



Africa's "Seed" Revolution and Value Chain Constraints to Early Generation Seeds Commercialization and Adoption in Ghana

Philip Tetteh Quarshie^{1,2,3*}, Abdul-Rahim Abdulai^{2,4} and Evan D. G. Fraser^{2,4}

¹ School of Governance and Public Services, Ghana Institute of Management and Public Administration, Accra, Ghana, ² Department of Geography, Environment and Geomatics, University of Guelph, Guelph, ON, Canada, ³ Guelph Institute of Development Studies, University of Guelph, Guelph, ON, Canada, ⁴ Arrell Food Institute, University of Guelph, Guelph, ON, Canada

OPEN ACCESS

Edited by:

Leslie Gray,
Santa Clara University, United States

Reviewed by:

Alisher Mirzabaev,
Center for Development Research
(ZEF), Germany
Alexander Nimo Wiredu,
International Institute of Tropical
Agriculture, Mozambique

*Correspondence:

Philip Tetteh Quarshie
pquarshi@uoguelph.ca

Specialty section:

This article was submitted to
Land, Livelihoods and Food Security,
a section of the journal
Frontiers in Sustainable Food Systems

Received: 07 February 2021

Accepted: 06 September 2021

Published: 30 September 2021

Citation:

Quarshie PT, Abdulai A-R and
Fraser EDG (2021) Africa's "Seed"
Revolution and Value Chain
Constraints to Early Generation Seeds
Commercialization and Adoption in
Ghana.
Front. Sustain. Food Syst. 5:665297.
doi: 10.3389/fsufs.2021.665297

The study aims to deepen understanding of how Early Generation Seeds value chain constraints impede commercialization and adoption of High Yielding Varieties (HYV) or improved Maize seeds by smallholders in Ghana within the broader strategies of a "Green Revolution for Africa". Using qualitative and quantitative information obtained through one-on-one interviews with 15 key informants, a household survey from 110 smallholder farmers and document reviews, we discuss constraints and bottlenecks engendered by value chain structures, processes and mechanisms in Ghana's formal seed distribution system. Seven main challenges were identified that undermine trust and hinder the expansion of HYVs: (1) the limited capacity of public institutions, (2) constrained capacity of the emerging private sector, (3) a lack of well-defined, fair and enforceable contracts between stakeholders in the delivery system, (4) land-tenure limitations, (5) poor forecasting of farmers' demands for seeds by research institutions and seed producers, (6) sparse marketing arrangements for improved maize seeds, and (7) concentration of power to control seed supply in the hands of few institutions. We argue these seven issues weaken power asymmetry within the maize seed value chain's governance mechanism to create nodal points that give prominence to key public institutions, NGOs, and research institutions who control the production and distribution of improved seeds. Ultimately, trust among actors and its value chain outputs is undermined, negatively affecting the commercialization, availability, and adoption of improved seeds. Moving forward, upgrading the maize seed value chain must be pursued through targeted public and private sector relationships that acknowledge diverse actors' critical roles in the value chain.

Keywords: early generation seeds, improved seeds adoption, green revolution, Public-Private Partnership (PPP), Sub-Saharan Africa, Value Chain (VC)

INTRODUCTION

In recent times, farmers' activities in Sub-Saharan Africa intersect with global trends in the growing demand for food, competition for land, water and energy resources, climate change, dietary changes, and the emergence of new technologies (see Stringer et al., 2020). To achieve needed food security in the region, scholars and practitioners posit high yielding seeds and other intensification technologies are needed to close the yield gap between what farmers currently obtain and what they could if they had access to better quality inputs (Tilman et al., 2011; Juma, 2015; Fraser et al., 2016). Gaining access to high Yielding Varieties (HYV) of Maize is understood as one pathway for transforming smallholder livelihood in Africa, improving yields and increasing food availability for food security (Juma, 2015). Yet, the adoption and use of these inputs, particularly hybrid seeds, remain limited (Langyintuo et al., 2010). The literature notes the adoption rate of hybrid seeds in Eastern and Southern Africa is 33 and 38%, respectively (Langyintuo et al., 2010). In Ghana, the government's ministry of agriculture estimates the adoption rate of improved seeds among rural farmers is around 10% (Ministry of Food Agriculture, Ghana, 2015), while others suggest drought tolerance maize (DTM) adoption is ~82% (Martey et al., 2020). However, 6 months of ethnographic emersion by researchers suggest smallholders are reluctantly adopting improved seeds and other technologies (Vercillo et al., 2020), with the hybrid seeds adoption rate standing at 8% (Nyantakyi-Frimpong and Kerr, 2015). Despite the great potentials touted within the broad vision of smallholder transformation and the deployment of Improved and High Yielding Seed Varieties (IHYSV), or what we refer to as the "African Seed Revolution," many nations in Sub-Saharan Africa, including Ghana, are less successful in turning the plethora of long-time efforts into changes for smallholder farm productivity and livelihoods. This limitation is due partly to challenges in evolving and emerging seed markets (Langyintuo et al., 2010; Akudugu et al., 2012), which limit availability and use of such seeds, thus preventing the much anticipated African Green Revolution (Juma, 2015) and sustainably achieving global food security across scale.

Previous research conducted in SSA to understand determinants of improved technologies adoption, particularly,

Abbreviations: AGRA, Alliance for a Green Revolution in Africa; CIMMYT, International Maize and Wheat Improvement Center; CRI, Crop Research Institute; EGS, Early Generation Seed; GLDB, Grains and Legumes Development Board; GMet, Ghana Meteorological Services Department; GSID, Ghana Seed Inspection Division; Ha/ha, Hectares; HYVs, High Yielding Varieties; ICRISAT, The International Crops Research Institute for the Semi-Arid Tropics; IITA, International Institute of Tropical Agriculture; IHYSV, Improved and High Yielding Seed Varieties; LCIC, Legacy Crop Improvement Centre; MoFA, Ministry of Food and Agriculture; NASTAG, National Seed Traders Association of Ghana; NARIs, National Agricultural Research Institutes; NGOs, Non-Governmental Organizations; NSC, National Seed Council; NVRRC, National Variety Release and Registration Committee; OPVs, Open Pollinated Varieties; PFJ, Planting for Food and Jobs; PPP, Public-Private Partnership; PPRSD, Plant Protection and Regulatory Services Directorate; SARI, Savannah Agricultural Research Institute; SSA, Sub Saharan Africa; SEEDPAG, Seed Producers Association of Ghana; SRID, Statistics, Research and Information Directorate; TVRC, Technical and Variety Release Committee; UN FAO, United Nations Food and Agriculture Organization; VCA, Value Chain Analysis; WACCI, West Africa Centre for Crop Improvement.

seeds of HYVs focused on factors constraining HYSV adoption at the farmer level [e.g., Adesina and Baidu-Forson, 1995; Caswell et al., 2001; Doss and Morris, 2001; Adeogun et al., 2010; Buah et al., 2011; Atilaw et al., 2016; Ainissyifa et al., 2018; Alliance for a Green Revolution in Africa (AGRA), 2018]. For instance, socio-economic issues such as financial and land resource constraints affect the adoption of HYVs among smallholders. Furthermore, agroecological complexities (Baidu-Forson, 1999; Atilaw et al., 2016; Ainissyifa et al., 2018), farmer demographic characteristics such as smallholders' age (Adesina and Baidu-Forson, 1995; Adeogun et al., 2010), farmers' level of education (Caswell et al., 2001; Buah et al., 2011), smallholders' gender (Doss and Morris, 2001; Doss, 2013), sociocultural settings and prevailing farm practices (Nyantakyi-Frimpong and Kerr, 2015; Vercillo et al., 2015; Kansanga et al., 2019), and more recently, the enduring intensification dilemma to adopt or not to adopt among smallholder farmers (Quarshie and Abdulai, 2021) have been determined as a significant determinant of improved seeds adoption in SSA. In contrast, minimal attention is given to the potential of seed value chain constraints that affect improved seeds' adoption rate (Langyintuo et al., 2010).

Hence, in this paper, we explore the institutional structures of Ghana's improved maize seeds value chain and the perceptions that farmers have of this value chain in order to identify bottlenecks that prevent farmers from utilizing HYV of Maize. Ghana is an appropriate place to explore these issues because Western Africa, including Ghana, accounts for more than 60% of agricultural output from the SSA over the past 24 years, and Maize is an integral part of the SSA's crop production output. However, production is being marred with challenges such as Land degradation and climate change (Ayanlade and Radeny, 2020). Ghana is also characterized by diverse seed systems, with relatively moderate success than many other African countries (Asante-Dartey et al., 2016), but not as much as is also experienced in parts of East and Southern Africa such as Kenya, Ethiopia, Zambia, Zimbabwe, South Africa among others (McGuire and Sperling, 2016; Hoogendoorn et al., 2018). Hence, Ghana's choice is informed by its centrality in understanding middle-level issues in African Agriculture. We draw on value chain analysis, which discusses how markets and governance mechanisms interplay to shape product conception through to delivery to consumers (see Kaplinsky and Morris, 2001; Mitchell et al., 2014), to shed light on Ghana's maize seed delivery system. We focus on maize seeds because the crop plays an essential role in the country and on the African continent in entirety.

Maize is an important food security crop in the SSA, with over 40M ha of farmlands dedicated to maize cultivation across over 32 countries in the region. Maize consumption capacity in the area stands at 100 g/day (FAO, 2021). With the SSA population projected to double by 2050 (Prasanna et al., 2021), the demand for cereals, particularly Maize for food, is forecasted to increase three-fold (van Ittersum et al., 2016). The importance of Maize is enshrined in the culture of the people of SSA. For instance, the crop is epitomized by a famous adage in Malawi "maize is life" (Langyintuo et al., 2010). In Ghana, an over five centuries-old maize-themed festival called "Homowo" is celebrated annually to mark the victory over hunger among the Ga-Adamgbe tribe

(Kwakye-Opong, 2014). Maize is cultivated in all agroecological zones in Ghana by most rural households and doubles as the second most important crop after Cassava (Ragasa et al., 2013; Alhassan et al., 2016). Maize accounts for about 62 and 55% of all staple crops produced and consumed in Ghana [MoFA–Statistics, Research and Information Directorate (SRID), 2016]. Hence, in this paper, we (1) describe the formal maize seed value chain, (2) identify bottlenecks within the maize seed value chain, and (3) provide a case study on maize seed adoption in Ejura Sekyeredumase Municipality. In particular, we reflect on how a number of key factors reduce the opportunity for the distribution of maize seeds, including the contestation of powers, interests, and influences of various actors in the system. Ultimately, we argue that the challenges and bottlenecks in the maize seed value chains hinge on the political and economic interests of few public institutions, NGOs and research institutes, which manifest at the expense of local farmers’ needs to undermine the successful delivery of maize seeds to smallholder farmers.

In what follows, we expand on these arguments. First, in the Background Context section, we provide an overview of agriculture value chains and Africa’s Green Revolution, with a focus on seed markets. The maize seed market is then described before we overview the study context and methods. Next, we present the results to show the challenges related to existing arrangements among institutions, power dynamics between public and private actors, and commercialization structures. Our discussion section emphasizes that the existing problems result from competing interests that erode trust in the fragmented value chain. Finally, the article concludes with calls for reforms to diverse action through the process and product upgrading and offers new directions for research.

BACKGROUND CONTEXT AND THEORETICAL APPROACH

Value Chain Analysis of African “Seed” Green Revolution

The concept of Value Chain Analysis (VCA) has been used in recent times to understand the evolution (and sometimes even a revolution) of activities and processes required to bring agricultural products/services from conception through production, delivery and end-use by users/consumers (Kumar et al., 2011; Trienekens, 2011). The goal of value chain analysis is to ascertain ways of upgrading the chain to ensure consistency and stability in delivering quality and quantity of product/service (Gereffi, 1994; Kaplinsky and Morris, 2001; Mitchell et al., 2014). Among other themes, the organization of agriculture commodities along the value-chain framework has been conceived as a strategy to bring more efficiency into the commodity value chain.

