use of a proper impact assessment technique that captures both the observed and unobserved heterogeneities.

The study hypothesizes that farm households' biomass use diversification decision influences food security. A dummy variable equals to 1 if a household diversifies and 0 otherwise was generated. This dummy is used in the OLS equation with the outcome variable, FCS, with the assumption that it is an exogenous variable. However, assuming households' diversification decision as an exogenous while it is endogenous negates the credibility of our estimation. The estimates are also not consistent and efficient (Maddala, 1983; WB, 2010). Other technique such as propensity score matching or Heckman selection model suffer from problems of endogeneity and selection biases as both fail to capture unobserved factors that account for heterogeneities on the outcome variable (e.g. Asfaw et al., 2012; Shiferaw et al., 2014). Single or diverse use of biomass is a farm households' subjective choice pursued. Thus, the endogenous switching regression (hereafter, ESR) model, which is a variant of the classical Heckman selection model, has been used for several reasons. Unlike other impact evaluation techniques, ESR overcomes the problem of self-selection and makes estimation of treatment effects in times of non-random allocation of subjects to treatment and control groups (Powers, 2007; WB, 2010). Another novelty of the ESR model is that it helps control both observed and unobserved heterogeneity between those who diversified and not.

Assuming that farmers are rational decision makers, they pursue the best biomass use decision that maximizes utility subject to their social and economic contexts. Households' diversification decision can be influenced by exogenous variables. Therefore, to examine the implication of farm households' diverse or non-diverse use decision on food security, a selection model for diversification explained by equation 4 below is used:

$$D_i^* = \alpha Z_i + \varepsilon_i \text{ with } D_i = \begin{cases} 1 \text{ if } D_i^* > 0 \\ 0 \text{ otherwise} \end{cases} \quad (4)$$

D_i^* is the latent variable that determines the decision to diversify the use of maize. Z_i are non-stochastic vectors of observed household characteristics (socioeconomic and demographic factors such as gender, access to market, access to alternative hybrid seeds, access to credit and markets and information and extension) that could influence diversification decision. α are vectors of parameters. ε_i are error terms associated with diversification.

D_i is the observed dichotomous realization of latent variable D_i^* of whether individual i decides to use maize for single or multiple purposes (Lokshin & Sajaia, 2004). In other words, D_i is an observable counterpart of the dependent variable, diversification, which is equal to one if a farm household diversifies and zero otherwise. However, D_i is a continuous variable which needs to be transformed into a binary dummy to fit the selection equation (Lokshin & Sajaia, 2004; Maddala, 1983). Thus, households are grouped into diversifiers and non-diversifiers by taking the midpoint of the diversification index. A dummy variable (DI) is thus generated which equals to one for households' scoring index value of 0.5 and above as diversifiers and zero otherwise. To minimize the subjective decision on the cutoff points for the two groups, the median (k) index value has also been used as a cutoff to check the robustness of our result (see Appendix 4.1). Furthermore, the diversification index only represents the grain biomass for several reasons. The grain and non-grain parts of biomass do not have equal market value and we do not equally know them. Thus, taking the diversification index of the whole biomass in our model might be misleading and might not reflect the true implication of the decision.

We adopt the ESR model of FCS outcome where farmers face two regimes: (1) to diversify (2) not to diversify defined by the following equations:

$$\text{Regime 1: } FCS_{1i} = \beta_1 X_{1i} + u_{1i} \text{ if } D_i = 1 \quad (5a)$$

$$\text{Regime 2: } FCS_{2i} = \beta_2 X_{2i} + u_{2i} \text{ if } D_i = 0 \quad (5b)$$

FCS_i is households' food consumption score in regimes 1 and 2, X_i are vectors of households' characteristics expected to influence the outcome FCS.

Following Maddala, (1983) and Di Falco et al. (2011), our model need to be identified. Thus, an identifier variable or selection instruments by imposing an exclusion restriction in the outcome equation 5 is required. Following Di Falco et al. (2011), instrumental variables are selected by carrying out a falsification test. According to this test, a valid instrumental variable satisfies the condition that it affects the selection function (diversification) but will not affect the outcome variable. Information-extension access on the use of maize qualifies this condition, and hence it is used as an instrument, so that our model easily identifies the selection and outcome functions.

Finally, error terms in equation 4, 5a and 5b are assumed to have a trivariate normal distribution, with zero mean and non-singular covariance matrix expressed as

$$\begin{bmatrix} \sigma_{\varepsilon}^2 & \sigma_{1\varepsilon} & \sigma_{\varepsilon 2} \\ \sigma_{1\varepsilon} & \sigma_1^2 & . \\ \sigma_{2\varepsilon} & . & \sigma_2^2 \end{bmatrix} \quad (6)$$

Where σ_{ε}^2 is the variance of the error term in the selection equation (diversification) which can be assumed to be equal to 1, since the coefficients are estimable only up to a scale factor (Maddala, 1983). σ_1^2 and σ_2^2 are the variances of the error terms for the outcome function, expressed by equation 5a and 5b. $\sigma_{1\varepsilon}$ and $\sigma_{2\varepsilon}$ are covariance of the error terms, ε_i and u_{1i} and u_{2i}, of the selection and outcome functions respectively. Maddala (1983) argues that if the error terms are correlated, OLS estimate will give inconsistent and inefficient parameter estimates. The error terms of the selection and outcome functions (ε_i and u_{1i} and u_{2i}) are assumed to be correlated implying that the expected values of u_{1i} and u_{2i} conditional on the sample selection are non-zero:

$$E[u_{1i}|D_i = 1] = \sigma_{1\varepsilon} \frac{\emptyset(Z_i\alpha)}{\Phi((Z_i\alpha)} = \sigma_{1\varepsilon}\varphi_{1i} \quad (7a)$$

$$E[u_{2i}|D_i = 0] = -\sigma_{2\varepsilon} \frac{\emptyset(Z_i\alpha)}{1-\Phi((Z_i\alpha)} = \sigma_{2\varepsilon}\varphi_{2i} \quad (7b)$$

Where $\emptyset(.)$ is the standard normal probability density function and $\Phi(.)$ is the standard normal cumulative density function, where $\varphi_{1i} = \frac{\emptyset(Z_i\alpha)}{\Phi((Z_i\alpha)}$ and $\varphi_{2i} = -\frac{\emptyset(Z_i\alpha)}{1-\Phi((Z_i\alpha)}$.

To test the null hypothesis of no sample selectivity bias, and to have evidence on the fitness of the ESR model, we need to estimate the covariance, $\widehat{\sigma}_{1\varepsilon}$and $\widehat{\sigma}_{2\varepsilon}$ which we do not know before estimation (Di Falco et al., 2011). And if we find statistically significant result, it proves that diversification decision and FCS are correlated implying that diversification decision is an endogenous variable. Indeed, this again provides evidence of appropriateness of use of the ESR model. An efficient method to estimate ESR model is the full information maximum likelihood estimation implemented using 'movestay' STATA command (Lokshin & Sajaia, 2004). Hence, the log likelihood functions on the error terms of the selection and outcome functions are given as:

$$\ln L_i = \sum_{i=1}^{N} D_i \left[\ln\emptyset \left[\left(\frac{u_{1i}}{\sigma_1}\right) - \ln\sigma_1 + \ln\Phi(\gamma_{1i})\right] (1 - D_i) \left[\ln\emptyset \left(\frac{u_{2i}}{\sigma_2}\right) - \ln\sigma_2 + \ln\left(1 - \Phi(\gamma_{2i})\right)\right]\right. \quad (8)$$

Where $\gamma_{ji} = \frac{\frac{(\alpha X_i + \rho_j u_{ji})}{\sigma j}}{\sqrt{1-\rho_j^2}}$ $j = 1{,}2$ with ρ_j signifying the correlation coefficient between the error terms of the selection equation 3 and the outcome function (4a and 4b), ε_i and u_{ji} respectively.

The above ESR model can be used to estimate the treatment effect of the treated and untreated by comparing the expected values of the outcomes of diversifiers and non-diversifiers in actual and counterfactual situations. Thus, the estimated treatment effect helps us to compare the outcome variable (FCS) for the observed groups or actual diversifiers and non-diversifiers denoted by a and b, respectively. Moreover, it enables us to probe the expected impact on the outcome variable in the counterfactuals (c) that diversifiers had they did not diversify, and (d) that non-diversifiers had they diversify. According to Di Falco et al. (2011), the expected treatment effects are computed as follows:

Diversifiers (observed in the sample)

$$E(FCS_{1i}|D_i = 1) = \beta_1 X_{1i} + \sigma_{1\varepsilon}\varphi_{1i} \quad (9a)$$

Diversifiers had they decided not to diversify (counterfactual)

$$E(FCS_{2i}|D_i = 0) = \beta_2 X_{2i} + \sigma_{2\varepsilon}\varphi_{2i} \quad (9b)$$

Non-diversifiers (observed in the sample)

$$E(FCS_{2i}|D_i = 1) = \beta_2 X_{1i} + \sigma_{2\varepsilon}\varphi_{1i} \quad (9c)$$

Non-diversifiers had they decided to diversify (counterfactual)

$$E(FCS_{1i}|D_i = 0) = \beta_1 X_{2i} + \sigma_{1\varepsilon}\varphi_{2i} \quad (9d)$$

The average treatment of the treated (ATT) is the difference between 9a and 9c.

$$ATT = E(FCS_{1i}|D_i = 1) - (E(FCS_{2i}|D_i = 1) = (X_{1i}(\beta_1 - \beta_2) - \varphi_{1i}(\sigma_{1\varepsilon} - \sigma_{2\varepsilon}) \quad (10)$$

The average treatment effect of the untreated (ATU) is the difference between 9d and 9b;

$$ATU = E(FCS_{1i}|D_i = 0) - (E(FCS_{2i}|D_i = 0) = (X_{2i}(\beta_1 - \beta_2) - \varphi_{2i}(\sigma_{1\varepsilon} - \sigma_{2\varepsilon}) \quad (11)$$

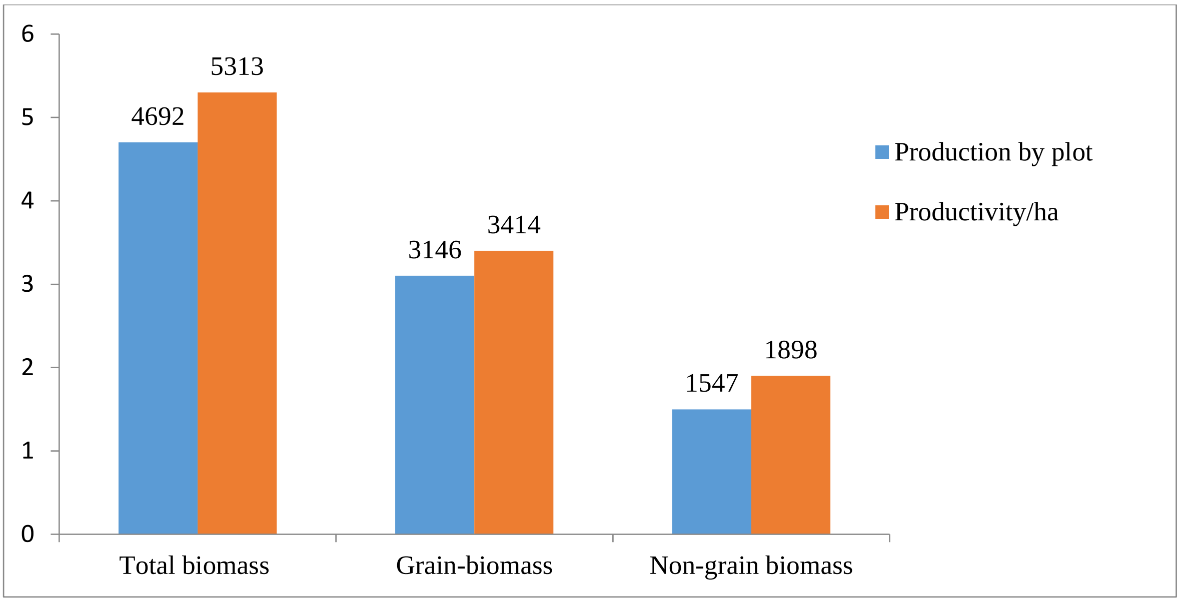
4.4 Results

This section first provides results on annual average maize biomass production and yield per hectare. The second sub-section presents intensity of maize biomass use, followed by a section that describes the food security profile of farm households. The last sub-section presents results of the food security implication of maize biomass use decisions and the challenges in biomass utilization.

4.4.1 Maize biomass production

Biomass production and productivity shape farm households' decision on biomass use decision. Figure 4.2 presents plot level average production and productivity per hectare for the total biomass and disaggregated grain and non-grain biomass-based on production of the 2014/5 main cropping season[25]. The annual average biomass production was about 4692 kg comprising of 3146 and 1547 kg of grain and non-grain biomass, respectively. The mean biomass yield per hectare was 5313 kg. The mean grain, non-grain biomass yield per hectare were about 3414 and 1898 kg, respectively. Biomass yield per hectare was relatively higher in Mecha district than Bako, yet grain yield per hectare was higher in Bako than in Mecha district.

[25] harvested between September 2014 and February 2015



Source: Authors analysis using the survey data.

Figure 4. 2 Amount of maize biomass in kg by plot and per hectare

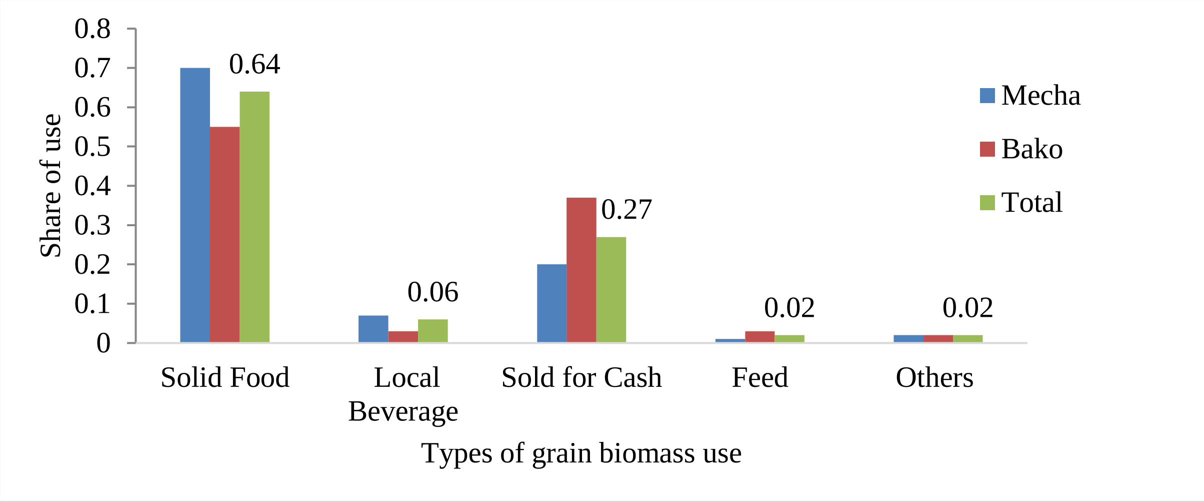
The average land holding size of the sampled maize farmers is about 1.6 hectares. Of this, two-thirds was allocated for maize production in 2014/5 cropping season.

4.4.2 Type and intensity of biomass uses

The most common maize biomass uses, and intensity of use are described by disaggregating into grain and non-grain biomass in the subsequent sub-sections.

a. Grain maize biomass uses

The total average grain maize biomass produced in 2014/5 has been used for varied purposes as cascaded on Figure 4.3. The main use of grain maize biomass includes direct home consumption in the solid form, sale for cash, local beverages and feed to livestock.



Source: Authors analysis using the survey data.

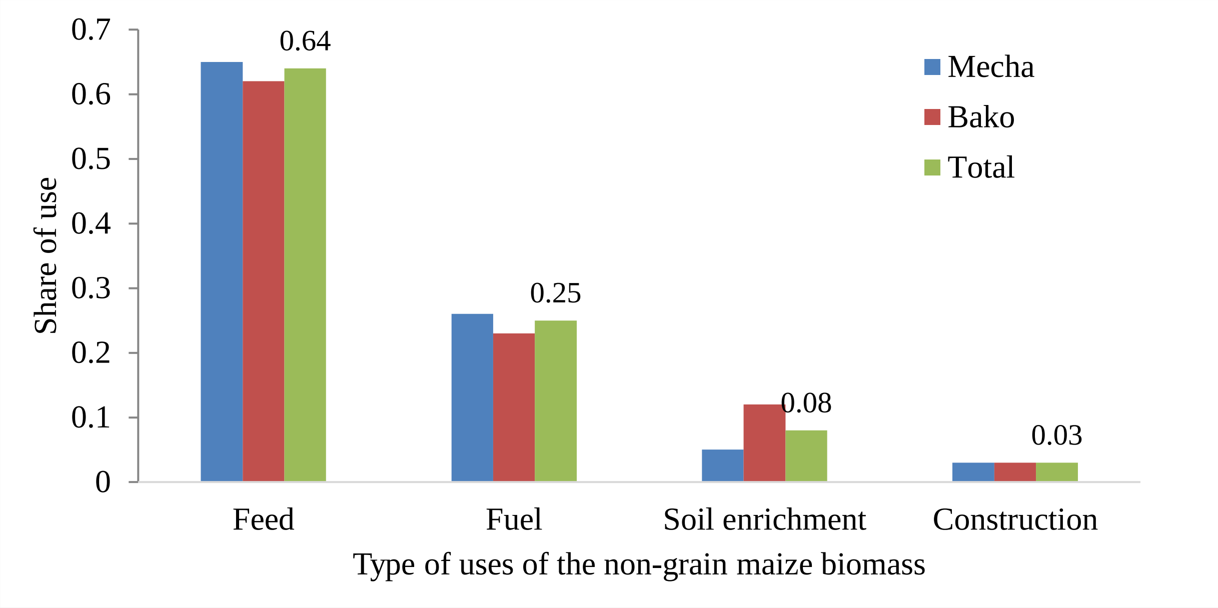
Figure 4. 3 Mean share of grain maize biomass uses of the 2014/15 main production season

Of the total average production of the 2014/5 cropping season, about two-thirds (3146 kg of grain biomass) was used for food in the solid form. The use of grain maize as source of calories in the solid food form is higher in Mecha than in the Bako district. Farm households marketed about 27% of their grain biomass in cash to generate income. The third largest area of grain use is local beverage making such as *'Tella'* and *'Areqi'*. Farm households make local beverages either for own home consumption or sell to local people and make money. Furthermore, maize grain has been used to feed livestock, accounting for about 2%. Other uses such as borrowing, seed, handout to relatives or neighbors, exchange with other crops or animal products or goods and services and payment for labor contribution accounts for about 2% of the production.

b. Non-grain maize biomass uses

The non-grain maize biomass components encompassing stalks, cobs and husk can be used for several purposes. Measuring total production, value and share of use of the non-grain biomass components remains difficult due to the lack of common unit. Components of the non-grain maize biomass could have different forms and hence could be measured using different units. A proxy unit called "*Shekim*", which approximately equals 25 kg, was used to measure the amount of the non-grain biomass production and the share of use of the non-grain maize biomass for the different uses.

Figure 4.4 shows potential areas where the mean total non-grain maize biomass was allocated for. The predominant uses of non-grain biomass were feed to animals and fuel wood, which together account about 90%. About two-thirds of the non-grain biomass has been used for livestock feed, followed by fuelwood accounting a quarter.



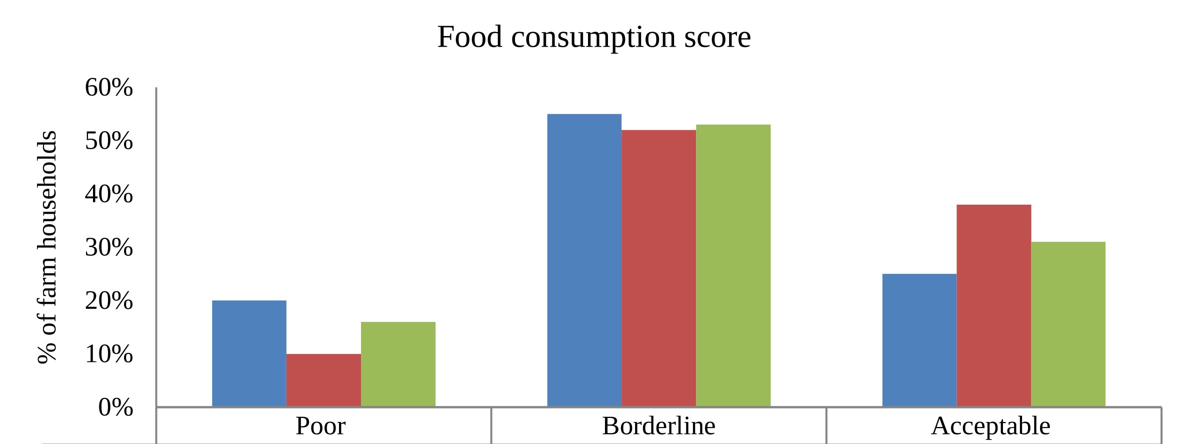
Source: Authors analysis using the survey data.

Figure 4. 4 Mean share of non-grain maize biomass uses (2014/15)

The third largest use of the non-grain biomass by sampled farm households is the part which is left on the farm, accounting about 8% which could be decomposed on the soil. About 3% of the non-maize was used for construction; farm and house fencing and making of local beehives.

4.4.3 Household food security profiles

Results of the food security profile of sampled farm households have been presented in Figure 4.5. Overall, the results show that more than half of the sample respondents scored an average food consumption profile. While about 31% and 16% of the sample households scored acceptable and poor food consumption profiles, respectively.



	Poor	Borderline	Acceptable
Mecha	20%	55%	25%
Bako	10%	52%	38%
Total	16%	53%	31%

Source: Authors analysis using the survey data.

Figure 4. 5 Farm households' food security situation

The disaggregated food consumption profile between districts further indicates that about 38% and 10% of sampled farm households in Bako scored acceptable and poor consumption profiles, respectively. Contrastingly, about 25% and 20% of the sampled farm households in Mecha district scored acceptable and poor consumption profiles, respectively.

4.4.4 Biomass and food security nexus

Having known production of biomass, farm households' food security profile and decision on the uses of the different components maize biomass, the question that arises is the relationship between biomass production and utilization and food security. Table 4.2 presents the average production and allocation of maize biomass for several purposes and compares whether a significant difference between the food secure and insecure households exists or not. It is worth mentioning in this comparison that households who scored the borderline food consumption profile are included in the food insecure groups. Accordingly, the mean annual production of maize biomass for the food insecure and secure households is 4192 and 5838 kg, respectively.