The weak economic and governance structures in agriculture commodity value chains, which remain pervasive, costly and inequitably distributed, severely limit smallholders’ ability to benefit from ill-structured value chains (Langyintuo et al., 2010; Trienekens, 2011). Furthermore, the dramatic and uneven control of agriculture commodity production processes

and prices of agriculture products, enmeshed within access restrictions, weak infrastructures, inadequate resources and institutional voids continue to expose the vulnerability of most agriculture value chains in meeting demands and investment by smallholder farmers to achieve food security (Langyintuo et al., 2010; Kumar et al., 2011), within the context of malfunctioning agriculture commodity value chain.

In Africa, issues related to competing and converging interests within agriculture stakeholders are subtly discussed in seed value chain literature (e.g., Langyintuo et al., 2010; Smale et al., 2013; Smale and Mason, 2014; Tripp and Ragasa, 2015; Atilaw et al., 2016). Scoones and Thompson (2011) examined Africa’s Green Revolution’s politics, focusing on how seed markets have evolved across SSA. Using case studies from Ghana, Ethiopia, Kenya, Malawi, Zimbabwe etc., these authors found a strong commitment to promoting agribusiness-oriented models led by the private sector and substantial government interventions and rushed energy programs in some cases. However, within such systems are a supposed win-win scenario that involves the State, NGOs, and private sector engagement, which creates a diversity of interests and resultant pathways of action. Core to these systems is the competing politics of formal and informal seed systems, where policy directions established for the seed “revolution” presupposes a weak and inefficient informal structure. However, farmers are inclined to rely on informal systems for many reasons, including diversity of seeds, autonomy and independence, the economics of seeds, compatibility with agroecological conditions, and lack of trust in formal delivery (Scoones and Thompson, 2011; Nyantakyi-Frimpong and Kerr, 2015; Vercillo et al., 2015; Kansanga et al., 2019).

In confirmation of the growing competing interests and governance structures within the new seed value chains, Poulton and Chinsinga (2018) conceptualized the factors that influence commercialization, a key element within the vision across Africa. Domestic political settlements, geography, and external interests driven by development partners (traditional and non-traditional) and international investors like agribusinesses shape the processes. Amanor (2011), in his analysis of the cereal seed market in Ghana, showed that some influential public and private actors continue to shape a neoliberal agenda that aims to construct a shared vision in the country around a capitalist seed market system. The said vision, however, is critiqued by some scholars who believe it “serves a narrow set of political interests and constrains local innovation and opportunity in the seed sector” (ibid: 48).

In summary, the previous studies lay the foundation for understanding the challenges of seed delivery in Africa and show how value chains constrain the delivery of high-yielding seed markets. However, to understand why small-scale farmers have not embraced HYV, we need to explore further and focus on more empirical work. While value chain analysis has been used to investigate the efficiency of seed delivery systems, particularly in SSA (e.g., Langyintuo et al., 2010; Asante-Dartey et al., 2016), much of the focus has been on food production to consumption at the broader commodity value chain level (Kumar et al., 2011; Trienekens, 2011) and in particular, improving the partnerships to establish more certified seed producing companies to ensure

consistent supply of certified seeds to smallholders (Langyintuo et al., 2010; Asante-Dartey et al., 2016; AGRA, 2020). This paper further uses the value chain theory to identify bottlenecks within the maize seed value chain, which can affect improved seed delivery and adoption in SSA. It does so by identifying actors in the seed value chain, the limitation these actors face, and how these challenges translate into complex but integrated constraints that culminate into poor improved seed adoption. While smallholder farmers in SSA are considered laggards to adopt green revolution technologies. This paper draws attention to challenges in the seed value chain, which also significantly influences smallholders' decisions to adopt improved seeds for agricultural productivity.

Background Context: Improved and Traditional Seeds in Ghana

Crop seeds in Ghana are categorizable into the traditional or farmers' saved seeds and improved seeds (UN-Food Agriculture Organization, 2017). The FAO notes that any seeds with characteristics including high yielding, ability to withstand drought, and early maturing should be considered as "improved seeds." This description, however, underscores traditional varieties that originally have such features. Farmers habitually select landrace varieties or save seeds over many generations for planting due to specific character traits like adaptation to the natural and cultural environment of growth. Farmers usually recognize specific morphological characteristics like shapes, sizes, and colors to keep seeds for the next planting season (Monela, 2014). With the adverse effect of drought, climate change and other environmental conditions, these farmer-saved seeds may be unable to yield enough to boost agricultural productivity among smallholder farmers and reduce poverty. This issue necessitates newer improved seeds to change the smallholder farmer's fortune (Stringer et al., 2020).

Improved or modern varieties are those obtained after a systematic and scientific process of selection and breeding (CIMMYT, 2020). Plant breeders change plants' traits to produce desired characteristics and increase their value to enhance their crop yield potential or resistance to certain adverse conditions. Improved varieties may have certain advantages like better nutritional content, adaptation to new agricultural areas, resistance to disease and insects, and higher efficiency during drought. More often than not, they also have an altered agriculture calendar to enable production outside traditional production periods [Alliance for a Green Revolution in Africa (AGRA), 2013]. Improved seeds are of two categories: Open Pollinated Varieties (OPVs) and Hybrid seeds (Cho, 2013). OPVs rely on natural processes such as insects, birds, and wind, to facilitate pollination. These processes allow for the reproduction of seeds that mimic their parent breeds, mostly for generations. Unlike the OPVs, hybrid seeds are environment and technique-controlled breeding to produce novel seeds that mostly differ substantially from their parents. For hybrid seeds, an end goal of improvements to growth potential, size, yield or other intended features are created into the pollination process.

Research has shown that hybrid maize seeds yield 25–43% more than OPVs in Sub-Saharan Africa (CIMMYT, 1997). Elsewhere in the United States, hybrid yields are about 50–100% more than OPVs (Kutka, 2011), making them a better option for smallholder farmers in SSA in terms of food security and economic wellbeing (Smale et al., 2013; Smale and Mason, 2014). However, farmers still prefer OPVs for several reasons, not the least of which is because they can save their grains from their harvests for replanting, whereas farmers who plant hybrids must purchase fresh seeds for planting every season (Ragasa et al., 2013; Monela, 2014;). According to Ragasa et al. (2013) and Tripp and Ragasa (2015), the use of OPV instead of hybrid seed is a backward step in terms of expected grain yield. Yet, improved OPVs represent an economical option for resource-poor maize farmers in marginal areas because hybrid seeds require a lot of labor input to apply fertilizer, not to mention that fertilizer prices are high relative to the price of grain.

Background: Overview of the High Yielding Varieties in Ghana

A review of documents on the Maize value chain shows a diverse and complex structure in Ghana. During the past decades, successions of government and donor interventions have sought to enhance the production and distribution of HYV of Maize to smallholder farmers. A few of the most notable is the Sasakawa Global 2000 (SG2000) project that was instrumental in establishing a system of small-scale seed producers in the country (Technical Centre for Agricultural Rural Cooperation, 1996). Between 2007 and 2015, CIMMYT, in collaboration with IITA, implemented the Drought Tolerant Maize for Africa (DTMA) project in 13 countries across Sub-Saharan Africa (SSA) to increase the food and income security of smallholder farmers through the development and dissemination of drought-tolerant, well-adapted maize varieties (CIMMYT, 2015). More recently, the organization has also launched the Stress Tolerant Maize for Africa (STMA) project, which seeks to develop new maize cultivars with tolerance and resistance to multiple stresses for farmers in 12 countries across SSA in a bid to replace obsolete varieties more than 15 years old and support local seed companies to produce seed of these cultivars on a large scale (STMA) (CIMMYT, 2021). This brief background provides the context for the data collected for this paper that identified 27 Improved Maize Varieties Planted in Ghana.

Of the 27 improved seed varieties identified by this research in Ghana, only 24 types were registered and documented in the National Variety Catalog released by the National Varietal Release and Registration Committee (NVRRC). Out of the 24 maize varieties designated in the catalog, only 10 are Hybrid Maize (see **Tables 1, 2**). Also, the West Africa Centre for Crop Improvement (WACCI) of the University of Ghana, with support from the AGRA, released three new hybrid maize seeds, WACCI-M-1205, WACCI-M-1210, and WACCI-M-1218 (AGRA, 2017; WACCI, 2017), which are yet to be added to the seed catalog.

TABLE 1 | Hybrid maize varieties released in Ghana.

Variety	Year of release	Color	Maturity period	Yield (t/ha)	Uses/characteristics	Preferred ecology
Mamaba (Hybrid)	1997	White	105–110 days	6.5	Food*, drought tolerant	All
Dadaba (Hybrid)	1997	White	105–110 days	6.5	Food*, drought tolerant	All
Cida-ba (Hybrid)	1997	White	105–110 days	6.5	Food*, drought tolerant	All
CSIR–Etubi (Hybrid)	2007	White	105–110 days		Food*, drought, and lodging resistant	Forest and forest transition
CSIR–Enii-Pibi (Hybrid)	2010	White	110 days	5.5	Food*, drought tolerant	Forest and forest transition
CSIR–Sika Aburo (imported hybrid)	2015	White	105–115 days	8	Low fat, high crude protein	All
Kunjorwari (DTMA hybrid)	2015	Yellow	110 days	6.9	Drought and striga tolerant	Forest, forest savanna transition, Guinea savanna
Suhudoo (DTMA hybrid)	2015	White	110 days	6.7	Drought and striga tolerant	Forest, forest savanna transition, Guinea savanna
Warikama (DTMA hybrid)	2015	White	90 days	5.8	Drought and striga tolerant	Sudan and Guinea Savanna, Forest savanna
Kparifaako (DTMA hybrid)	2015	White	90 days	5.7	Drought and striga tolerant	Sudan and Guinea Savanna, Forest savanna

*QPM, Quality Protein Maize; DTMA, Drought Tolerant Maize for Africa.
Source: Catalog of Crop Varieties, 2015.

TABLE 2 | Open pollinated maize variety released in Ghana.

Variety	Year of release	Color	Maturity period	Yield (t/ha)	Uses/characteristics	Preferred ecology
Golden Crystal (OPV)	1972	Yellow	105–110 days	4.6	Feed	
Obatanpa (OPV)	1992	White	105–110 days	4.6	Food*	All
Dodzi (OPV)	1997	White	80–85 days	3.5	Food	Guinea, Sudan savanna
CSIR–Golden Jubilee (OPV)	2007	Yellow	105–110 days	5	Food* and feed	Forest and forest transition
CSIR–Aziga (OPV)	2007	Yellow	105–110 days	4.7	Food* and feed	Forest and forest transition
CSIR–Akposoe (OPV)	2007	White	85 days	3.5	Food*	Forest and forest transition
CSIR–Omankwa (OPV)	2010	White	90 days	5	Food*, drought, and striga tolerant	Coastal Savanna
CSIR–Aburohema	2010	White	90 days	5.5	Food*, drought, and striga tolerant	Forest and Sudan savanna
CSIR–Abontem (OPV)	2010	Yellow	75–80 days	4.7	Food*, feed, drought, and striga tolerant	Guinea and Sudan savanna
Sanzalima (OPV)	2012	White	110 days	5.4	Drought and lodging tolerant, disease-resistant	Guinea and Sudan savanna
Ewulboyu (OPV)	2012	White	110 days	5.4	Disease resistant, drought, and lodging tolerant	Guinea and Sudan savanna
Wangdataa (OPV)	2012	White	90 days	4.7	Drought, striga and lodging tolerant and disease resistant	Guinea and Sudan savanna
Bihilifa (OPV)	2012	Yellow	90 days	4.6	Drought, striga and lodging tolerant and disease resistant	Guinea and Sudan savanna
Tigli (OPV)	2012	Yellow	120 days	5.2	Disease and lodging resistant	Guinea savanna, transitional and forest

*QPM, Quality Protein Maize; DTMA, Drought Tolerant Maize for Africa.
Source: Catalog of Crop Varieties, 2015.

Tables 1, 2 provide details on some of the promising HYV and their characteristics.