Table 4. 2 Average production of maize biomass across food security groups

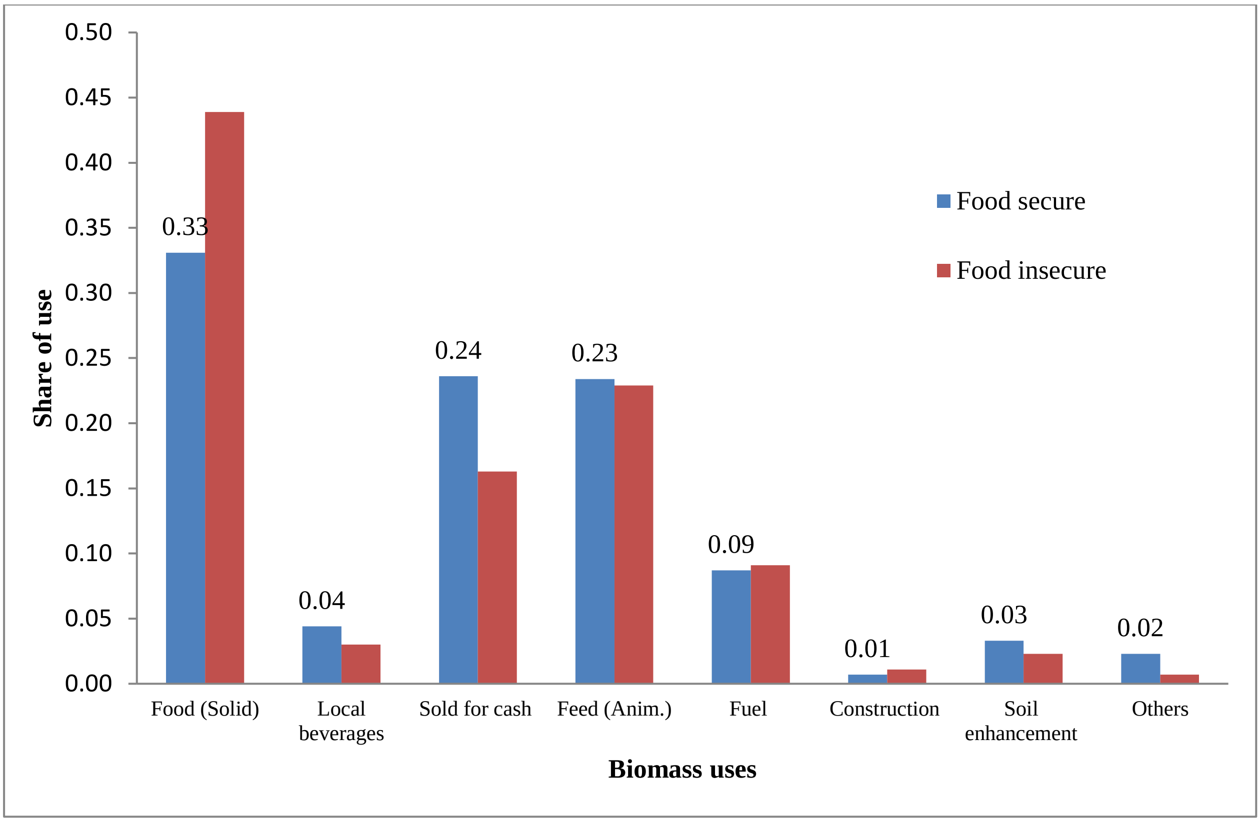
Biomass Production in kg	Food insecure (n=224)	Food secure (n=98)	
	Mean (a)	Mean (b)	Mean Diff.(a-b)
Biomass by plot	4192	5838	-1646 ***
Grain biomass by plot	2783	3975	-1191 ***
Non-grain biomass by plot	1409	1863	-455***
Grain yield/ha	3334	3597	-262**
Biomass yield/ha	5262	5431	-169
Non-grain biomass yield/ha	1927	1833	93

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.01, respectively.

Source: Authors analysis using the survey data.

The annual average production of grain maize biomass is 2783 and 3975 kg for food insecure and secure households, respectively. The mean non-grain biomass production was about 1409 and 1863 kg for food insecure and secure households, respectively. However, the grain yield per hectare is 3334 and 3597 kg for the food insecure and secure households, respectively. The t-statistics indicates a significant mean difference in production of total, grain and non-grain biomass between the food secure and insecure households where the food secure households produced larger amount than the food insecure. This shows the strong correlation between volume of biomass production and farm household food security.

On top of this, the share of biomass use within the same food security group varies as shown in Figure 6.



Source: Authors analysis using the survey data.

Figure 4. 6 Share of biomass uses by food security level of households

The largest share of the biomass, about 44%, goes for direct food (solid) purpose for the food insecure households whereas the food secure households only allocate 33% for the same purpose. The second largest destination of biomass for the food secure households is the market which accounts for about 24% while it is 16% for the food insecure ones. Animal feed use is placed second and third in terms of share of biomass use for the food insecure and food secure households, respectively. However, its share for both groups equals 23%. Similarly, the share of maize biomass allocated for fuelwood use by the food secure and insecure households is similar and accounts for about 9%. Another essential biomass use decision is the parts left on the farm. The share of biomass, stalks, and cobs without grain, leaves, husks, silks and roots that could be left on the farm was small and accounts for about 3% and 2% for the food secure and insecure households, respectively.

Table 4. 3 Mean biomass uses across food security groups

Biomass allocation in kg	Food insecure (n=224)	Food secure (n=98)	
	Mean (a)	Mean (b)	Mean Diff.(a-b)
Food solid	1624	1776	-151
Local beverage	111	235	-125 ***
Marketed for cash	976	1612	-636**
Construction	51	44	7
Soil enrichment	109	189	-80 **
Fuel	370	488	-117**
Feed	903	1341	-437 **
Others	39	150	-111 ***
TLU	4.68	6.49	-1.81***

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.01, respectively.

Source: Authors analysis using the survey data.

Table 4.3 compares the mean allocation of maize biomass for diverse purposes between the food secure and insecure households. Results of the t-statistics show, except for direct food (solid) and construction uses, significant mean difference between the food secure and insecure households. The negative mean difference reported in the last column indicates that the relatively food secure households allocate larger amounts of biomass for market, feed, fuel and soil enhancement purposes. For instance, the relatively food secure farm households allocate 636 kg more grain biomass for cash sale than the food insecure ones. This proves that the relatively food secure farm households transact larger quantity of maize biomass in the market than their counterparts. This widens the share of maize income for the total farm income[26] between the food secure and insecure households as depicted on Figure 4.7. This decision enables farm households to use the income either for buying other food groups for home consumption or yield enhancing inputs.

[26] We computed farm income based on the expenditure approach. Where the expenditure- the marginal propensity to consume (MPC is 0.21). Thus, total farm income is equals to the product of total expenditure multiplied by the marginal propensity to consume, (i.e. Farm income=Expenditure*MPC) where about 70% has been assumed to be consumed at the household level.

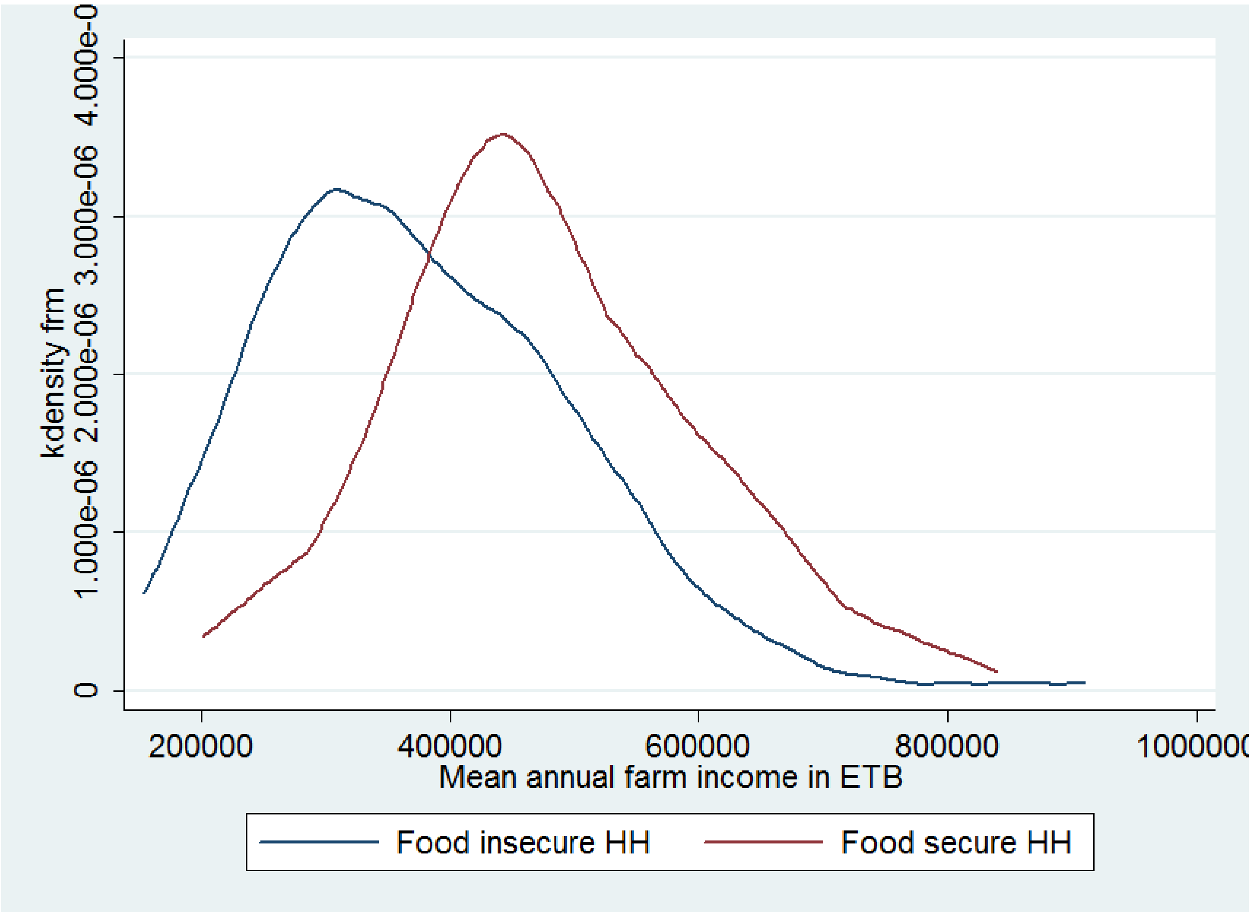


Figure 4. 7 Mean annual farm income by household food security

Source: Authors analysis using the survey data.

In addition to the single biomass use decision, intensity of use (whether diverse or non-diverse use decision) contributes to household food security or not is the next question examined in the next section.

4.4.5 Empirical model results: Intensity of biomass use and food security nexus

Table 4.4 presents estimation results of the ESR model. The estimated coefficients for the selection equation, diversification, and the outcome variable, FCS, for diversifiers and non-diversifiers are reported in column a, b and c of table 4.4, respectively. In our model, sets of household characteristics are controlled and included in the estimation.

The value of ρj in the last row and bottom of column b and c of table 4.4 shows the estimated coefficient of correlation between the error terms of the selection and the outcome equations. The significant result of ρj suggests that the error terms of the selection (diversification) and the outcome (FCS) functions are correlated suggesting that both observed and unobserved factors influence farm households' diversification and FCS. This supports our assumption that diversification is endogenous and ascertains fitness of the use of the ESR model. The value of σi in the second last row, which is the square root of the variance of the error terms of the outcome equations, indicates the degree of heterogeneity in the outcome equations (variation in FCS between diversifiers and non-diversifiers). Hence, FCS function of households who diversified maize use is significantly different (at the 1% statistical level) from those who did not diversify as reported in column (b) and (c) of table 4.4.

Table 4. 4 Parameter estimates of maize use diversification and food consumption equations

Model	**(a)**	**(b)**	**(c)**
	ESR		
		Diversification=1 (Diversifiers)	**Diversification=0 (Non-Diversifiers)**
Dependent variable	Diversification	FCS	FCS
Diversification1/0			
Age square	-0.00 (0.00) *	-0.00 (0.00) **	0.00 (0.00)
Gender	-1.27 (0.49) **	3.00 (2.60)	0.36 (2.43)
Education square	-0.00(0.00)	-0.01 (0.03)	0.01 (0.02)
Family size	-0.06 (0.05)	-0.48 (0.31)	-0.24 (0.24)
District	-0.63 (0.22) **	-0.19 (1.28)	0.84 (1.09)
Lalndln	0.32 (0.20) *	2.65 (1.12) **	-1.47 (0.96)
Cooperative	0.25 (0.25)	1.41 (1.66)	-0.20(1.11)
Market	0.73 (0.24) **	4.12 (2.04) **	2.09 (1.10) **
Selling price/100kg	0.01 (0.00) **	0.07 (0.02) **	-0.00 (0.02)
Irrigation	0.43 (0.18) **	-0.94 (1.14)	0.74 (0.92)
TLU	0.11 (0.04) **	0.48 (0.22)	0.28 (0.24)
Alternative varieties	0.70(0.15) ***	0.33(1.09)	1.00 (0.76)
Farmdist.	-0.00(0.00)	-0.03 (0.02)	-0.02 (0.02)

Credit (1=yes)	0.34(0.20) *	1.08 (1.12)	0.08 (1.08)
Inform-extension (1=yes)	0.66 (0.18) ***		
Constant	-4.85 (1.31) ***	-3.84 (8.85)	25.85 (7.01) ***
σi		4.76 (0.36) ***	6.28 (0.41) ***
ρj		0.18 (0.37)	-0.53 (0.22) ***

Note: *, ** and *** indicate p<0.1, p<0.05 and p<0.01, respectively. Standard errors in parentheses

Source: Authors analysis using the survey data.

The model results pinpoint the driving factors behind farm households' diversification decision. These factors listed in the first column and the corresponding estimated coefficients in column a of table 4.4. These factors encompass demographic factors such as age, gender, and assets (such as land size, TLU) and enabling institutions such as access to market, access to credit, access to extension and information on the diverse uses of maize and number of maize varieties available. Age and gender of household heads are significant but affect diversification negatively. Thus, older household heads are less likely to diversify than younger heads. The possible justification for this could be the fact that older household heads have limited capacity to travel to markets, access information and limited capacity to transform maize into other forms of use compared to younger household heads. Similarly, male-headed households diversify less than their female counterparts even though the majority, about 96% of our sample, is male-headed (see Appendix 3.2). Furthermore, farm households owning larger land plots, irrigable land, and larger numbers of livestock have been using maize for diverse purposes than their counterparts. The justification for this could be the fact that large land size and irrigation access both enhance maize production first which in turn provides farm households the power to diversify use. Farm households who have larger number of livestock use maize for diverse purpose since they might use part of their maize for livestock feed. Further, farmers who have better market access use maize for diverse purposes. Farm households who have access to market with fair selling price diversify by selling part of their maize for cash. Access to credit plays a positive and significant role as those who have access to credit diversify better than those who do not. Besides, access to larger number of maize varieties tailored for specific or dual purposes significantly and positively influences diversification. This means that farm households who have better access to these types of hybrid maize varieties diversify better than those who do not. Farm households' information-extension access on the uses of biomass positively and significantly influences diversification. Better information and extension access encourages farmers to use maize for diverse purposes.

As the value of σi in the second to last row of column b and c indicates, the FCS functions (5a and 5b) of diversifiers and non-diversifiers are heterogeneous. The factors that accounted for this heterogeneity are reported in column b and c of table 4.4. A demographic factor such as age has significant but negative effect on the FCS of the treatment group. Access to markets and farm income both significantly and positively affect FCS of both diversifiers and non-diversifiers. Grain selling price/kg is also significant and affects FCS of diversifiers positively. However, a contrasting impact on FCS has been found in relation to land holding size. Land size influences the food consumption score of diversifiers positively.

Table 4. 5 Average food consumption score in the factual and the counterfactual

	Decision stages		
	To diversify (actual) (n=110)	Not to diversify (counterfactual) (n=212)	Treatment effects
Households that diversified	(a)35.12 (0.39)	(c)26.26 (0.27)	ATT= 8.8*** (0.33)
Households that did not diversify	(d)29.0 (0.30)	(b)28.65 (0.20)	ATU=0.37 (0.33)

Note: *, ** and *** indicate $p<0.1$, $p<0.05$ and $p<0.01$, respectively. Standard errors in parentheses

Source: Authors analysis using the survey data.

Table 4.5 reports the expected FCS under the actual and counterfactual conditions. Cells (a) and (b) represent actual and observed FSC while c and d are the counterfactuals, respectively. The findings suggest that the expected FCS of households who diversified is statistically higher than the counterfactual. The expected FCS of households is 35 (a) and 28.6 (b) for those who diversified and did not diversify, respectively. Therefore, the last column of table 4.5 reports the average treatment effect of diversification. The average treatment effect of diversification is about 9 food consumption scores. This means farm households who diversified (a) would have scored about 8 points less if they did not diversify (c). The average treatment effect of diversification on the untreated is insignificant. Non-diversifiers did not diversify because of comparative advantages. Their food security would have been negatively affected if they did diversify as the value of ρj also ascertains in the last row last column of table 4.4.

4.4.6 Challenges in biomass utilization

Our qualitative assessment using the FGDs with maize growers and KIIs highlight some of the challenges in relation to production and consumption of maize biomass. The challenges can be grouped into three themes as lack of access to information-extension on biomass production and utilization, lack of biomass processing and value adding technologies and underdeveloped grain and feed markets. Our qualitative result is consistent to the model results on the determinate of diverse use decisions. Farmers access to extension and information support via the development agents (DAs) has been limited to grain yield enhancement with no advice on the production and uses of biomass. The national research and extension system is focused on the development of varieties that have high yield potential. Thus, access to use specific or dual purposed biomass maize varieties for maize growers as well as food processers is very much limited. This has been consistently explained by one of our key informants:

> "Our main priority is aligned with the national maize development strategy. We are very much focused on the development of vigorous and high grain yielding varieties to boost food production and achieve food security, not on biomass. We have developed few alternative varieties such as quality protein yellow maize to improve nutritional content; however, they are not yet well popularized."[27]

Access and availability of biomass processing technologies is almost negligible. As a result, farm households have been processing and using biomass inefficiently. For instance, food and feed processing (such as Chopper, Mixer, Miller and Sheller) and value adding and energy saving technologies are inaccessible. One key informant at Anno agro-industry in Bako explained that:

> "We got these technologies [Chopper, Mixer and Miller] from the USAID to support us process our seed crop residue and make feed for our livestock we keep along seed multiplication. Nevertheless, due to frequent power interruption and shortage we are

[27] Interview with maize researcher in Bako National Maize Research Center, November 25, 2015

unable to use it. Farmers residing around our farm have been also requesting us to rent and use the technology, but we are unable to do so."[28]

Market challenges for both grain and feed are pervasive. Lack of access to the grain market, power asymmetry in setting price of grain maize, volatile nature of price, and underdeveloped feed markets are prevalent and common denominators of the maize sector in Ethiopia. One maize producing farmer in Mecha district expressed some of market related challenges he has been experiencing:

> "I came to Merawi town today to sell maize but getting buyer with a fair price is difficult. We have lost hopes on maize because we have been selling the 10 sehan [local unit equals to one kg] for three ETB our buyers offer in the last two years. We are almost giving it away for free. The price of our maize we are receiving vis-a-vis the cost of seed and fertilizer we are paying are incomparable; imagine we buy seed for about 500 ETB and fertilizer for 1500 ETB. We are about to stop planting of maize."[29]

The maize sector diagnosis study indicated some potential 'demand sinks' and new hopes in the livestock and food processing sectors that would help to overcome market related constraints. Nevertheless, several challenges have been identified in these sectors.

Table 4. 6'Demand sinks' and associated challenges

S. No	Sample sub-sectors interviewed	Major bottlenecks blocks
1	Food processing industries [30]	• Shortage of sufficient yellow maize • Lack of demand for maize bread • Lack of milling technologies
2	Poultry feed processors[31]	• Rising price of feed ingredients causing feed price hike • Shortage of hard currency to import feed ingredients
3	Poultry farms	• Limited number of chicken and feed suppliers

[28] Interview with expert Anno agro-industry, November 25, 2015
[29] Interview with maize farmer, Merawi town, October 24, 2015.
[30] Interviewed with food processors: FAFA Food Share Company and Shewa Bakery, Addis Ababa, October 3, 2015. Addis
[31] Interviewed poultry farms and feed processors; Alema Farms PLC, Friendship Agro-Industry PLC, Abel Poultry (Micro and small-scale farm)

		• Rising cost of vaccination and chemicals • Falling demand & price of egg during fasting season • Inconsistence feed content and feed quality • Lack of trained poultry manpower

Source: Authors compilation based on KIIs

Table 4.6 presents some sector specific factors, which are hampering the use of maize as an input. Despite emergence of new hope in the food and poultry sector to support the growth of the maize sector, arrays of factors decelerate uptake of maize as an input in these subsectors. One of the main challenges in the poultry sector, particularly in small-scale poultry farms, is the rising price of feed and the volatility of egg price due to fluctuating feed price and egg demand. Thus, the lack of market and competition in the feed market remains a challenge for poultry business. Despite low market price and 50% share of maize in poultry feed, the price of feed remains high and leads small poultry farms get out of the business.

4.5 Discussion

More than any other region of the world, SSA remains an island of food insecurity despite high cereal biomass and yield potential. In Ethiopia, maize has been a food and cash crop, supporting more than nine million farm households (CSA, 2014b). As a result, it has been placed at the forefront in the fight against poverty and food insecurity. Previous studies (e.g. Abate et al., 2015; Alemu et al., 2010; Rashid et al., 2010; Taffesse et al., 2011) focused on supply side factors, and more specifically, on grain maize production and productivity successes. While others (e.g. (Asfaw et al., 2012; Teklewold et al., 2013) studied the impact of adoption on welfare outcomes. On the consumption side, very few (e.g. (CSA, 2011, 2014) assessed the uses of grain maize while others (Jaleta et al., 2015, 2013; Mekonnen et al., 2017; Tegegne et al., 2013) looked at the uses of non-grain maize biomass. Empirical evidence on the uses of the total maize biomass and its impact on the wellbeing of farmers and the challenges remain limited. This study thus aims to fill this gap by using a mixed methods approach.

This study identifies four major areas of use of maize biomass; food, sale for cash, feed to animals and fuel. As our results indicate, biomass production is important for food security not only by allowing farmers to allocate larger quantity on individual use but also to allocate for more diverse purposes. This is consistent with the findings of Jaleta et al.(2015) who argue that crop residue production influences crop residue utilization. Our statistical analysis how the lack of significant mean difference in the amount of maize biomass allocated for food between the food secure and insecure households. Thus, the non-food use decisions are main contributors of the significant mean difference on the food security of farm households. Feed use of biomass, which is placed third in terms of share of use serves as source of animal feed, for instance enhances farm households' likelihood of consuming home produced and processed animal products (e.g. milk and meat) and sustains access to animal power. As a result, it enhances food security, as animal products are one of the eight food groups constituting food security indicator, FCS. As our results in table 4.3 indicate, the relatively food secure households allocate larger amount of biomass for feed and have larger TLU than the food insecure ones. This is consistent with the findings of Lule et al.(2012) and Tegegne et al.(2013) who underscored the feed role of crop residue in a crop livestock system where size of grazing land is dwindling. Fuel use is the fourth largest destination of maize biomass. This decision helps reduce cost of fuel wood and time allotted for fuel wood collection, which in turn encourages farmers to invest more time on farm activity and increase productivity and food security, which is consistent to the findings of Lule et al.(2012) and Mekonnen et al.(2017). The amount of biomass retained on the farm is very small compared to other uses, though the food secure households allocate relatively larger quantity than the food insecure.