Of the most commonly used breeds, only three varieties are imported onto the local market for farmers to access. These varieties are Pan 53 (White Maize), widely known as Sika aburo, which is released and registered by the National Varietal Release Committee; Pan 12 (with registered name Nkunim), yellow Maize and 30Y87, which is imported but awaiting release. Hence,

the seed market is locally based, which may signal efforts to embed the green revolutions within places.

The intense marketing by the MNCs through the use of out-grower schemes contributes actively to awareness of the seeds to farmers. In 2015, about 600 MT of hybrid seeds was imported by MNCs (MOFA, Ghana, 2016). Commercial farms (over 1,000 ha) tend to grow mainly imported hybrid maize seeds, while smallholder farmers (≤ 3 ha) usually grow Obatanpa.

Smallholders are also likely to recycle the seeds for a while before replacing them (Ministry of Food and Agriculture, 2010). The production and distribution structures partly influence farmers' behaviors toward these seeds and how effective HYV proliferate in farm communities. However, our study shows farmers are reluctant to adopt these HYVs (see later sections), despite the existence of these breeds in the country since 1972. Previous research shows only 1 percent of farmers adopt and use hybrid seeds (Azinu, 2014). Our study confirmed that the adoption of hybrid maize seeds in Ghana is still low, with only 3 percent of farmers in our study district adopting Kparifaako, a more recently released hybrid maize variety.

RESEARCH SETTING AND DESIGN AND METHODS

This research was a part of a comprehensive study that investigated the factors that enhance or militate the adoption of HYV of Maize in Ghana. The study examined the delivery structure broadly while using a case-study of the Ejura Sekyeredumase Municipality (**Figure 1**) to assess the local-level dynamics. Established by Legislative Instrument 1400 (L. I. 1400) in 1988, the Municipality is one of the currently 27 local district units in the Ashanti region of Ghana. The area lies within Longitudes 1°5"W and 1°39"W and Latitudes 7°9"N and 7°36"N. The location of the District means it is sandwiched between Atebubu-Amantin District to the North-West, Sekyere South District to South, Offinso Municipality to the West and Mampong Municipality to the East. The District covers an area of 1,782.2 sq. Km, which is about 7.3% of the total land area of the Ashanti Region. There are about 20 communities in the Municipality, and with a total estimated population of about 85,446 in 2010. Males constitute 50.20%, while females make up for the remaining 49.8%. Agriculture is a significant livelihood activity in the area, as about 60.20% of the populace participate in some form of the sector (Ghana Statistical Service, 2014). With much of the land area located in the forest/savanna transitional zone, about 80% is considered suitable for crop production. Crops like mangoes, avocados, cashew, guava, shea, Maize, yams, cassava, cowpea, groundnuts, plantain, guinea corn, rice etc., with vegetables such as garden eggs, okra, tomatoes, pepper etc. are common. About 13,486.44 Ha cropland is dedicated to maize production due to its significance to the settlers in the area, with average farm sizes of about 1.02 Ha per farmer household. The district produced 28,861 tons of Maize in 2014, the highest of any Ashanti Region production area (MOFA, Ghana, 2016). However, like many other places in Ghana, rain-fed agriculture still foregrounds crop productions in the region, necessitating the search for productive seeds. A few of the notable donor/government-supported agriculture and food security projects undertaken in the districts include the Millennium Development Authority (MiDA) and AGRA Scaling Seeds and Technology (SSTP) projects which seek to increase production and dissemination of improved planting materials to

smallholder farmers [MoFA–Statistics, Research and Information Directorate (SRID), 2016].

Climate-wise, the Municipality has favorable conditions as it experiences both forest and savanna conditions. Across the year, the region experiences high temperatures with a mean monthly of 21–30°C. Like other southern areas, bimodal rainfall patterns exist, with a primary season from April to August and a minor from August to November. The dry season occurs between November–April. The annual rainfall for the District varies between 1,200 and 1,500 mm. However, the rainfall pattern is erratic and unreliable for most parts. The rainy periods are associated with very high relative humidity, as high as 90% experienced in June and as low as 55% in February, making it the Ashanti Region's driest area (GMet, 2016).

The study used qualitative and quantitative data collected between January 2018 and March 2018 to answer our research question. We used a survey, key informant interviews and document review. We complemented these data with the lived experiences of one of the authors who was raised in the area and worked as a project manager in the sector. Some earlier reports from some of the projects were presented in reports on strengthening Africa's seeds system (see Langyintuo et al., 2010; Asante-Dartey et al., 2016; Mabaya et al., 2017). This study relied heavily on qualitative survey information obtained through one-on-one interviews with 15 key informants, comprising breeders, seed producers, agro-input dealers, officers from the ministry of food and agriculture and some NGOs. The data gathered during the interviews information was complemented with quantitative data obtained using an open-ended household questionnaire to collect data from 110 farmers (see **Supplementary Material**), randomly selected using quota sampling technique, using the ratio of the population of the five communities with the highest population in the Municipality: Ejura, Sekyeredumase, Anyinsu, Hiawoanwu, and Dromankuma (**Table 3**). The selection of these larger areas was informed by the concentration of agricultural activities in those regions and their surrounding rural communities. The quantitative data were analyzed using an excel sheet to produce basic descriptive statistics as needed. The qualitative elements of the surveys, together with interviews and program reports, were analyzed using Nvivo 11. All documents were uploaded into the software and coded according to predetermined themes, using content-based analysis. The predetermined themes were formed in line with the objectives of the research. The content analysis was focused mainly on the intensity of discussions of issues as they reflect on the research themes. The focus of the coding process was to show issues and processes that undermine the effective delivery of quality HYV to farmers in Ghana. The qualitative sections of the analyses mainly formed the basis of this paper.

Six EGS value chain processes were identified, the strength and weakness of value chain actors and enablers were assessed to understand constraints to the production and supply of maize EGS. The EGS value chain analysis was done using qualitative studies to capture the nuances at each production section of the value chain and understand the sectors' repression

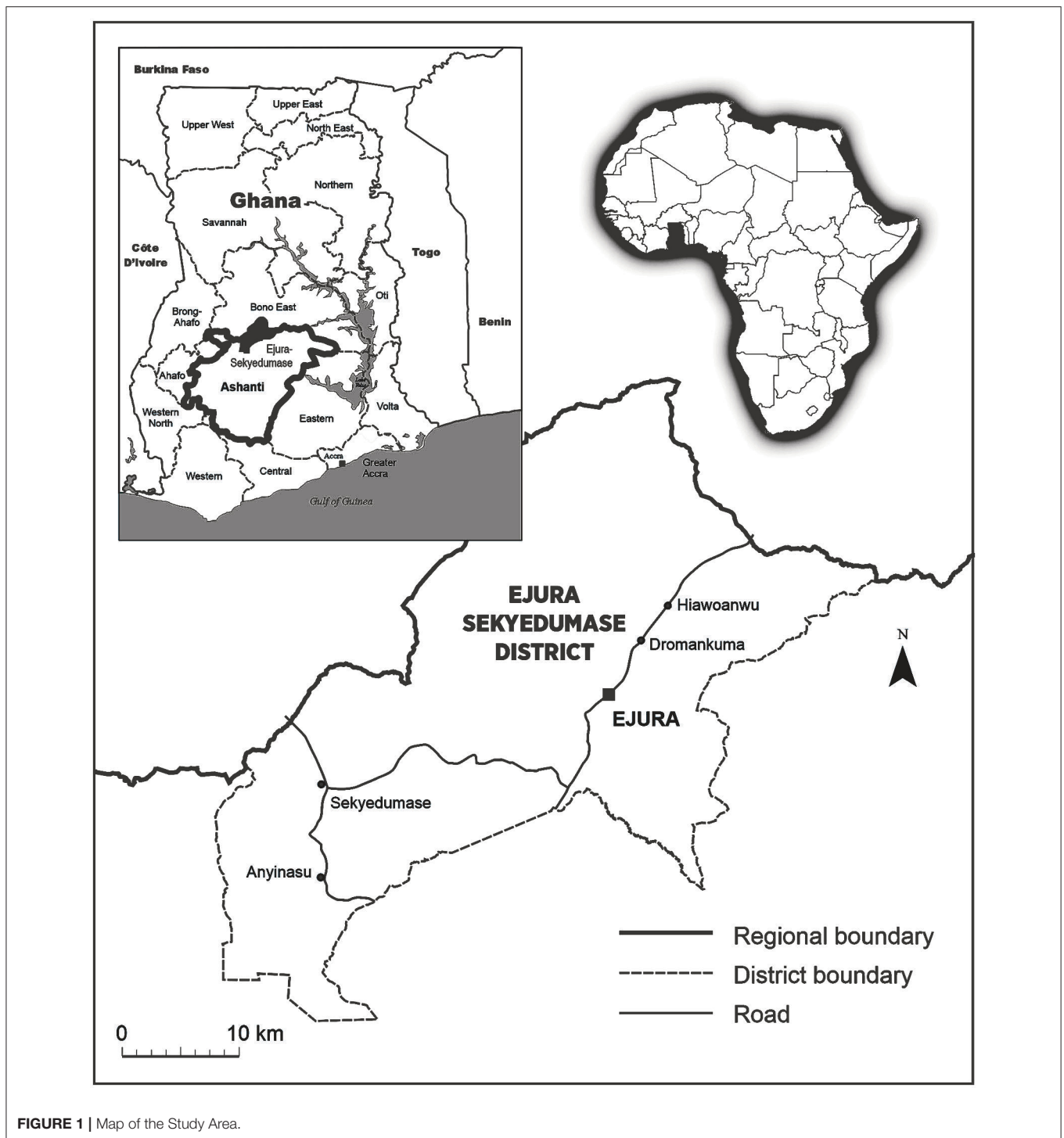


FIGURE 1 | Map of the Study Area.

of improved seeds delivery and smallholder farmers' resistance to adoption. This will enable the finding to be generalized in line with the intersectional generalizability approach as suggested by Fine et al. (2008), Schinke and Blodgett (2016), and Smith (2018) for community-based research that tracks patterns of repression across space and movement of resistance.

The quantitative household survey presents us the opportunity to understand how EGS value chain constraints undermine smallholder farmers' efforts to adopt improved seeds in the study area. This approach is also supported by a broad range of researchers (e.g., Laws et al., 2003; Sumner and Tribe, 2008; Scheyvens, 2014) who advocate for this approach to address

TABLE 3 | Respondent selection and distribution table.

Name of community	Total population	Percentage out of 85,446 ppl	Number of respondents	Selected percentage (%)
Ejura	34,414	40.28	72	72.36
Sekyeredumase	8,530	9.98	18	17.53
Anyinsu	4,325	5.06	9	9.08
Hiawoanwu	2,718	3.18	6	5.71
Dromankuma	2,334	2.73	5	5.90
Total	52,321	61.23%	110	100.00

Source: Author, 2021.

research challenges arising as a result of critical concerns such as ethical, methodological, ontological and epistemological issues surrounding the researchers' positionality in terms of philosophical standpoint, race, nationality, sexuality, age, social and economic status etc.

STUDY RESULTS

Following the three objectives of this paper, this results section is organized in the following way: (1) description of the structure of the Maize Value Chain in Ghana, and (2) identification of bottlenecks within the formal maize seed value chain, and (3) description of a case study on maize seed adoption rate in Ejura Sekyeredumase Municipality.

Objective 1: Structure of the Maize EGS Value Chain in Ghana

The maize sector is the most developed formal seed system in the country, with the most active private sector participation. Our research revealed that Ghana's seed system is categorized into three primary delivery methods: formal, informal, or a combination of both formal and informal networks, which is also known as the intermediary or community-based production system. The interaction of these sectors produces a complex seed structure with diverse actors.

The informal seed system is unstructured and unregulated, and its activities are not monitored or supervised by any public or private institution. The government is not in charge of monitoring and controlling standards within the informal seed sector. Seed production regulations and policies within the informal sector are influenced mainly by indigenous knowledge, standards, and social capital. The sector's informality makes it hard to know the number of varieties circulated and controlled with the system. Variety selection, multiplication and distribution are all done within a local context or specific geographical area, influenced by place-based cultural beliefs and structures. The primary source of seed for most farmers is the seeds saved on-farm from the previous harvest.