The optimum use of biomass has been undermined by a broad set of factors. These factors can be grouped into three for the sake of discussion: lack of information-extension, lack of value adding and biomass processing technologies and lack of markets. Our results, consistent with a previous study by Jaleta et al. (2013; 2015) indicate that information and extension on the uses of biomass have the potential to increase farmers' awareness about the types, benefits and costs of trade-offs of uses. Our result also reaffirms that access to information and extension support encourages farm households to diversify the use of maize and improve wellbeing. However, our qualitative assessment shows that information and extension access, particularly on the non-grain maize biomass, is low and as current research and extension system focuses on grain biomass only, which disregards the non-grain biomass. Efficiency enhancing, value adding and food and feed processing technologies such as choppers, mixers and maize-shellers are inaccessible to farmers. Thus, farmers are relying on traditional and inefficient ways of processing and using biomass. Our qualitative results indicated that lack of access to technologies on biomass processing for feed and fuel are main challenges undermining productivity and livelihoods. Mekonnen et al.(2017) consistently underscored productivity and welfare impact of on farm production of fuel. The third limiting factor in biomass utilization is the lack of market. Our result indicates that access to markets has the power to stimulate both single and diverse use of biomass and thereby impact livelihoods positively. However, we found that the transaction cost of maize is very high due to lack of lack of maize buyers and power asymmetry between buyers and maize growers. Both grain, feed and non-grain biomass markets remain a challenge. This complies with previous studies by Lule et al. (2012), Tegegne et al.(2013) and Rashid et al.(2010) who found that markets in general, and feed markets in particular are underdeveloped. Even the potential demand sinks identified and recommended by the diagnosis study to overcome market constraints have remained trapped by challenges of technology, infrastructure and lack of access to suitable maize varieties.

4.6 Conclusions and policy implications

Achieving sustainable economic growth has become a global challenge. This encouraged shifts towards sustainable and renewable resources that build a bioeconomy. This fosters an efficient utilization of biomass and thereby enhances food security in sub-Saharan African countries including Ethiopia. It is a well-established fact that maize is one of the most important bioeconomy crops that serve multiple purposes. It can be used for food and non-food purposes, which makes it a significant contributor to the global economy. So far, the development of the sector has been tilted towards grain productivity, particularly in SSA countries. Empirical evidence on the uses of the entire biomass components and its welfare (food security) impact and the challenges in this regard are very limited. This study therefore examines production and intensity of maize biomass utilization and its implication for farm households' food security and development of a bioeconomy in Ethiopia. The study uses a mixed methods approach and combines qualitative and quantitative techniques. The analysis was based on data collected from 322 randomly interviewed farm households, focus group discussions and key informant interviews in two high maize potential districts, Bako and Mecha.

The findings of the study convey three policy relevant implications. First, enhancing quantity of maize biomass is important to enhance farm household food security, which in turn supports biomass-based growth. An increase in the quantity of biomass not only increases the amount of biomass allocated for individual use but also provides farm households the opportunity to use it for diverse purposes. The study further finds positive effect of farm households' diverse biomass use decision on food security. Despite positive effects on biomass production and utilization, factors such as access to information-extension on biomass use, access to biomass markets and biomass processing and value adding technologies stimulate this decision though lacking in the Ethiopian maize sector. Therefore, the study underlines the importance of policy innovations to provide better access to extension, research and marketing systems in order to fully unlock the food security and growth potential of maize.

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Chapter Five: General Discussion and Conclusions

This chapter has four sections. The first section presents a summary of the main findings of the three case studies, followed by a section that presents general discussions on the overarching findings of the thesis. The third section present contributions and limitations of the study. The last section presents policy implications.

5.1 Summary of main results and concluding remarks

Chapter 2 examined the institutional arrangements and the governance challenges in hybrid maize seed production and quality regulation and how to overcome it. The findings show that seed production is largely dominated by public seed enterprises which lack the incentive to maintain robust internal quality control. And the public certification agency is deprived of human and logistical resources and the reform does not overcome such constraints. The study further shows that the system does allow seed inspectors, laboratory analysts and samplers to compromise on seed quality standards. Seed testing process is influenced by vested interests, and seed enterprises are often able to circumvent the system. Farmers' participation and interests are neglected and there is an overall lack of accountability in the seed certification and quality control processes.

Chapter 3 looked at the supply and demand sides of the seed distribution system with a focus on the governance challenges in the reformed seed distribution and marketing system, and farmers' preferences for attributes of the distribution system. The study finds that seed distribution and marketing reform has brought some advances particularly in terms of dealers' incentives and handling of unsold seeds. The full benefits of the reform are however curtailed by governance challenges. For instance, the discrimination and the exclusive dealership right given to private actors and cooperatives in Oromia and Amhara regions, respectively, eliminated competition among dealers and seed producers. These dealers have however do not have the capacity to effectively distribute seeds and several governance challenges such as corruption, absenteeism of seed shopkeepers and problems of adulteration of seeds occur. Besides, dealership, in the reformed DSM program, is being dictated by informal and unwritten rules. For instance, seed pricing is determined by the dominant players, public seed enterprises forum.

The LCM model results on the demand side of seed distribution system based on the CE show a positive and homogeneous preference for attributes of seed quality improvements, increase in number of sales outlet and credit as an alternative mode of payment by the majority of farmers. And these farmers are also willing to pay for improvements in these attributes. Complementary to what was found in the first paper seed quality improvements remains important from the farmers' perspective confirming the inefficiency of the seed system to supply quality seeds. Whereas preferences for attributes of group purchase, seed quantity and seed price vary across classes and contexts of farmers. This shows that smallholders in Ethiopia favor the promises made in the reformed system, although the ways reform has unfolded thus far leave them dissatisfied. For instance, the reform does not provide farmers multiple mode of payments, sales outlets and good quality seeds. The results of the choice experiment on attributes of the distribution systems show how reform outcomes in the seed system, particularly seed quality regulations and seed distribution and marketing systems, fall apart from farmers' preference. This shows that identified governance challenges further hamper translation of good intentions behind the distribution system reform into better outcomes from the perspective of farmers.

It is worth to note that merely enhancing maize productivity through the use of improved seed quality does not guarantee food security although it does enhance food availability. Another dimension, biomass utilization, is equally important for achieving food security. In view of this, we asked farmers how much maize biomass (grain and other components of maize) did they produce in the main cropping season? And for what purpose did they use it and how much? The study finds multiple areas of use of biomass, but the majority of those are underdeveloped and underutilized. The endogenous switching regression model results further show households who diversify the use of biomass achieved better food security. The results suggest that for stimulating biomass production and utilization, it is crucial to enhance accesses to extension services, promote multi-purpose maize varieties and improve access to markets and value adding technologies. Building upon the findings of the first and second papers in chapter 2 and 3, improving the efficiency of the seed system not only increases biomass production but also supports utilization of maize biomass for several purposes. Furthermore, the qualitative assessment suggests that the livestock and poultry sectors which were identified as potential "demand sinks" to support growth and facilitate transition from food to biomass supplying maize sector by the diagnosis study face several challenges. By taking a cue from this recommendation, this study found that enabling policies and strategies in relation to development of "demand sink" are lacking. As a result, both maize producers and the poultry and livestock and feed and food processing industries despite potential do not benefit from each other because of lack of important conditions such as access to maize varieties tailored to demands of these sectors, and farmers' awareness in view what variety to plant and to whom to supply for and how to process and use the different components of maize biomass is very limited.

5.2. Discussion on key findings

For the emerging bioeconomy in Africa, biomass productivity increases alongside ensuring food security are two important aspects, which are investigated in this study. The specific focus of the study is on aspects of seed system which is essential to enhance biomass productivity, and the use of the different components of biomass and its implications for food security.

Seed System

As stated in the introductory chapter, robust seed system is essential for developing the biomass-based value webs. The two empirical studies in Chapter 2 and 3 indeed confirmed that there are major problems for increasing biomass productivity. The findings of the two empirical studies provide evidence on why performance of the seed sector is poor. The main reasons for these include the lack of incentives for private sector participation in the production quality control and distribution of seeds, lack of implementation capacity and lack of political incentives in reform implementation and other governance challenges.

The findings in Chapter 2 ascertain that ensuring supply of good quality seeds to enhance biomass productivity cannot be guaranteed simply by enforcement of quality regulation. Availability of incentives in the different components such as seed production and seed distribution is also important (Component A of the conceptual framework). The findings in chapters 2 and 3confirm that despite participation of all types of actors (private and public) in production of certified hybrid maize seed, incentives available are very low and unequal. As discussed in Chapter 2, the private sector for instance, do not have equal access to the most important production factors (basic seeds and land) that can make a substantial difference in quality. The public sector has better access to land for production of certified seeds seed while the private sector mainly outsources to smallholder farmers. This mode of production increases production costs and fuels the challenge of internal as well as external quality control through certification. Another key factor to consider is SEs access to basic seeds. Majority of the SEs are multiplying varieties developed and released by the national research system. And in real terms, almost all SEs are agents of the public because they are largely dependent upon public varieties. An incentive related problem identified in Chapter 3 of this thesis is the non-market-based pricing of seeds. Price of seeds is largely determined by the public seed enterprises forum, which provides the public seed enterprises the incentive not to maintain robust internal seed quality control. The limited source of basic seeds and limited access to land (Chapter 2), the discretionary power of public SEs in deciding seed price and authorization of dealership monopoly (Chapter 3) diminish incentives of private SEs. The findings of this study underline that effective policy and institutional environments (component B of conceptual framework) are crucial for the bioeconomy because it is deficiencies in the policy environment that lead to the identified problems in the seed sector.

In addition to incentive problem, capacity related challenges are pervasive in the Ethiopian seed system, as confirmed in Chapter 2 and 3 of the thesis. Chapter 2 for instance highlighted that seed enterprises have a limited internal capacity (human and logistical) for both strict quality control via field inspection at the farm level and to test seed quality in laboratories. Besides, the seed quality regulatory body has not yet established the required human and resource capacity compatible to the demands of the service despite reforms. Similar to what we found in Chapter 2, the findings in Chapter 3 about seed distribution and marketing system identify the same capacity problem which contributes to the poor performance of the seed sector.

Full implementation of reform is vital to improve the performance of a system. The findings in Chapters 2 and 3 point to the importance of full reform implementation, which is yet to realize because of insufficient political incentive. This has been witnessed in several ways. For instance, the findings in Chapter 3 outline the seed distribution reform from the CBD to the DSM program, which was implemented in a way that excluded one actor and fully authorized another dealer. Similarly, the non-market-based pricing of seeds was against drivers of distribution reform and the principles of free market as discussed in Chapter 3. The findings in Chapter 2 further indicate that despite reform in quality regulation, only regulatory power was transferred from central to regional governments. The findings in Chapter 2 underscore that the process of certification is non-participatory, non-transparent, and the certification agency lacks full autonomy. The lack of political will in full reform implementation led to deficiencies in the system. Chapter 2 for instance identified some of the problems in this regards that include rent-seeking behavior and quality standards compromises. Seed testing process is also influenced by vested interests, and seed enterprises are often able to circumvent the system. The findings in Chapter 3 further highlight some of the governance challenges such as corruption, potential adulterations of seeds and absenteeism, which exacerbate problem of access to good quality seeds.

Apart from the supply side of reform, the demand side is also essential to improve the system. In view of this, the performance of the reformed seed distribution was analyzed using a choice experiment. The findings of the CE in Chapter 3 establish that attributes of seed quality, sales outlets number and credit mode of payment remain unaddressed by the reform. The findings of the willingness to pay estimate for these attributes also show that framers are willing to pay for improvements in these attributes. Supply of seeds to farmers via a single shop or dealers with a limited capacity encourages dealers to develop rent-seeking behavior, adulterate seeds and undermine farmers' choice of seed variety and quantity. The reformed distribution system allows only cash as a mode of payment, which hinders cash-constrained maize farmers. Yet preferences for attributes of seed quantity, group purchase and seed price vary across classes and contexts of farmers. The current minimum packaging size (i.e.12.5kg), however, discourages those farmers who want to plant less than a half hectare of land due to high transaction cost of forming a group or finding another partner to share the seeds. These results reveal that the reform did not consider local conditions of farmers. This is in line with past studies that have highlighted the importance of local contexts in policy implementation (e.g. Grindle, 2007; M. Grindle & Thomas, 1989).

Arguably, ensuring access to good quality seeds enhances biomass productivity but other aspects of the seed system are equally important. The findings in chapter 2 and 3 prove that the performance of the sub-components of the seed system, namely production, quality regulation, and distribution and marketing systems (Component A of the conceptual framework presented earlier on) and the institutions and policies governing them (Component B of the framework) are crucial. Thus, ensuring access to good quality seeds remains difficult without addressing incentive and capacity related problems in seed production, quality regulation and distribution systems. The diminishing of incentives coupled with the governance challenges in the seed sector push private SEs out of seed business and hampers the growth of bioeconomy.

Biomass Utilization

Alongside reforming the seed sector for boosting biomass productivity, there is also an issue of how to use the biomass effectively in a way that does not jeopardize food security. The different components of maize biomass (cascaded in component C of the conceptual framework) can be used for several purposes (Component E) which in turn influences food security outcomes (Component F). The findings of the empirical study in Chapter 4 establish that biomass has been used for multiple purposes such as food, feed, fuel, market, construction and for soil enhancement. Further, the findings prove that majority of these areas of uses are underutilized and underdeveloped because of lack enabling conditions such as access to multi-purpose maize varieties, extensions services, markets and biomass value adding technologies. The endogenous switching regression model results show that households which diversify the use of biomass achieve better food security. The findings of the switching regression model results further show that farm households' decision to diversify the use of maize is influenced by access to extension, access to multi-purpose maize varieties and markets. This finding in fact suggest that performance of the maize seed sector, explained in Chapter 2 and 3, not only affects productivity but also utilization of biomass for several purposes as access to maize varieties is an important biomass use stimulating factor. The findings further suggest that for stimulating biomass production and utilization, it is crucial to enhance accesses to extension services, promote multi-purpose maize varieties and improve access to markets and value adding technologies. The findings in Chapter 4 provide evidence on the food security role of biomass utilization which is in line with the findings of Mekonnen et al. (2017) that on-farm production and use of crop residue for fuelwood purpose increases value of agricultural outputs and makes fuelwood collection more convenient and saves labor.

Overall, the study highlights the importance of political will in full reform implementation if reform is to be successful in meeting the intended objectives of boosting the bioeconomy in SSA. For instance, production of foundation seeds, pre-basic, and basic seeds are still under the direct control of public SEs, which curtail the development and release of multi-purpose maize varieties by the private sector. The empirical findings in Chapter 2 and 3 prove government's reluctant to create a level playing field for private actors' participation through full implementation of reforms. This is in line with other studies (e.g. Kjær, 2017; Poulton, 2014) in the context of SSA which found that lack of political will is a major factor for the inadequate growth in the agriculture sector in SSA. This thesis thus suggests the importance of alleviating governance challenges for improving the performance of the seed sector by engaging the private sector in order to foster the development of the bioeconomy.

5.3. Limitations and recommendations for future research

As explained in the conceptual framework earlier on, the study emphasized on two aspects; seed system and farm households' biomass use which have the potential to foster the development of the bioeconomy. However, the potential and the challenge of other contextual factors in relation to the bioeconomy are not sufficiently addressed in this study and require future research.

In addition, following a mixed method approach the study has made methodological contribution as it combined qualitative and quantitative methods in understanding governance challenges in the emerging bioeconomy from demand and supply sides seed system and utilization of biomass. Nevertheless, some limitations have been identified that could be improved in future research.

In chapters 2 and 3 of the thesis, for instance PNM was used to visualize processes, identify actors and uncover governance challenges in seed quality regulation and distribution. Practically, PNM is implemented either based on individual expert interviews or focus group discussions. Despite the later provides better opportunity to explain implementation process and identify challenges through discussion among discussants, the he PNMs in chapter 2 and 3 of this thesis were conducted predominantly using individual expert interviews. This was because of the difficulties to assemble stakeholders from various offices and regions together for discussion. This, of course, on the one hand limits the development of an agreed upon idea with lesser involvement of the researcher. On the other hand, it allows our key informants to freely indicate potential entry points for governance challenges including corruption. The limitation of the PNM was however resolved to some extent by aggregating individual PNMs.

With regards to the quantitative techniques used in Chapter 2 and 3, some limitations were identified. For instance, in chapter 3, the study used a choice experiment implemented via the household survey. The choice experiment method is a useful technique often used in the marketing research to solicit preferences of consumers for attributes of consumer goods and services. In this thesis, the method is used to analyze farmers' preferences for attributes of the seed distribution system. Thus, this thesis makes an important methodological contribution for policy making by bringing in the demand side of reform implementation which looked only the supply side of programs or reforms. However, the method has got some limitations with respects to implementation because of complexity of some processes particularly during data collection. Once the choice sets are formulated, understanding the sets of attributes and their levels in every alternative of a choice situation by respondents is not easy. This also depends on the ability and interest of data enumerators' in properly explaining the alternatives in every choice to make sure that respondents make choice with full knowledge of their choice. In this regard, attempt was made to help farmers understand and differentiate alternatives in every choice process using three colored cards representing the three alternatives in a choice situation.

In chapter 4 of the thesis, an endogenous switching regression (ESR) technique was applied to analyze the relationship between intensity of biomass uses and food security of farm households. In contrast to other impact evaluation techniques, ESR model controls both observed and unobserved factors and minimizes selection biases and problem of endogeneity and provides better results. In the process, the variables diversification and food security were measured using Hirschman Herfindahl Index (HHI) and food consumption score, respectively. These methods have got some limitations. First, after computing the diversification index, a subjective rule of thumb was used to classify households into diversifiers and non-diversifiers by taking midpoint of the index value. In order to overcome such subjective categorization, however, the median value was used as an alternative to the midpoint value and to check the robustness of the results. With regards to the food security measurement, the standard food security assessment technique called the food consumption score was used. However, it is always debatable to certainly report food security situation by applying a single instrument because of the multidimensionality of food security. Besides, the analysis was based on a one-year plot level cross sectional data, which is difficult to draw generalization and calls for future research with large sample size and data of extended years.

5.4 Implications of institutional and governance challenges for the bioeconomy

As stated earlier on, the development of the bioeconomy requires an efficient seed sector and effective utilization of biomass. This part therefore presents the policy recommendations specific to these two aspects.

i. Policy recommendations in relation to the seed system

Seed is a crucial input for biomass productivity growth. Based on empirical findings of Chapter 2 and 3, the following policy recommendations are suggested to overcome the governance challenges in the system.

a. Clarifying seed quality standards and enhancing farmers awareness

In the context of the bioeconomy, supply of good quality seeds is essential to enhance biomass productivity. This requires clear certification and quality control standards although the findings of the empirical studies in Chapter 2 confirm that this is not the case in the maize seed system in Ethiopia. Seed quality standards lack clarity in many respects and the certification agency does not follow clear procedures. For instance, the number and timing of field inspections are done arbitrarily. Furthermore, the issue of certification fee per hectare remained unclear. Besides, farmers' level of awareness about seed quality standards, labeling on seed packages and procedures that should be followed at times of sale of adulterated and substandard seeds by dealers is very low. The legal cost when a farmer sues seed producers because of crop failure, and the activities that should be done to bring the case to court are not clearly known to the farmers. Thus, further clarification of standards and enhancing farmers' awareness about such cases would help to hold accountability in the system.

b. enhancing capacity of seed quality control systems

Apart from logistical and human constraints, quality of personals working in seed certification is important and thus provision of a continuous learning opportunity to inspectors and laboratory analysts to upgrade their skills and knowledge is recommended. In addition, adequate incentive has to be provided to law enforcing personnel, seed inspectors and lab analysts to minimize rent-seeking behavior. As capacity is a function of both service providers and service recipients, seed producers' effort in maintaining seed quality via own internal seed quality control practices has to be enhanced and supported. In this regard, enhancing the capacity of internal seed quality control of seed producers is important through the provision of land for the construction of storage facilities and seed processing plants and tax-free importation of laboratory equipment and regular training opportunities.

Additionally, a similar capacity limitation has been identified in the reformed seed distribution and marketing system. The post-reform authorization of dealership role to the same dealers, i.e. primary cooperatives in the Amhara region for instance and complete exclusion of cooperative dealers in the Oromia region would not help much in overcoming earlier challenges. Thus, it is important to carefully revisit capacity of dealers in terms of staff' and other seed distribution facilities. Moreover, absenteeism of shopkeepers and unnecessary dictation of farmers variety choices by sellers have become potential entry points for corruption. Thus, enhancing capacity of dealers in this regard is crucial if seed distribution system is to become efficient.

c. Allowing third party certification agency

Providing full range of seed certification services and making seeds available for distribution without delays become a challenge due to the limited capacity of the certification agency. Third party certification, which could be done by private or non-governmental agencies, has the potential to reduce the public burden, help to properly effect seed quality standards, enhance quality of certification services and ensure supply of good quality seeds. In this regard, the public could play a "watchdog" role to make sure that the third party has done the job without quality compromises.

d. Appropriate incentive mechanism should be in place to enhance private actors' participation

It is true that incentives are crucial for private seed producers to remain in the seed business, to adopt innovate working procedures, to conduct research and follow a strict seed quality control practices. The incentives for maintaining standards in certification services are very low, which is tied up in part to the partial implementation of reforms in seed distribution. This is manifested in the form of discrimination and restriction of some actors to participate in seed distribution. Further, price setting as currently practiced in Ethiopia is against the principle of free market, with a potential to negates competition and, in turn, supply of good quality seeds. Besides, private seed producers require sufficient incentives to apply strict internal quality assurance techniques. These incentives are profit margins from the sale of seeds. The findings in chapter 2 and 3, however, prove that seed system eliminated such incentives as they are taken-up by the largest and dominant public seed enterprises, which have the power to set seed price. Thus, returning incentives back to all participating actors by avoiding non-competitive and unjust pricing mechanism is essential to foster competition and thereby improve the supply of quality seeds and facilitate transition towards bioeconomy.

e. Considering local contexts and preferences of farmers in the design and implementation of reforms

Results of the choice experiment in chapter 3 prove that although the reform has not been implemented fully, the preferences of farmers for some of the distribution attributes such as the seed quality, mode of payment and number of sales outlet do not show the positive outcome of the reform. Thus, farmers still demand improvements in these attributes. Yet, the preference for the remaining attributes; seed quantity, price and group formation vary across class and contexts of farmers. The current cash-based marketing of seed does not fit into farmers' choice and rather denies access to cash constrained farmers. Besides, minimum seed packaging size in the system is 12.5kg which does not consider farmers who own or want to allocate less than half a hectare of land for maize production, and to avoid the unnecessary cost of forming a group at the time of seed purchase. Thus, the reform has to consider such contexts to achieve "best- fit" in reform outcomes and preferences of wide range of farmers.

ii. Policy recommendations in relation to maize biomass utilization

a. A shift from grain to biomass-oriented research and extension systems is important

Access to extension services on the likely usages of maize components stimulates biomass uses and thereby food security and bioeconomy. The scope of the current extension and research systems disregards components of maize other than grain. The research focus is also on yield enhancement regardless of the biomass potential. Development and access to multi-purpose maize varieties that suit to the diverse agro-ecologies of the country (18 major and more than 60 sub-agro ecological zones) is difficult. The findings in chapter 4 of this study however suggest the paramount importance of maize biomass. This calls for the need for policy innovation by reshaping the scope and focus of the research and extension systems from grain to biomass. Agricultural knowledge centers (e.g. Revising curriculums of TVET colleges to make a shift towards biomass-based agricultural education) could foster this revitalization process and thereby accelerate transition from food to biomass-based production system and foster the development of bioeconomy.

b. Developing a strategy and linking of farmers with "demand sinks"

Despite potential of the "demand sinks" to somehow overcome maize marketing challenges, there is no clear strategy that can bridge maize farmers with these markets so far. This study identified several challenges in the potential demand sinks: poultry and food and feed manufacturing industries, which require a strategy and policy attention without which it is difficult to contribute towards the bioeconomy.