The Intermediary or Community-based seed system bridges the gap between the informal and formal seed sources. It emerged as a result of donors, NGOs and other entities working with farmers to facilitate availability, access to and adoption of improved seeds by smallholder farmers. Respondents noted that this sector is usually controlled by some seed producers who

produce their foundation seeds, which they then multiply to produce certified seeds for supply to smallholder farmers. This feature is attributed mainly to the lack of trust in the quality of foundation seeds produced and supplied by the government parastatal. The intermediary sector is sandwiched between the formal and informal and can exhibit partial characteristics of both systems.

The formal seed delivery system comprises interlinked activities and actors (see **Figure 2**). The sector comprises resource management processes, variety breeding research and crop improvement, variety testing and release, conditioning and storage, marketing and distribution, and the use of the seeds by farmers. As described in the national seed policy, this system is headed by the Ministry of Food and Agriculture, which hosts the national seed council and national variety release committee. Other key actors include research and public institutions, the Grains and Legumes Development Board (GLDB), the Ghana Seed Inspection Division, NGOs/projects and the private sector.

The system provides for a hierarchical structure of distribution. Crop Research Institute (CRI), Savannah Agriculture Research Institute (SARI) and West Africa Centre for Crop Improvement (WACCI) undertake the breeding of new maize varieties in Ghana. WACCI source parental lines from IITA and CIMMYT and combine with local germplasm to produce breeder seeds. The breeder seeds are then supplied to the Grains and Legumes Development Board (GLDB) for multiplication into foundational seeds. The GLDB maize foundation seeds constitute the primary output that feeds the formal seed sector. The National Seed Council (NSC), National Variety Release and Registration Committee (NVRRC), Technical and Variety Release Committee (TVRC) also plays a crucial role within the maize seed value chain in Ghana. The NSC, NVRRC, which is a standing committee, and the TVRC is known to provide technical advisory support to the seed sector. Their mandate to operate and function is established by the Plant and Fertilizer Act of 2010 (MoFA, 2010). NVRRC's role is to maintain the national variety list and give appropriate recommendations regarding the release of seed varieties, removal, and adding new varieties to crop files. Aside from conducting technical reviews, the TVRC is required by law to advise NSC on issues of registration, certification procedures, and appropriate fees to charge. They are also mandated to publish a list of crop varieties grown in Ghana and, to some extent, crop lists to be included in the ECOWAS catalog.

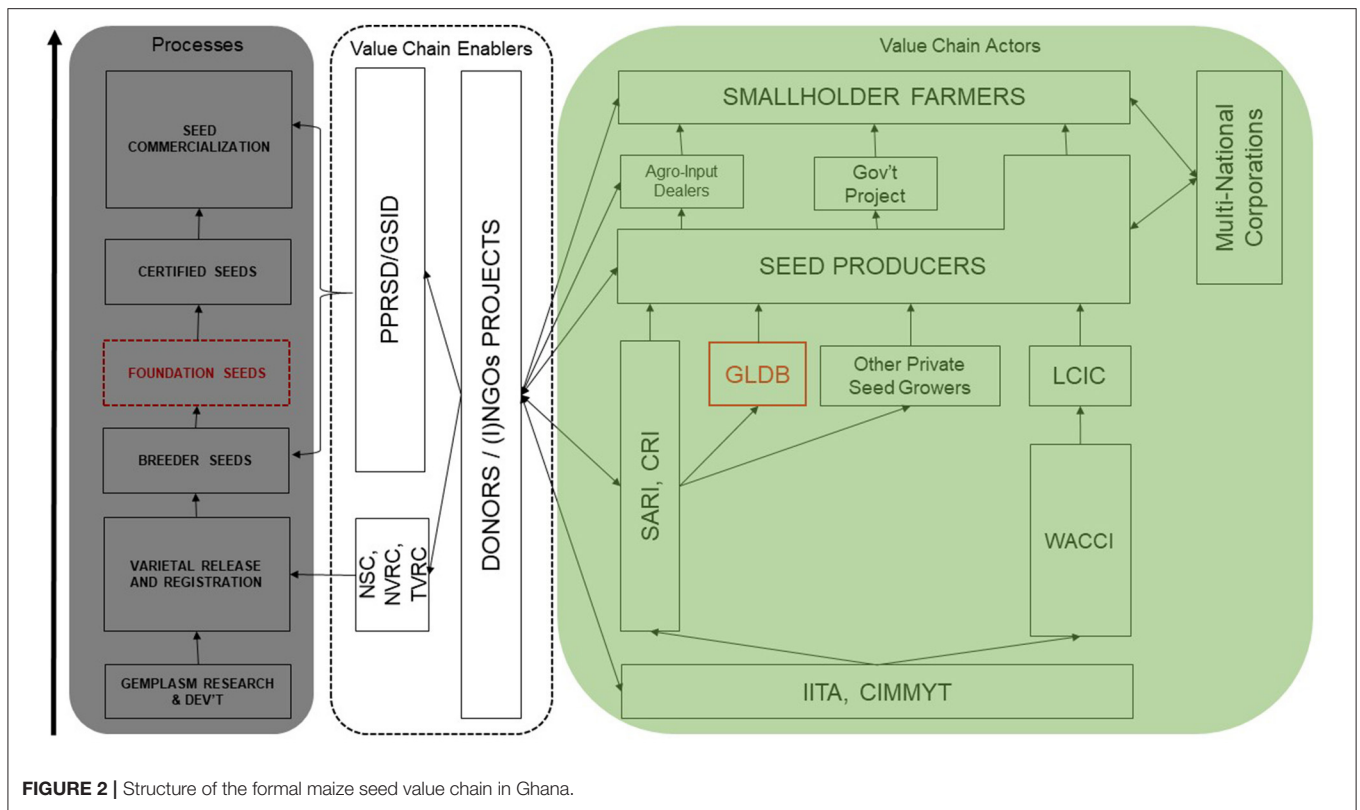


FIGURE 2 | Structure of the formal maize seed value chain in Ghana.

Another government institution, the Ghana Seed Inspection Division (GSID) of Plant Protection and Regulatory Services Directorate of MOFA, acts as inspectors who visit fields to train, supervise and approve commercial seed production. GSID has an exclusive supervisory role over the production of breeder seeds through to the sale of certified seeds to grain producers or farmers. GSID plays a role in producer training and the provision of standard packaging materials in which nearly all certified seeds are sold. The seed companies are mostly private sector actors, the majority of whom form part of the Seed Producers Association of Ghana (SEEPAG) or National Seed Traders Association of Ghana (NASTAG). These actors multiply the seeds into certified seeds for distribution to smallholder farmers across the country. Private seed companies and seed producers are involved in producing both certified OPVs and hybrid maize seeds on their production plots and through a network of out-growers who produce seeds under supervision. The study also notes that some private seed companies and TNCs with the capacity to produce foundational seeds have been granted a license to produce their foundational seeds for further multiplication into certified seeds. The criteria and requirements to acquire this license are still unclear to most actors in the seed value chain.

The formal seed system’s ability to deliver improved seeds to farmers is quintessential since the goal of the broader green revolution agenda is to have HYV reach smallholders. However, despite the anticipation that the formal seed system would help solve the supposed dysfunctional informal sector, our

study found that institutional constraints in the sector affect the viability of seeds produced and the efficiency of the seed value chain.

Objective 2: Bottlenecks Within the Formal Maize Seed Value Chain

Our interviews revealed seven key bottlenecks were as standing in the way of the distribution of high-yielding varieties of seed in Ghana’s formal Maize value chain. These issues emanate at the intersections of public and private actor interactions and processes, leading to the unsuccessful functioning of the maze value chain (See Figure 5). This section uses key quotations from interviews to show these challenges as consistently referred to by diverse stakeholders in the seed value chain.

The Limited Capacity of Public Institutions

One constraint is the limited capacity of public institutions to deliver the services required to produce the needed seeds for adoption. In addition, GLDB, mandated to produce foundation seeds, is ill-equipped to respond to growing foundation seeds volume and product range requirements. This concern was expressed by one seed producer who said during an interview:

“I don’t trust the foundation seeds I get from them, GLDB. Their seeds are produced in poor conditions because they don’t have the right resources” (Seed producer 1).

This situation is aggravated by the fact that GLDB mostly relies on rain-fed for production, making it more vulnerable to climate perturbations. The over-reliance on rain-fed production and lack of functional seed conditioning facilities depresses output by research institutions and GLDB and undermines the ability to make available sufficient quality breeder and foundation seeds of many. Likewise, respondents noted that the three national institutions (CRI, SARI, GLDB), which play a front role in producing all breeder and foundation seeds, operate at low capacity due to financial constraints. Other public institutions like the NSC, NVRRC, and TVRC are also resource-constrained and unable to meet regularly to discuss matters relating to varietal release. In most cases, as seed producers alluded to, varietal release meetings must be facilitated by organizations seeking to apply to release a crop variety.

Constrained Capacities of Private Actors

The second bottleneck is the constrained capacity of the emerging private sector. We identified limited investment in promoting efficient seed production equipment and technologies like irrigation facilities, planters, boom sprayers and seed conditioning facilities. The inability to procure the right production materials negatively affects the purity and quality of hybrid seeds. In addition, breeders hardly provide descriptors and management requirements for new varieties, resulting in the inability of seed companies to successfully bulk up EGS, especially hybrids:

“From ages, new varieties are introduced by either IITA, CIMMYT, ICRISAT, and breeders don’t have any knowledge on the parentage of the varieties. After it has been released, then there is pressure on them to provide descriptors but no fund to plant parental lines for descriptors documentation—(Maize Breeder).

Beyond the physical capacities, technical competence, capacity and quality assurance systems are not optimally developed by seed producers, impacting product quality and delivery. The outcome is low maintenance of breeder lines and weak adherence to strict quality assurance protocols, which impact the germination and purity of seeds, creating credibility challenges for breeding institutions.

Poor Legal Regulatory Oversight

At the intersection of the limitations of the private and public sectors is a lack of well-defined, fair and enforceable contracts between stakeholders in the delivery system. Key informants noted that public institutions and seed companies have limited binding rules to deliver:

“Our seed law do not provide explicit room for dispute resolution in case of bad seed supplied by an institution. The only place for redress is the court, and looking at the bureaucracy in our judicial system, one will prefer to let it go rather”—(Maize Breeder).

In a rare scenario, where there is a formal contractual agreement between public institutions and the private sector does exist.

They are one-sided, skewed in favor of the public sector, with no non-performance clauses and mechanisms for enforcement, leading to a lack of follow-through on agreed terms and conditions, such as product quality, volumes to be delivered, and quantities to be picked up. Since farmers do not hold the power to influence GLDB, they are left to the mercies of the organization’s institutional capacity to meet demand needs for foundation seeds. Likewise, the relationship between agro-input dealers and seed producers are non-binding and weak at best. Respondents noted that even when agreements are reached between input dealers and seed companies, enforcement is tough. For example, as one official noted, most agro-input dealers *“...take seeds on credit and pay after they sell to farmers, but it’s hard to hold them accountable since we can’t tell when they sell”* (Official 3). The weak and non-binding ties among institutional sectors in the value chain mares the working relationship between these actors, restrict EGS availability and limits maize seeds’ quantities effectively distributed to farmers.

Weak Land Tenure System for Seed Production

Land-tenure systems, which are embedded in institutional arrangements of the value chain, are of concern:

“It is difficult to get 10 Ha farming land which is own by one family. Even if you get one family owning it, you may not get all the family heads agreeing to give you that piece of land for farming” (Seed Producer).

The fragmented and challenging land tenure system currently functioning in Ghana was noted to restrict seed companies from securing large tracts of land for proper plant isolation. However, breeding arrangement necessitates large tracts of land at certain times to avoid cross-contamination of seeds with weaker plant breeds. The non-availability and lack of land ownership for seed production limit the ability to produce seeds effectively, undermining both the quality and quantity of seeds produced for distribution to smallholder farmers.