c. Enhancing inter-sectoral collaboration

It is evident from the findings that maize biomass has been used for several purposes: food, feed and energy. This implies possible inter-sectoral collaboration among the food, livestock and energy sectors. For instance, about 90% of rural Ethiopia's energy is obtained from biomass, particularly crop residues and animal dungs (Geissler et al., 2013). Similarly, crop biomass is one of Ethiopia's main sources of livestock feed. The country’s huge livestock potential can benefit from other sectors as well through collaboration. This is because inter-sectoral collaboration fosters transfer of knowledge and investment. Collaboration has also been one of cornerstones in facilitating the development of the bioeconomy as it encourages transfer of new ways of biomass production, processing and utilization. Effective utilization of maize biomass thus needs a concerted effort and collaboration of sectors. Streamlining of efforts of individual sectors is important to avoid duplication of efforts and to assemble knowledge that would enhance efficiency of use of biomass and thereby accelerate growth of the maize sector and the bioeconomy.

d. Strong political will and reforming of ambivalent attitudes of government is crucial

It is widely acknowledged that political will and incentives, are crucial in supporting smallholder-led agricultural growth, (Poulton, 2014). Thus, implementation of reforms in seed sector requires strong political determination without which reforms may not succeed. The government of Ethiopia, despite a huge emphasis on agriculture, has shown ambivalent attitude towards the private sector’s active role, and its reluctance has been demonstrated in reform implementation as dealt in chapters 2 and 3. Therefore, in order to move the agriculture sector forward and to enhance food security and foster bioeconomy, government has to change its approach towards private sector. The analysis presented in chapters 2-4 shows paramount importance of active engagement of the private sector in order to ensure productivity growth in the maize sector and thereby boost food security and bioeconomy development. Without political will, however, reforms may end up with “barking up the wrong tree”(Goodfellow, 2015). Besides, political commitment is also necessary for holding accountability and transparency in seed system and to make a transition to robust bioeconomy.

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Appendices

Appendix A: Process Net-map Guide

Dear Key Informants/Discussants, we kindly request you to share with us the step by step process of hybrid maize seed production, certification and distribution. We appreciate your time and cooperation in advance.

Interviewee code------------------**Name** ----------------**Interview Date** -------------**Sex**-----
Age----------------- **Ditrict** -------------------------**PA** -------------- **Education**----------------------
Organization ----------------------**Position** -----------------------------

1. Would you explain to us the process you followed to produce/certify/distribute hybrid maize seeds? ---
2. Where in the process of hybrid maize seed production/certification /distribution you think implementation bottleneck occur? ---
3. What do you think are the reasons for the problem? --------------------------------------
4. What possible solutions do you suggest overcoming the problem? ------------------------ ---

Appendix B: Key Informant Interviews Guide

a. Perspectives of maize farmers

This is A CHECKLIST to understand problems in the maize sector. Dear Key informants, we kindly request you to tell us the issues that matters the most in maize production and marketing and we appreciate your time and cooperation in advance.

1. Do you think that improved maize seed is available to you and other farmers at the right time, place and quality? What challenges did you see in this regard ---------------- --
2. Do you think that seed companies and suppliers are capable to supply the required seed to farmers and what major challenges do you observe in doing so? ----------------- --
3. What major problems do you observe from the side of farmers in taking up of the commercial maize seed in the area you live in? And what do you think the reason is? - --
4. Can farmers access seed from the nearby cooperatives whenever they need? If not, what do you think the reasons are and your view in this regard? -------------------------- --
5. What are the challenges related to maize market in your locality? And do farmers often produce and sell maize for grain and non-grain purposes in your locality? What are the challenges you have observed from farmers and seed suppliers side? ------------ ---
6. For what purposes do farmers often use maize grain Stover? What are the challenges in advancing the use of maize Stover to improve livelihood of farmers and what

interventions are available and which one do you think are lacking in this regard?------
----

7. What problems do you experience in relation to production of maize for grain and non-grain purposes? --

b. Perspectives of experts of seed enterprises, researcher centers and government offices

1. Do you think that the number and quality of seed you produce are sufficient enough to meet farmers' seed demand?
   ----
2. Are the seeds you produce, and sale tailored to the needs of smallholder farmers? If not, why? --
3. What constraints did you face in producing the required amount of seed in time and trying to tailor towards farmers' tastes and preferences? ----------------------
   ----
4. Do you think that farmers have the capacity and the enabling conditions to get the required seed they need? If no, which one do you think is a bottleneck?
   ----
5. What external and internal factors influence you in producing, multiplying and distributing of the required quantity and quality of maize seeds to farmers? ------------
   ----

c. Perspectives of wholesalers and food and feed processors

6. What major challenges did you face in the last three cropping seasons with regard to maize trading and marketing? ---
7. Do you have any policy support to transact with maize farmers?
   ----
8. For what purposes do your grain maize clients usually buy you? Do they have any special variety preferences when they come to your store? ----------------------------
9. What major challenges did you face in the previous years with regards to access to maize to process? What other challenges did you experience as far as maize processing is concerned? -------------------------------------

Appendix C: Focus Group Discussion Guide

1. What are the main issues you consider as bottleneck in the maize seed distribution system? ---
2. Why are they pressing in the current reformed seed distribution system?
   ----
3. On what major aspects did you observe improvements in the new distribution system compared to the old one? --
4. What should be done to make it fit to your choice? --

Appendix D: Household survey Questionnaire

Tilahun W.

Dear Respondent: the purpose of this research is to understand the governance and institutional issues in the maize subsector. Hence the questions are formulated to collect pertinent information on the maize value webs with a due emphasis given to formal (hybrid maize) seed subsystem. Your honest and genuine response will improve the quality of our research. And will enable us to understand the problems deeper and suggest reliable and feasible policy recommendations that would make the maize sector more efficient, competitive and responsive to the global realities. The information you have given us will be confidential and won't be disclosed to any other party. *Thank you for your time and contribution in advance!*

Part 1: A. Socio-demographic and Economic Characteristics of Households

1. District__________kebele ____________Village Name ____________Enumerator's Name_________________Starting Time__________

<table>
<tr><td>No</td><td colspan="4">Questions</td><td>Code</td></tr>
<tr><td>1</td><td colspan="4">Respondent's name (Household head)</td><td></td></tr>
<tr><td>2</td><td colspan="4">Sex of the respondent: 0.Female 1.Male</td><td>|___|</td></tr>
<tr><td>3</td><td colspan="4">Age of the respondent in years as of the interview date?</td><td>|___|</td></tr>
<tr><td>4</td><td colspan="4">Education level of the respondent completed in year's:</td><td>|___|</td></tr>
<tr><td>5</td><td colspan="4">Religion of the respondent: 1.Orthodox 2.Catholic 3.Protestant 4.Muslim 5.Other......</td><td>|___|</td></tr>
<tr><td>6</td><td colspan="4">Marital Status: 1.Single 2.Married 3.Divorced 4.Widowed</td><td>|___|</td></tr>
<tr><td>7</td><td colspan="4">Are you the head of the household? 0.No 1.Yes</td><td>|___|</td></tr>
<tr><td>8</td><td colspan="4">If no, what is your relation with the head of the household? 1. Spouse 2.Brother 3.Child 4.Uncle 5.Aunt 6.wife 7. Cousin 8.Other</td><td>|___|</td></tr>
<tr><td>9</td><td colspan="4">What is the size of your household (number of people living in the house, including you)? 0-14years ___________ 15-65 years___________ >65 years____________</td><td></td></tr>
<tr><td>10</td><td colspan="4">In which livelihood system you think you are in? 1. Crop producer 2. Agro-Pastoralist 3.Pastoralist 4.Civil servant 5.Others, specify please………..</td><td>|___|</td></tr>
<tr><td>11</td><td colspan="4">If you produce crop, what is your current land holding right status? 1. Own land 2.Rented in 3.Rented out 4.other…</td><td>|___|</td></tr>
<tr><td>12</td><td colspan="4">What is the size of this land in hectare?</td><td>|___|</td></tr>
<tr><td>13</td><td colspan="4">How do you explain the nature of the land orientation? 1. Irrigable 2.Non-irrigable 3.Half irrigable 4.other…</td><td>|___|</td></tr>
<tr><td>14</td><td colspan="4">For how many years did you commit yourself in farming activities?</td><td>|___|</td></tr>
<tr><td></td><td colspan="4">Which labor did you use on your farm in the previous production season? (2007E.C)</td><td>|___|</td></tr>
<tr><td></td><td colspan="2">15. Family labor</td><td colspan="2">16. Hired labor</td><td></td></tr>
<tr><td></td><td>No of family labor use</td><td>No of full days worked average/year</td><td>No of hired labor</td><td>No of full days worked average/year</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td colspan="4">From which activity do you generate lion share of your household income? 1. On farm 2.Off farm 3.Non-farm 4.Remittance 5.Pension 6.Other ...</td><td>|___|</td></tr>
<tr><td>18</td><td colspan="4">Did you or any of your household member get involved in off -farm activities to earn extra money in the previous production season?(2007)0=No(Jump Q19)1= Yes</td><td>|___|</td></tr>
<tr><td>19</td><td colspan="4">If Yes to the above question, how much net income did you earn by all participating household members in birr?</td><td>|___|</td></tr>
</table>

		From Sept-Dec 2014		From Jan to April 2015		From May to August 2015	
	Type of activity	No of days	Income in Birr	No days	Income in Birr	No of days	Income in Birr
a	Hire out family labour						
b	Others specify…….						
20	Did you or any of your household members were involved in non-farm activities to earn additional income in 2007? 0. No 1. Yes (if No please jump Q21)						
21	How much net income did you earn by all participating household members from the different non-farm activities in birr in 2014/5?						
		From Sept-Dec 2014		**From Jan to April 2015**		**From May to August 2015**	
	Type of activity	No of days	Income in Birr	No of days	Income in Birr	No of days	Income in Birr
a	Petty trading						
b	Grain milling service						
c	Livestock trading						
d	Wood and metal works						
e	Others specify……						

B. Household Asset and Expenditures Profile

Assets IF no, PUT 0	Oxen	Cow	Goat	Sheep	Calves	Heifers	Horse	Mule	Donkey	Poultry	Beehives	Animal cart	Push Cart	Grain mill	Water pump	Radio or tape	Cell phone	TV	Butagas	Wood stove	ቤት እና ብስክሌት
Number																					
Value in birr																					

What was your household's level of consumption Expenditure for the following items in the last Production year in birr? (2007E.C)

Expenditure Items	Input						Transport	Storage cost	Fuel	Clothing	Medicine & health care	Education	Livestock Feed	Household food items	Others
	seed	Fertilizer	Hired labour	Herbicide	pesticide	Others									
Total Expend. in birr															

Part 2. Dear Data Enumerators: Before filling in the response to each choice set, you are kindly requested to briefly explain the purpose of the experiment and the two hypothetical alternatives possessing different attributes and levels and tell them that the choice of one specific alternative wouldn't have any immediate consequence on their actual way of accessing seed, and make sure that your respondent fully understands the choice cards presented to him/her and allow him/her to change his choice if he/she wants to do so in the course of answering the remaining choice sets. Please refer the description of each attributes on the separate sheet given while you are explaining the attributes to your respondents.

Card No. 1

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet number	4	2	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 80%	
Seed quantity	Half increment	Double increment	
Group formation	Individual	Group	
Credit mode of payment	50%	100%	
Price	500 Birr	575Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 2

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	4	3	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	99%	SE with 99%	
Seed quantity	Half increment	Double increment	
Group formation	Group	Individual	
Credit provision	50%	100 %	
Price	525 Birr	500 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 3

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	3	2	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 80%	
Seed quantity	Half increment	Double increment	
Group formation	Group	Individual	
Credit provision	50%	50%	
Price	575 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 4

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	3	2	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 99%	SE with 80%	
Seed quantity	Half increment	Double increment	
Group formation	Group	Individual	
Credit provision	100%	50%	
Price	500 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 5

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	3	3	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 99%	SE with 95%	
Seed quantity	Double increment	Double increment	
Group formation	Individual	Group	
Credit provision	50%	100 %	
Price	500 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card N<u>o</u> 6

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	3	2	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 80%	
Seed quantity	Double increment	Half increment	
Group formation	Individual	Group	
Credit provision	50%	100%	
Price	500 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card N<u>o</u> 7

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	3	4	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 95%	
Seed quantity	Double increment	Half increment	
Group formation	Group	Individual	
Credit provision	50 %	100%	
Price	500 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card N<u>o</u> 8

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet number	4	2	Neither Choice 1, nor Choice 2.
SE's seed purity level	SE with 80%	SE with 80%	
Seed quantity	Double increment	Half increment	

Group formation	Individual	Individual	I would remain with the current status quo
Credit provision	50 %	100 %	
Price	500 Birr	575 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 9

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	2	4	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 99%	
Seed quantity	Half increment	Double increment	
Group formation	Individual	Group	
Credit provision	50%	100%	
Price	575 Birr	525 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Card No 10

Assuming that the following are the hypothetical settings and your ONLY choices through which hybrid maize seed is distributed, which one would you prefer?

Attributes	Choice 1	Choice 2	Choice 3
Sales outlet	4	4	Neither Choice 1, nor Choice 2. I would remain with the current status quo
SE's seed purity level	SE with 95%	SE with 99%	
Seed quantity	Half increment	Double increment	
Group formation	Group	Individual	
Credit provision	100%	100%	
Price	500 Birr	575 Birr	

I would prefer Choice 1 ☐ Choice 2 ☐ Choice 3 (Status quo) ☐ please tick one option (✓)

Part 3. Consumption, storage, access to market and use diversification)

1. Do you often have a predefined purpose of producing maize? 0. No 1. Yes

2. If Yes for question 1, for what purpose do you produce maize?
    1. For grain 2. Non-grain 3. Seed 4. Both 5. For seed and grain 6.For grain and seed 7. For sale
3. If No for Q1, could you tell us the possible reasons?
    1. Lack of information 2. Lack of differentiated market/buyers 3. Lack of advice/extension 4. Lack of variety to produce for other purposes 5. Lack of land 6. Lack of credit and Insurance 7. Others…….
4. Did your household member/s consume all of your grain maize in the past production season? (If yes Skip Q 5 below) 0. No 1. Yes
5. If No for Q 4, what did you do with the surplus?
    1. Borrow to neighbours 2. Gave it to relatives 3. Sold it out
    4. Feed it to animals 5. Stored it 6. Others specify please…

Last year, if you were a net seller (if not jump 8 to 30), did you get access to market where you can sell your	
6. Grain maize 0. No 1. Yes	7. Non-grain biomass 0. No 1. Yes
In the previous year, if you were a net seller, were you able to know the nearby market price for	
8. Grain maize 0. No 1. Yes	9. Non grain maize (Residue, if you often sale) 0. No 1. Yes
If you were a net seller, where did you often sale large share of your	
10. Grain?(CODES C)	11. Non-grain? (CODES C)
Do you mainly use vehicles to transport maize to the nearest village market?	
12. Grain 0. No 1. Yes	13. Non-grain 0. No 1. Yes
If Yes, what is the average transportation cost you pay per quintal in Birr?	
14. Grain (quintal)	
If you do not use transportation services, how do you get your grain and non-grain maize to the market?	
15. Grain: 1. Pack animals 3. Family labour 2. Both 4. Others.........	16. Non-grain: 1. Pack animals 3. family labour 2. Both 4. Others..........
How frequently did you travel to the market in search of the right maize buyers in the last production season?	
17. Grain 1. Once 2. Twice 3. Three and above times	18. Non-grain 1. Once 2. Twice 3. Three and above times
19. On average how much does your frequent travel in search of your buyer and just price costs you in birr?	
20. How did you obtain information about the market in the last production season? If you were a net seller.	

CODE A		**CODE B**	
1) Call to partners 2) ECX information centre 3) Via cooperative **4)** Via relatives, friends/neighbours	5) Via DA's 6) Via Radio 7) Walking to the market 8) Others......	1. Cooperatives 2. Wholesalers 3. Local consumers 4. Large scale livestock production centres 5. Fertilizer and biogas plant	6. EGTE(Ethiopian Grain Tr Enterprise) 7. Local livestock owners 8. Poultry farms 9. Food reserve authority 10. Others specify please

CODES A	CODES B	CODES C	Codes D	
0. No **1. Yes** **2. Not applicable**	1. Retailing (food-solid) 2. Milling 3. Local beverage 4. Poultry 5. Livestock Feed 6. For own home consumption 7. Animal 8. Do not know 9. Others......	1. At the farm 2. At nearest village markets 3. At nearest urban markets 4. At the zone market 5. At regional market 6. At ECX 7. Others..........	1. Price incentive 2. Subsidy 3. Storage facility 4. Post-harvest handling tools	5. Production advice 6. Credit Provision 7. Link with processors 8. Animal feed 9. Others....

21. Do you have access to all weather roads to take your maize to markets? 0. No 1. Yes
22. If yes for Q20, how far is your farm to this road in walking hours

23. Overall what kind of major marketing problems did you face last year?
    1. Lack of market 3. Lack of market information 4. Storage 5. Low market price 2. High transportation cost 6. Lack of transportation 7. Others specify please.....

Part 4. Miscellaneous: Cooperatives and access to Services

24. Did you receive extension advice in relation to non-grain maize use? 0. No 1. Yes
25. How often did you receive extension support last year, on average?
26. If No for Q 24, Why?
    1. Unvailability of the service 2. Inadequate services provided 3. Ignorance 4. Does not yield any result 5. It is overlooked in the extension system 6. Others, specify please-------------
27. If Yes for Q24, the number of times you talked to extension agents in the last six months?
28. Did you need credit in the past production season? 0. No 1. Yes
29. If yes for question 24, did you get the service? 0. No 1. Yes
30. If yes for Q28, for what specific purposes did you mainly take it for?
    1. To buy fertilizer 2. To buy improved seeds 3. To pay for land rent 4. To transportation fee 5. Others
31. If yes for Q 28, where did you get or who provided you credit service?
    1. Micro financial institutions 2. Cooperatives 3. Families 4. Banks 5. Other traders 6. Others.......
32. If No for Q28, what do you think is the main reason for?
    1. Unavailability of the service 2. Unable to pay the loan 3. Ignorance 4. Does not yield any result 6. Others, specify please-------------
33. Are you a member of multipurpose farmers' cooperative in your locality? 0. No 1. Yes
34. If No for Q33, why?
    1. Ignorance 2. Lack of information 3. Unaffordable Membership fee 4. Don't trust it 5. Others……..
35. If Yes for Q33, since when did you become a member of this cooperative?
36. What kind of services do you get from these associations? 1. Input market information 2. Output market 3. Credit 4. Storage facility 5. All 6. Others specify please…….
37. Did you play a role in forming the cooperative in which you are in? 0. No 1. Yes
38. What drives you become a member of this cooperative? 1. Dividend given to members 2. External pressure to be a member 3. Only for the sake of getting fertilizer and seed 4. Neighborhood and peer influence 5. Others…..
39. If yes for Q33, do you have any leadership position? 0. No 1. Yes
40. If you are a member, what role are you playing in?

1. Only user of all the services 3. Participate in production of improved seed via clustering scheme
2. Involved as innovator of technology 4. Promoter and business developer 5. Others…..

41. Did anyone of your nearby primary cooperatives buy your maize whenever you are unable to get market to sale your surplus at a fair price last year? 0. No 1. Yes

You are highly appreciated for your collaboration and valuable time. We assure you that the information you have given us will be kept confidential and is only for academic exercise.

/End Time………………/

6. Curriculum Vitae of Tilahun Woldie Mengistu

Social and Institutional Change in Agricultural Development (490C)
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70599 Stuttgart, Germany
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Education

Since June 2014:	PhD student at the department of Social and Institutional Change in Agricultural Development, University of Hohenheim, Germany Dissertation on "Governance Challenges of Developing Biomass- Based Value Webs: The Case of Maize in Ethiopia"
2010-2012:	Master of Science (MSc.) in Development Studies with a focus on Food Security Studies, College of Development Studies, Addis Ababa University, Ethiopia
2002-2006:	Bachelor of Arts (BA) Degree in Economics, Faculty of Business and Economics, Jimma University, Jimma, Ethiopia

Scholarships

Since June 2014:	German Academic Exchange Service (DAAD)

Conference and Workshop contributions (Presentations, Posters and Trainings)

Mengistu, T., Gupta, S., and Birner, R. (2017). What do smallholder maize growers do with maize biomass? Empirical evidence from the maize belt of Ethiopia. Paper presented at GlobE Status Seminar 2017. October 16-17, 2017.Seminaris CampusHotel Berlin (Oral Presentation)

Gerster-Bentaya,M., Herrera, B., Mekonnen, F. and **Mengistu, T.** (2017). A Training Workshop on **I*nteractive method in client-centered extension*.** September 1-30, 2017 Assela, Ethiopia**.** IP consult in Collaboration with GIZ's Green Innovation project (Training offered)

Mengistu, T., Gupta, S., and Birner, R. (2017). What do smallholder maize growers do with maize biomass? Empirical evidence from the maize belt of Ethiopia. Paper presented at the International Conference research on food security, natural resource management and rural development. Tropentag 2017. "Future agriculture: socio-ecological transitions and bio-cultural shifts". 20-22 September 2017 in Bonn, Germany (Oral Presentation)

Mengistu, T., Gupta, S., and Birner, R. (2016). How would smallholders like to access hybrid maize seeds? Evidence from a choice experiment on the attributes of seed distribution system in Ethiopia. Poster presented at the International Conference Tropentag 2016, “Solidarity in a competing world —fair use of resources” September 18-21, Boku Vienna, Austria (Poster)

Mengistu T., (2013). Urban household food insecurity amidst price shock: Empirical evidence from Ethiopia. Poster presented at the International Conference Tropentag 2013, “Agricultural development within the rural-urban continuum”, September 17-19, University of Hohenheim, Stuttgart, Germany (Poster)

Mengistu T. (2013). Price shock and urban household food insecurity: Empirical evidence from Gulele, Ethiopia. (Oral). 11th international conference on the Ethiopian Economy organized by the Ethiopian Economics Association (EEA) in collaboration with IFFPRI (ESSP-II). July 18-20, 2013, Addis Ababa, Ethiopia (Oral Presentation)

Training and Workshops attended

- Workshop on Choice Experiments in Agricultural and Food Economics, June 28-29, 2016. Geo-Institute, Celestijnenlaan 200E,3001Heverlee KULeuven, Belgium
- Training Workshop on “Project Management for Young Scientists.” From November 28 to 2nd December2016. Freie Universität, Berlin, Germany
- A training workshop on Impact Evaluation Techniques. The International Food Policy Research Institute (IFPRI) and the Ethiopian Development Research Institute (EDRI). April 23- 24, 2013, Addis Ababa, Ethiopia

Employment

Oct 2014 - Nov 2017 **Doctoral Candidate**
Division of Social and Institutional Change in Agricultural Development (490c), University of Hohenheim, Stuttgart, Germany

Aug.2008-May 2014: Lecturer, department of Economics, Hawassa University, Hawassa, Ethiopia

Mar.2007-Aug.2008: Food Security Expert, GidanWoreda Agriculture and Rural Development Office, Wollo, Ethiopia

Project Participation

Since June 2014:“Improving Food Security in Africa through Increased System Productivity of Biomass-based Value Webs (BiomassWeb), Work Package 6.1 “Governance”; funded by the German Federal Ministry for Education and Research (BMBF) and Federal Ministry for Economic Cooperation and Development (BMZ).

Professional Memberships

- Ethiopian Economics Association (EEA)
- Ethiopian Statistics Association (ESA)

Stuttgart /November 2017
(Place and date)

Tilahun Woldie Mengistu