Poor Planning and Forecasting

Poor forecasting of farmers’ demands for seeds by research institutions and seed producers present challenges within the supply chain. The study revealed that there is no formal system in place to forecast seed demand reliably:

“What we lack as an association is a system that can accurately forecast seed demand and supply, and the same goes for the farmers too...”—(NASTAG Official).

Consequently, value chain actors either guess or use past sales records to guesstimate demand for improved seeds by smallholder farmers. Such an approach is not sustainable and dependable, inhibiting the growth potential of the seed sector. An official referred to the inability of NASTAG to

meet the Government of Ghana's request to supply improved maize seeds for the first-year implementation of the Planting for Food and Jobs (PFJ) programme as a representation of this issue.

The Ministry of Food and Agriculture (MoFA), in rolling out the Government of Ghana's vision of PFJ in February 2017, solicited tenders from private seed companies to supply fertilizer and certified seeds of Maize, soybean, rice, sorghum, onion, pepper, tomato, and cabbage to 200,000 smallholders as part of the government's subsidy program to stimulate farmer adoption. Out of the 4,860MT of maize seeds requested by the government, only 2,645MT were supplied by seed producers, creating a demand gap of 2,215MT (Ministry of Food Agriculture, 2017). Subsequently, the government had to rely on seed imports for the program (See **Figure 3**). "...recently the government spent about US\$44M to import 10,000 tones of hybrid maize seeds from Burkina Faso, Nigeria, Malawi and South Africa for the PFJ Programme." (Official from Ministry of Agric).

Poor Marketing and Business Development Strategies

Officials also noted that there are poor marketing and awareness activities on improved maize seeds in Ghana. Advertisement on seeds availability is done partly through radio programs or mobile outreach in some selected but few locations per time. Talking about product information, almost all seed producers market their seeds in GSID/NASTAG/SEEDPAG branded polybags. The government recently provided the Planting for Food and Jobs (PFJ) sacks for seed distribution (See **Figures 3, 4**).

Only a few seed producers are allowed to brand their products for sale, undermining the commercial competitiveness associated

with differentiated products. The selection criteria for these "selected few," who mostly have political influence, remain unclear. Unfortunately, seed producers can only write their company's name on these packaging materials using either pen or markers, limiting company-based marketing and traceability. The high possibility of adulteration of seeds by fraudulent persons seeking their selfish interests makes this arrangement unsuitable. Such arrangements also limit the motivation to ensure high-quality seeds gain authenticity.

Power Concentration

The complexities of the challenges highlighted so far, coupled with experiences in the field and participants' views, reveal the concentration of seed power in the hands of few institutions in the formal system. Institutions at the higher level of the hierarchy wrestle power to control and dictate the flow of seeds, sometimes to the detriment of lower-level organizations who are unable to exert any change.

"The last time, I said at seed sector stakeholder meeting that the foundation seeds which was sold to me had lost gem (germination power), Dr. X and his team almost beat me up. They threaten not to give me any foundation seeds again" (seed producer).

Since only a few institutions produce the foundation seeds, they exert much influence and control how the lower-level entities must behave.

These bottlenecks identified in this section do not stand in isolation but interact through the value chain. The bottlenecks' dynamics and crosscutting characteristics hinder seed production, distribution, extension and commercialization efforts, and ultimately adoption among farmers (see **Figure 5**).

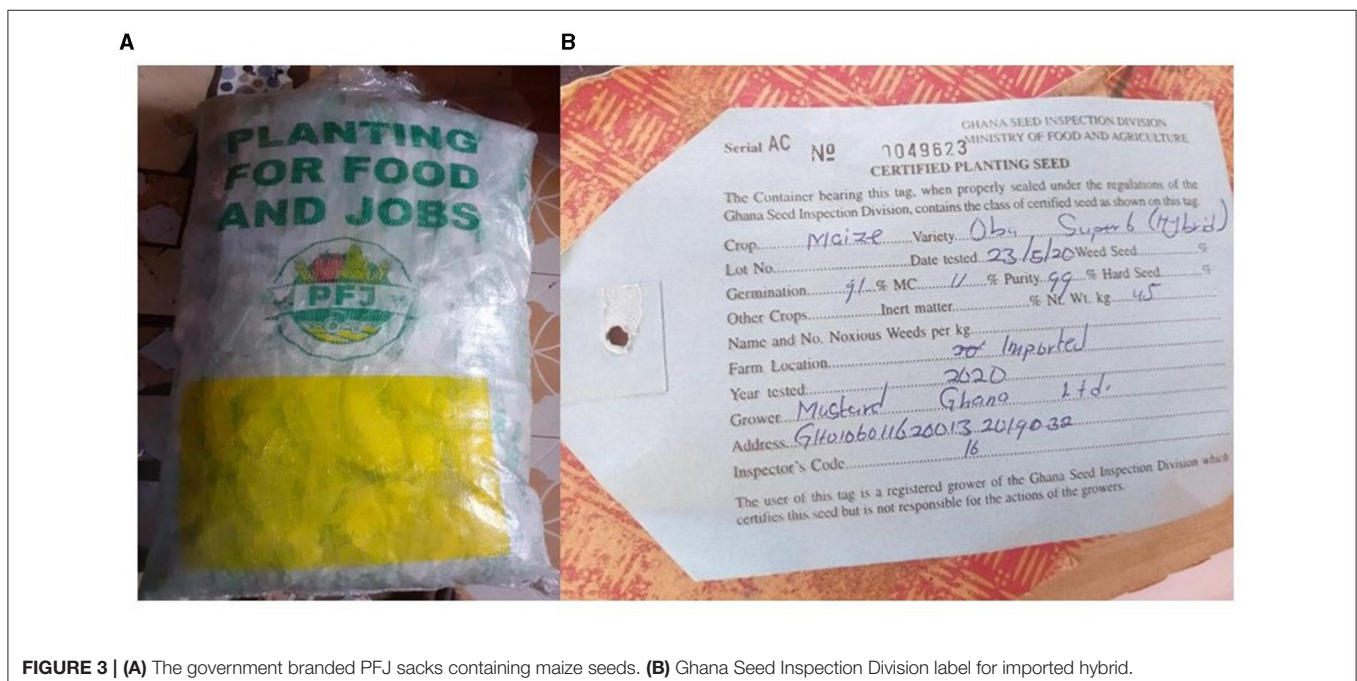


FIGURE 3 | (A) The government branded PFJ sacks containing maize seeds. **(B)** Ghana Seed Inspection Division label for imported hybrid.



FIGURE 4 | Certified maize seed packaged in Ghana Seed Growers Association branded sacks with the name of seed varieties written with pen/marker.

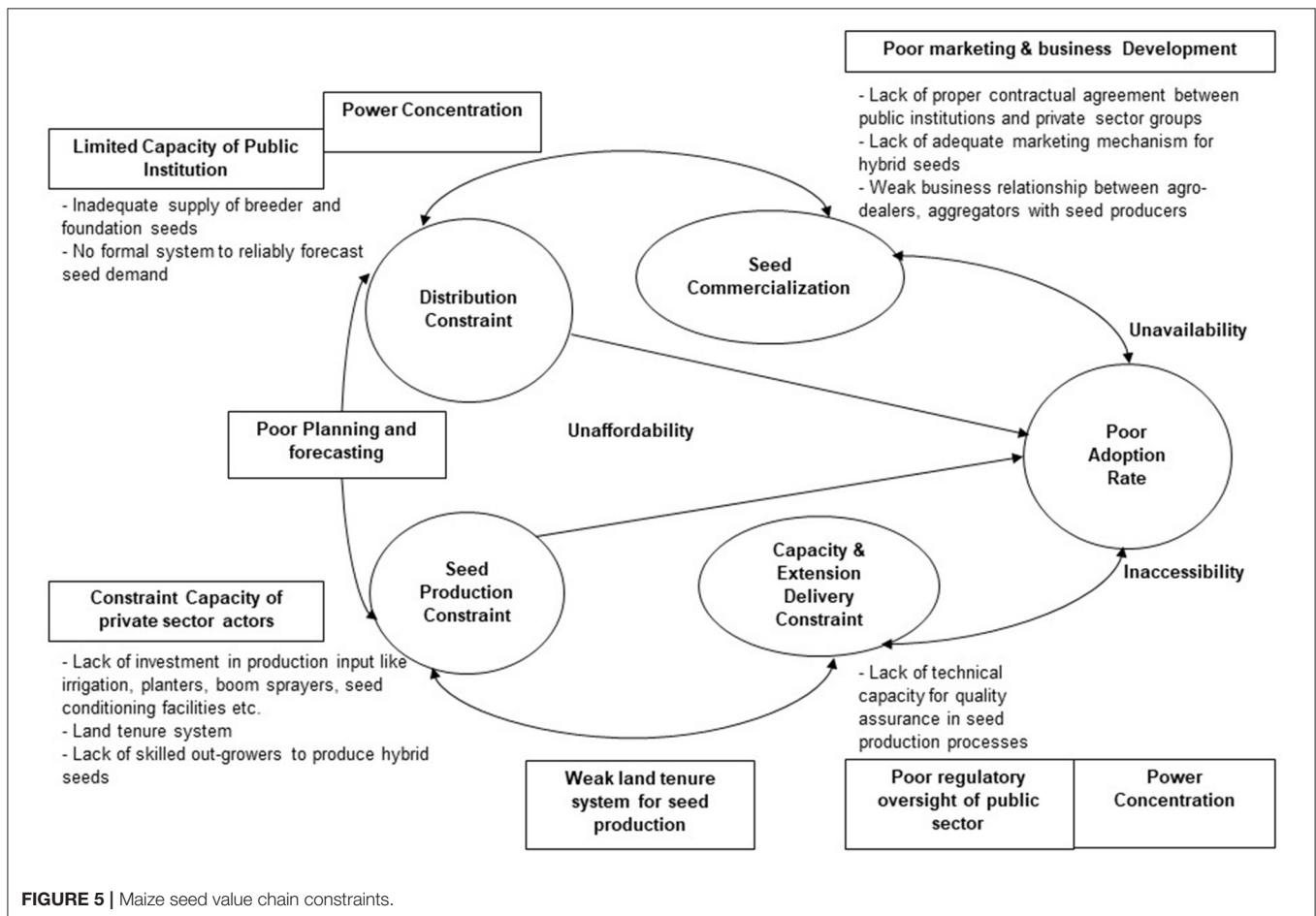


FIGURE 5 | Maize seed value chain constraints.

Ultimately, the outcome of the challenges outlined is a formal maize seed delivery system that is unable to produce the required quality to meet the needs of farmers. Our findings indicate that institutional bottlenecks and challenges largely contribute to low-quality seeds and limited availability of certain varieties, undermining access to smallholders. To help grasp the scope of impacts of the issues at the local level, we provide a case study of farmers' adoptions and perceptions of the HYV in the Ejura Sekyeredumase District.

Objective 3: A Case Study of Adopting Improved Seeds by Smallholder Farmers in Ejura Sekyeredumase District, Ghana

Our case study examined how farmers in the area interact with HYV, their perceptions, challenges and coping strategies. Farmers in the area have considerable knowledge of the benefits of improved seeds. However, they are skeptical about adopting it due to the quality of seeds on the market, partly attributed to challenges in the maize seed value chain.

In terms of knowledge on Maize HYVs, only 3% have heard of Kparifaako, which is a drought and striga tolerant hybrid maize seeds released by the NVRRC in 2015 and suitable for the climate of the area. With regards to Mamaba, which is also a high-yielding hybrid seed released in 1997, only 5% of the respondent have heard of it. The result also pointed out that majority of the respondent interviewed have heard of local maize seeds or old varieties produce and distributed to farmers in the study area: Aburohuma 16%, Aburotia 15%, Ekomasa 15% and Suntem 14% (see **Table 4**). In terms of usage, about 87% of farmers procured the first improved seeds they planted either in cash or kind from their neighbor or relative. Although these farmers are willing to recommend their first improved seeds experience to other farmers, only 26% of these farmers indicated that the particular variety they have adopted is always available.

Farmers in the area have many concerns about HYV seeds. The rest indicated a lack of sustained availability of their desired hybrid seed. For many farmers, they are forced to abandon hybrid seeds altogether when they are no longer able to access their tried and tested varieties. The reason for such decisions is partly because available seeds do not give them the yield they expected. A follow-up interview to understand the extent of this problem revealed that the germination strength of certified seeds purchased by farmers was compromised from the parent material, which is the foundation seeds multiplied. The situation worsens as the breeder seeds are also compromised, hence the lack of germination power of the foundation seeds and, subsequently, the certified seeds multiplied for farmers' adoption.

I select and save the good seeds from my previous harvest and plant them again because I know they are my seeds, and they give me good yield.—Farmer 1

I no longer buy seeds from the agro-input dealer because they are not good. They don't yield like my own seed.—Farmer 2

Also, smallholder farmers have to carry the burden of paying more for seeds purchased in recent times. About 91% of these

farmers interviewed confirmed that the cost of improved seeds determines if they will adopt, while 70% agree they prefer their own saved seeds from the previous harvest because it is readily available to access (**Table 5**). More specifically, 65% of the farmers we interviewed indicated their unwillingness to continue using improved seeds because of the cost involved in purchasing them (see **Figure 6**). When production reaches economies of scale, the price of a commodity may drop. The research findings suggested that due to the high cost involved in producing and distributing of improved seeds in an inefficient structure, the limited quantity of maize seeds produced for distribution drives high the cost of the commodity. The high cost of the seeds, among other limitations, is attributable to the many bottlenecks and challenges that fraught the HYV environment in the country, as earlier discussed.

Furthermore, smallholders attest to the fact that even though they are willing to adopt improved seeds, most often than not, these seeds are not available to access. For example, the study noted that 56% of smallholder farmers interview through the survey mentioned that sometimes the particular HYVs they want to purchase are not available on the market (see **Figure 7**). And all respondents attributed these to challenges evident at the broader level of the seed system. Due to these challenges, farmers adopt diverse strategies to overcome what is clearly an ineffective formal seed value chain. Farmers' approach to tackling this problem is relying on farmer saved seeds or traditional seeds, which have lower yields compared to improved seeds, particularly hybrid maize seeds. While these seeds serve farmers well in reliability of access, their ability to yield the right outputs within challenging climatic conditions are questionable. Some seed producers in the area have produced their foundation seeds and multiplied them to certified seeds for farmers since they cannot trust the foundation seeds supplied by the government institutions mandated to produce and distribute foundation seeds to seed producers.

DISCUSSION

The study outlines the structure of the maize hybrid seed delivery system in Ghana, revealing the complexity of the political and economic interests of public and private entities that create bottlenecks and challenges in the value chain. The maize delivery system, with government agencies, agricultural research institutions, extension officers, donor projects, private producers, and farmers, is a complicated structure of public and private entities and stakeholders. Our findings suggest that Ghana's formal maize seed value chain cannot deliver the mandate of ensuring the production of quality seeds in the right quantities to meet the needs of farmers due to the identified bottlenecks across the chain. This challenge is driven by the intersecting and crosscutting bottlenecks under the production, distribution, extension and commercialization efforts of HVY maize seeds.

The issues identified in this study was validated and widely circulated in the local media by Ghana Trade and Livelihood Coalition, whose research claimed, "farmers' trust in improved

TABLE 4 | Distribution of maize variety adopted by smallholder farmers.

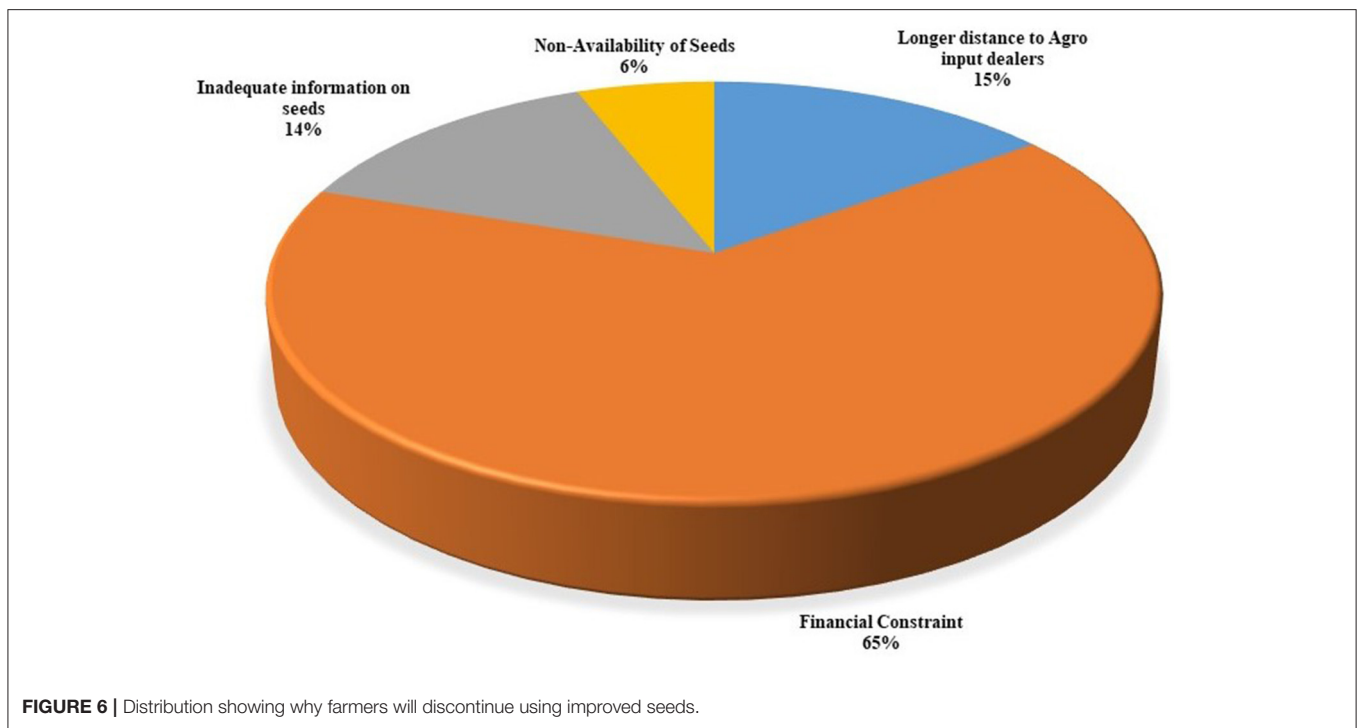
Maize variety	Frequency of adoption responses	Maize seed adoption rate (%)	Seed variety adoption per sex (%)		Seed variety adoption rate by level of education–(both sexes) (%)					Seed variety adoption per age range–(both sexes) (%)				
			Male	Female	No edu.	Primary incomplete	Primary complete	Secondary complete	Higher	20–30	31–40	41–50	51–60	Above 61
Aburohuma	18	16	50	50	29	33	12	14	12	40	30	30	0	0
Aburotia	17	15	53	47	27	33	13	7	20	0	40	40	20	0
Cida-ba	4	4	75	25	0	0	0	100	0	20	40	40	0	0
Dada-ba	4	4	75	25	0	56	0	44	0	60	40	0	0	0
Kparifaako	3	3	33	67	0	0	0	22	78	0	100	0	0	0
Mamaba	5	5	60	40	20	20	0	60	0	0	100	0	0	0
Timtim	6	5	83	17	20	0	40	40	0	0	100	0	0	0
Aseda	1	1	100	0	0	0	0	0	100	100	0	0	0	0
Obaatampa	12	11	75	25	60	0	0	40	0	40	40	20	0	0
Ekomasa	16	15	50	50	50	25	25	0	0	60	30	10	0	0
Panaa	5	5	60	40	0	0	0	60	40	0	100	0	0	0
Etubi Pibi	1	1	100	0	0	0	0	100	0	0	100	0	0	0
Suntem	15	14	53	47	40	40	10	10	0	60	40	0	0	0
Opeaburo	3	3	100	0	0	0	0	25	75	0	100	0	0	0

Adopted from Quarshie et al. *nd* (under review).

TABLE 5 | Determinant of improved maize seeds adoption among smallholder farmers.

No.	Statement	Disagree		Neutral		Agree	
		Freq.	%	Freq.	%	Freq.	%
1	The cost of improved maize seeds determines if smallholder farmers will choose to plant it	12	10.90	7	6.40	91	82.70
2	The high rate of adoption of improve maize seeds is a result of the availability of information on seeds in their area	16	14.50	45	40.90	49	44.50
3	Smallholder farmers prefer their own saved seeds from the previous harvest due to their availability and accessibility	14	12.70	18	16.40	77	70.00
4	Low adoption of improve maize seeds is a result of bad seeds available in the market	21	19.10	48	43.60	41	37.30
5	Smallholder farmers usually prefer seeds that are given to them by their colleague farmers	22	20.00	9	8.20	79	71.80

Adopted from Quarshie et al. nd (under review).

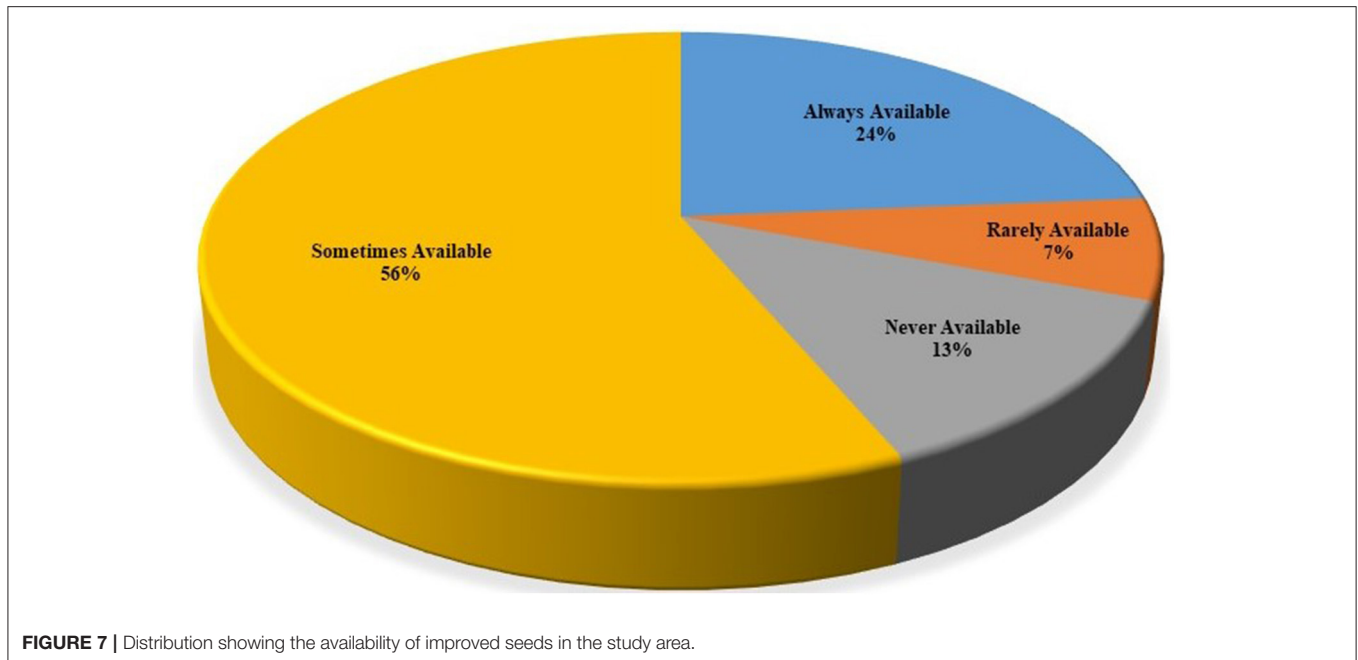


seeds supplied under the government’s PFJs programme dropped significantly” (Ghanaweb, 2020), with some complaining of low germination, leading to rejection of the seeds by many smallholders. As noted earlier, the ability of the seed value chain structure to produce only 54.42% of maize seeds requested by the Ghana Government for PFJs Program in 2017 is a testament to this failure. Likewise, farmers’ continuous complain of seed quality, as recorded in this study and confirmed by earlier works (Nyantakyi-Frimpong and Kerr, 2015; Vercillo et al., 2015), further alludes to the failures of the current structure:

I don’t think...I really do not see these seeds succeeding because of the politics we all do in the value chain. Each of us (institutions) are concerned with what we get and how we will remain relevant,

rather than what will best work for the sector. We all look over our shoulders...not trusting institutions. I can say...all the problems I have told you about is our making, and with them, the sector is going nowhere. (Official of a seed-producing company)

The complex web of public and private stakeholders’ interest yields weak economic rent and weak power asymmetry within the maize seed value chain’s governance structure (Gereffi, 1994). This has opened up nodal points that give state apparatus prominence to control production and distribution of improved seeds. For example, the production of seeds through centralized public bodies (like GLDB with a majority stake in foundation seeds) for onward distribution is contested by farmers who yearn for autonomy in seeds and view themselves



as better-placed for the production of economically and agro-ecologically-sensitive seeds. The interests and stakes of public entities within the structure undermine private participation at certain stages of the value chain, especially with limited formal agreements among actors. This finding contradicts the broader thought that the hybrid seed markets across Africa are created on ideals of the neoliberal capitalist system that favors commercialization at all production stages (Amanor, 2011). This finding shows that despite the seed value chain's supposed market-oriented structures, the dominant role played by government organizations and research institutes in Ghana reveals continuous power limitations to the private sector.

Specifically, the competing interests within the web of stakeholders creates institutionally charged constraints that undermine trust within the value chain. Inability to trust breeders or public and private entities to trust each other or trust the quality of what is delivered hampers efforts to disseminate this critical prescription of the Green Revolution for Africa. For most parts, the concentration of power and lack of accountability of actors in the structure cause fragility. The lack of trust among institutions breaks the value chain and compromises both the effectiveness and efficiency along the line. With each institution fixed on furthering their political and or economic interest(s), the ultimate victim is not just the lack of adoption but also the creation of a failed project propelled by the very institutions and systems tasked to deliver it. The definitive goal is to put seeds in the hands of farmers, who are expected to show willingness and readiness to adopt. However, as studies have suggested (Vercillo et al., 2015) and confirmed in this research as well, farmers' lack of trust in the formal system is furthered by the institutional bottlenecks and challenges.

The study also identified institutional and organizational challenges such as the constrained capacity of private sector

actors to invest in efficient seed production equipment and technologies. Quality assurance issues on the part breeders and seed producers impact the delivery of both quantity and quality improved seeds to smallholder farmers. Furthermore, the lack of well-defined, fair and enforceable contracts between stakeholders in the seed value chain and weak land tenure systems restrict EGS availability and limits maize seeds' quantities effectively distributed to farmers. This situation often results in high prices driven by demand among smallholder farmers. At the heart of these challenges is the poor planning and forecasting of seed demand and poor marketing and business development strategies by actors in the EGS value chain. The "guesstimation" of EGS demand by suppliers in the value chain and the inadequate advertisement on seed availability denuded within insufficient product information on packaging materials act as a catalyst for the high possibility of adulteration of seeds by fraudulent persons seeking their selfish interests makes this arrangement unsuitable. Such arrangements also limit the motivation to ensure high-quality seeds gain authenticity.

Our study's findings confirm results from other studies that outline the challenges of delivery, adoption, and farmers' participation in what potentially is an ineffective seed revolution in Ghana (Nyantakyi-Frimpong and Kerr, 2015; Vercillo et al., 2015; Vercillo and Hird-Younger, 2019). These findings are also in consonance with the broader discussions on maize value chains in Africa. Previous literature has noted that many challenges undermine the success of seed value chains in Africa, including bureaucratic processes and weak policy environments to support demand and supply processes where the literature has emphasized (Scoones and Thompson, 2011). Relatedly, most of the barriers identified in this study are related to institutional politics, organization, and implementation processes in the value chain (Acemoglu and Robinson, 2009). With a focus on

institutional-level challenges, our work empirically enriches the literature while expanding on the issues that need to be addressed to enhance HVY maize value chains in Africa. More importantly, our discussions of trust within the context of the identified challenges. Indeed, for any sector to develop, actors must have access to trusted institutions with the capacity and capability to deliver (Pritchett et al., 2013). Hence, the institutional challenges highlighted in this paper offer avenues to further empirical engagements in Ghana and other parts of Africa.

Overall, key actors of the seed value chain acknowledge the benefits of hybrid seeds. However, the existing bottlenecks in the formal structures limit the success of the approach and undermines its ability to effectively complement the supposed ineffective informal system (Langyintuo et al., 2010). The ability to strengthen the institutional structures, arrangements and mechanisms for delivery in the value chain will be crucial in building trust toward the success or otherwise of improved seeds under the "African Seed Revolution" agenda in Ghana and beyond. However, that will not mean socio-economic and socio-ecological barriers identified in earlier studies (Nyantakyi-Frimpong and Kerr, 2015; Vercillo et al., 2015) are irrelevant to the cause. The institutional issues must be duly considered within a framework of building capacity of the sector that includes the solutions to the institutionalized political-economic elements identified in this paper and socio-economic, cultural and ecological constraints.

TOWARD A FUNCTIONAL SEED VALUE CHAIN IN GHANA

Considering the challenges discussed above, many solutions would be required to ensure efficiency in the seed system. However, we recommend a more functional Public-Private Partnership (PPP) mechanism as a key mitigation solution to start with, which will lay the foundation for further interventions. The PPP will provide opportunities for both the public and private sectors to leverage their strengths and resources and mobilize industry expertise and networks. For instance, case studies in Malawi, Zambia, the state of Chiapas in Mexico, and Bihar in Indian noted smallholder farmers were increasingly adopting improved maize seeds because of existing well-functioning and structured seed value chains (Hoogendoorn et al., 2018). According to Langyintuo et al. (2010), PPPs were essential in establishing most seed companies in Eastern and Southern Africa while at the same time building capacity of agro-dealers to ensure consistent supply of HVYs of seeds smallholder farmers. Such an approach will allow private sector formal access to public officials, public goods and technical expertise and enhance credibility and scale. The public sector will also benefit from private sector managerial and business skills, expanded markets and commercialization prospects and resources while making their operations more sustainable. Public sector dominance in the seed sector will now give way to growing private sector engagement and investment in the seed system in Ghana, leading to the

development of working relationships. For example, one of the critical bottlenecks in the current EGS system in Ghana is the unreliable supply of good-quality foundation seeds. Hence, an enhanced PPP at this level will boost production and supply. Breeder seeds will remain the public sector's responsibility, and the private sector will continue to spearhead certified seed production and marketing. However, all levels of seed production will benefit from improved working relationships to be developed.

Furthermore, the partnership between traditional and formal actors in the seed value chain was essential in delivering improved planting materials to climate-prone regions in Mexico (Bellon et al., 2011). Again, the findings from McGuire and Sperling (2016) in six countries covering 40 crops suggest smallholders are willing to pay in cash for seeds that are easily accessible as a result of a well-structured and functioning seed value chain. In Ghana, PPPs have been implemented in multiple sectors, particularly agriculture commodity value chains such as cocoa, which have seen significant success, positioning the nation as a leading producer and exporter of cocoa globally (Choudhary et al., 2011; Bateman, 2015). While, we acknowledge the existence of PPP in the maize value chain in Ghana, and for that matter, the maize seed value chain, the weakness and one-sidedness public institutional benefits of existing partnership is a major threat to making improved seeds available to smallholders for adoption, particular the availability of foundation seeds both in quality and quantity. A strong partnership built on a mutually beneficial relationship for all actors with a commitment to continuity of making seeds available and affordable to smallholders while at the same time promoting broader transparency of engagement from actors is a sine qua non to ensuring smallholders get access to quality certified seeds for adoption.

To achieve these PPPs, we recommend enabling business environment and reforms, allowing breeders to take credit/incentives from the intellectual property right for maize seeds developed. This is essential to boost commitment to continuity in the development of HVYs to smallholder farmers at such a time when existing crop varieties cannot withstand the perturbations of global climate change (Bellon et al., 2011; Bossuet and Thierfelder, 2019). Furthermore, the unsatisfactory performance of the GLBD in ensuring availability of both quality and quantity foundation seeds necessitates full private sector participation and take over as this bottleneck is the most critical to supply of HVYs of maize seeds to smallholder farmers. The GLBD can assume advisory, supervisory and capacity-building roles for private sector actors producing foundation seeds. Again, the GSID/PPRSD should be given full autonomy via devolution to undertake their regulatory, inspection, testing, and seed certification roles within the seed value chain. Again, information management is critical for this particular sector. Information on guidelines for seed varietal release and registration processes should be made available and easily accessible to actors in the seed value chain. Most importantly, ICT and digital tools should be deployed to rapidly inform agricultural extension officers and GSID inspection officers about the released and registered seed varieties, especially information on a new maize seed variety.

CONCLUSION

The study discusses the Maize HYV delivery value chain in Ghana to show that institutional challenges limit the ability to deliver quality seeds to farmers. Our study has shown that the promotional goals of the African Seed Revolution are undermined in a practical sense. The State-dominated seed system undermines other actors' participation, culminating in failure to deliver quality seeds to smallholder farmers (Langyintuo et al., 2010; Tripp and Ragasa, 2015; Asante-Dartey et al., 2016). The study identified seven main challenges suggested to undermine trust and hinder the expansion of HYVs in Ghana, and these are; (1) the limited capacity of public institutions, (2) constrained capacity of the emerging private sector, (3) a lack of well-defined, fair and enforceable contracts between stakeholders in the delivery system, (4) land-tenure limitations, (5) poor forecasting of farmers' demands for seeds by research institutions and seed producers, (6) sparse marketing arrangements for improved maize seeds, and (7) concentration of power to control seed supply in the hands of few institutions. These challenges collectively unleash a triple burden of unavailability, inaccessibility, and unaffordability for smallholder farmers, culminating in a poor adoption rate of improved seeds, particularly hybrid maize seeds. Furthermore, the competing political and economic interests among the complex web of actors mandated to deliver the seeds ironically undermine the ultimate purpose. Hence, through a diversity of challenges identified across the system, we argue that weak power asymmetry within the governance mechanism of the maize seed value chain has enabled nodal points that gives prominence to key public institutions, NGOs, and research institutions who control production and distribution of improved seeds in ways that undermine the effective delivery of maize seeds. Likewise, the power dynamics obstacles undermine trust among value chain actors in ways that negatively affect seeds' delivery.

Our results move the literature beyond the socio-economic and ecological explainers that have been the center of attention to the failures of the seed revolution. Our focus on value chain and institutions extends both the African green revolution literature on the subject by injecting a much-needed institutional dimension to the struggles of HYV in Ghana and with implications for SSA. Our paper provides an essential step to institutional changes to the structures and mechanisms of HYV seeds delivery in Ghana and other Sub-Saharan African nations. Given our findings, we propose the stakeholders pursue process and product upgrading (see Gereffi, 1994) to address the triple burden of availability, accessibility and affordability unleashed by bottlenecks within the maize seed value chain. This could be achieved through effective coordination and collaboration by key value chain actors to build trust in the seed delivery system. Likewise, the government's effort to partner with the private sector and other key players, including farmers, is critical within the seed value chain to ensure continuous production and distribution of improved seeds both in quality and quantity to smallholder farmers (Atilaw et al., 2016; Mabaya et al., 2017).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by School of Public Service and Governance, Ghana Institute of Management and Public Administration, Accra Ghana. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

This manuscript was produced from MA thesis research understand by PQ. He drafted the first copy of the manuscript and subsequently the rest of the co-authors incorporated their input into it. All the authors equally worked on draft paper for submission.

FUNDING

PQ received funding from the Canada First Research Excellence Fund, the Canada Research Chairs program and Department of Geography, Environment and Geomatics, University of Guelph, Ontario, Canada. A-RA received funding from the Arrell Food Institute at the University of Guelph. EF received funding from the Canada First Research Excellence Fund, the Canada Research Chairs program, SSHRC and NSERC, the Ontario Ministry of Agriculture, Food and Rural Affairs, and George Weston Ltd. He is the vice-chair of the Maple Leaf Centre for Action on Food Security and is a member of the scientific advisory panel for the Weston Seeding Food Innovation Fund.

ACKNOWLEDGMENTS

The authors would like to acknowledge Dr. Joseph Taabazuing, who supervised the lead authors' MA research and thesis work. Furthermore, we commend Yogesh Ghore and Farouk Jiwa, Coady International Institute, StFX, for their excellent facilitation of the livelihoods and market course, particularly agricultural commodity value chain analysis. Finally, I appreciate the valuable suggestions from the reviewer(s). We credit Marie Puddister with the map of the study area.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2021.665297/full#supplementary-material>

REFERENCES

- Acemoglu, D., and Robinson, J. A. (2009). “Paths of economic and political development,” in *The Oxford Handbook of Political Economy*, Vol. 1, eds D. A. Wittman and B. R. Weingast (Oxford: Oxford University Press).
- Adeogun, S. O., Olawoye, J. E., and Akinbile, L. A. (2010). Information sources to cocoa farmers on cocoa rehabilitation techniques (CRTs) in selected states of Nigeria. *J. Media Commun. Stud.* 2, 009–015.
- Adesina, A. A., and Baidu-Forsion, J. (1995). Farmers’ perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *Agric. Econ.* 13, 1–10. doi: 10.1111/j.1574-0862.1995.tb00366.x
- AGRA (2017). *University of Ghana Releases Three New WACCI Hybrid Maize Varieties*. Available online at: <https://agra.org/university-of-ghana-releases-three-new-wacci-hybrid-maize-varieties/> (accessed May 6, 2020).
- AGRA (2020). *Africa Agriculture Status Report 2020: Feeding African Cities—Opportunities, Challenges, and Policies for Linking African Farmers with Growing Urban Food Markets. Alliance for a Green Revolution in Africa (AGRA)*. Available online at: <https://agra.org/wp-content/uploads/2020/09/AASR-2020-Feeding-African-Cities.pdf> (accessed September 5, 2020).
- Ainisyifa, H., Wulan, E. R., Muhyiddin, A., and Ramdhani, M. A. (2018). Innovation and technology diffusion in agricultural sector. https://www.researchgate.net/journal/IOP-Conference-Series-Materials-Science-and-Engineering-1757-899X/IOP_Conf_Ser_Mater_Sci_Eng_434:012247. doi: 10.1088/1757-899X/434/1/012247
- Akudugu, M. A., Guo, E., and Dadzie, S. K. (2012). Adoption of modern agricultural production technologies by farm households in Ghana. What factors. *J. Biol. Agric. Healthc.* 2.
- Alhassan, A., Salifu, H., and Adebani, A. O. (2016). Discriminant analysis of farmers adoption of improved maize varieties in Wa Municipality, Upper West Region of Ghana. *SpringerPlus* 5, 1–12.
- Alliance for a Green Revolution in Africa (AGRA) (2018). *Africa’s Agriculture Status Report*. Nairobi: AGRA.
- Alliance for a Green Revolution in Africa (AGRA) (2013). *Africa’s Agriculture Status Report*. Nairobi: AGRA.
- Amanor, K. S. (2011). From farmer participation to pro-poor seed markets: the political economy of commercial cereal seed networks in Ghana. *IDS Bull.* 42, 48–58. doi: 10.1111/j.1759-5436.2011.00235.x
- Asante-Dartey, J., Azinu, A. R., and Amekuse, L. (2016). *Early Generation Seed Study in Ghana*. Accra: Alliance for a Green Revolution in Africa.
- Atilaw, A., Alemu, D., Bishaw, Z., Kifle, T., and Kaske, K. (2016). Early generation seed production and supply in Ethiopia: Status, challenges and opportunities. *Ethiop. J. Agric. Sci.* 27, 99–119.
- Ayanlade, A., and Radeny, M. (2020). COVID-19 and food security in Sub-Saharan Africa: Implications of lockdown during agricultural planting seasons. *Npj Sci. Food* 4:13. doi: 10.1038/s41538-020-00073-0
- Azinu, A. R. (2014). *Evaluation Of Hybrid Maize Varieties in Three Agro-Ecological Zones in Ghana*. Accra: University of Ghana.
- Baidu-Forsion, J. (1999). Factors influencing adoption of land-enhancing technology in the Sahel: lessons from a case study in Niger. *Agric. Econ.* 20, 231–239. doi: 10.1111/j.1574-0862.1999.tb00569.x
- Bateman, R. (2015). *Pesticide Use in Cocoa. A Guide for Training, Administrative, and Research Staff. 3rd Edn*. London: International Cocoa Organization.
- Bellon, M. R., Hodson, D., and Hellin, J. (2011). Assessing the vulnerability of traditional maize seed systems in Mexico to climate change. *Proc. Nat. Acad. Sci. U.S.A.* 108, 13432–13437. doi: 10.1073/pnas.1103373108
- Bossuet, J. D., and Thierfelder, C. (2019). *Can we scale out Climate-Smart Agriculture?* Harare: CIMMYT. Available online at: <https://repository.cimmyt.org/handle/10883/20308> (accessed February 24, 2020).
- Buah, S. S., Nutsugah, S. K., Kanton, R. A., Atokple, D. K., Dogbe, W., and Karikari, A. S. (2011). Enhancing farmers’ access to technology for increased rice productivity in Ghana. *Afr. J. Agric. Res.* 6, 4455–4466.
- Caswell, M., Fuglie, K., Ingram, C., Jans, S., and Kascak, C. (2001). *Adoption of Agricultural Production Practices: Lessons Learned from the U.S. Agricultural Economic*. Washington, DC: USDA, 1–110.
- Cho, R. (2013, February 8). Improving seeds to meet future challenges. *State of the Planet*. Available online at: <https://blogs.ei.columbia.edu/2013/02/08/improving-seeds-to-meet-future-challenges/> (accessed September 14, 2020).
- Choudhary, V., Bateman, R., d’Alessandro, S., and Mann, E. (2011). *Supply Chain Risk Assessment: Cocoa in Ghana*. Washington, DC: World Bank. Available online at: <http://siteresources.worldbank.org/INTCOMRISMAN/Resources/RapidAgriculturalSupplyChainRiskAssessmentConceptualFramework.pdf> (accessed November 3, 2014).
- CIMMYT (ed.). (1997). *Book of Abstracts: The Genetics and Exploitation of Heterosis in Crops: An International Symposium*. Mexico City: CIMMYT.
- CIMMYT (2015). *DT Maize: A Quarterly Bulletin of the Drought Tolerant Maize for Africa Project*. Harare: CIMMYT. Available online at: [https://repository.cimmyt.org/xmlui/bitstream/handle/10883/4723/57029-2015%20v4\(4\).pdf?sequence=4&disAllowed=y](https://repository.cimmyt.org/xmlui/bitstream/handle/10883/4723/57029-2015%20v4(4).pdf?sequence=4&disAllowed=y) (accessed July 19, 2021).
- CIMMYT (2020). *Seeds of Discovery (Seed)*. Mexico City: CIMMYT. Available online at: <https://www.cimmyt.org/projects/seeds-of-discovery-seed/> (accessed May 15, 2020).
- CIMMYT (2021). *Stress Tolerant Maize for Africa*. Harare: CIMMYT. Available online at: <https://repository.cimmyt.org/xmlui/bitstream/handle/10883/17933/58079.pdf?sequence=1&disAllowed=y> (accessed July 19, 2021).
- Doss, C. (2013). Intrahousehold bargaining and resource allocation in developing countries. *World Bank Res. Obs.* 28, 52–78. doi: 10.1093/wbro/lkt001
- Doss, C. R., and Morris, M. L. (2001). How does gender affect the adoption of agricultural innovations? the case of improved maize technology in Ghana. *Agric. Econ.* 25, 27–39. doi: 10.1016/S0169-5150(00)00096-7
- FAO (2021). *FAOStat*. Rome: Food and Agriculture Organization of the United Nations.
- Fine, M., Tuck, E., and Zeller-Berkman, S. (2008). “Do you believe in Geneva? methods and ethics at the global-local nexus,” in *Handbook of Critical and Indigenous Methodologies*, eds N. Denzin, Y. Lincoln and L.T. Smith (London: Sage), 157–177.
- Fraser, E., Legwegoh, A., Kc, K., CoDyre, M., Dias, G., Hazen, S., et al. (2016). Biotechnology or organic? extensive or intensive? global or local? a critical review of potential pathways to resolve the global food crisis. *Trends Food Sci. Technol.* 48, 78–87. doi: 10.1016/j.tifs.2015.11.006
- Gereffi, G. (1994). “The organization of buyer-driven global commodity chains: how U. S. retailers shape overseas production networks,” in *Commodity Chains and Global Capitalism*, eds G. Gereffi and M. Korzeniewicz (London: Praeger), 95–122.
- Ghana Statistical Service (2014). *2010 Population and Housing Census*. Accra: Ghana Statistical Service.
- Ghanaweb (2020). *Farmers’ Trust in Improved Seeds Fell in 2019—Research*. Ghanaweb. Available online at: <https://www.ghanaweb.com/GhanaHomePage/business/Farmers-trust-in-improved-seeds-fell-in-2019-Research-1138829> (accessed December 24, 2020).
- GMet (2016). *District Fact Sheet*. Accra: Ghana Meteorological Agency.
- Hoogendoorn, J. C., Audet-Bélanger, G., Böber, C., Donnet, M. L., Lweya, K. B., Malik, R. K., et al. (2018). Maize seed systems in different agro-ecosystems; what works and what does not work for smallholder farmers. *Food Secur.* 10, 1089–1103. doi: 10.1007/s12571-018-0825-0
- Juma, C. (2015). *The New Harvest: Agricultural Innovation in Africa*. Oxford: Oxford University Press.
- Kansanga, M., Andersen, P., Kpienbaareh, D., Mason-Renton, S., Atuoye, K., Sano, Y., et al. (2019). Traditional agriculture in transition: Examining the impacts of agricultural modernization on smallholder farming in Ghana under the new Green Revolution. *Int. J. Sustain. Dev. World Ecol.* 26, 11–24. doi: 10.1080/13504509.2018.1491429
- Kaplinsky, R., and Morris, M. (2001). *A Handbook for Value Chain Research*. Ottawa, ON: IDRC.
- Kumar, A., Singh, H., Kumar, S., and Mittal, S. (2011). Value chains of agricultural commodities and their role in food security and poverty alleviation—a synthesis. *Agric. Econ. Res. Rev.* 24:13. doi: 10.22004/ag.econ.109516
- Kutka, F. (2011). Open-pollinated vs. hybrid maize cultivars. *Sustainability* 3, 1531–1554. doi: 10.3390/su3091531
- Kwakye-Opong, R. (2014). Clothing and colour symbolisms in the homowo festival: a means to sociocultural development. *Res. Human. Soc. Sci.* 4, 122–125.
- Langyintuo, A. S., Mwangi, W., Diallo, A. O., MacRobert, J., Dixon, J., and Bänziger, M. (2010). Challenges of the maize seed industry in eastern and southern Africa: A compelling case for private-public intervention to promote growth. *Food Policy* 35, 323–331. doi: 10.1016/j.foodpol.2010.01.005

- Laws, S., Harper, C., and Marcus, R. (2003). *Research for Development*. Thousand Oaks, CA: SAGE Publications, Ltd.
- Mabaya, E., Adzivor, S. Y., Mugoya, M., and Wobil, J. (2017). *Ghana Brief 2017—The African Seed Access Index*. The African Seed Access Index (TASAI).
- Martey, E., Etwire, P. M., and Abdoulaye, T. (2020). Welfare impacts of climate-smart agriculture in Ghana: does row planting and drought-tolerant maize varieties matter? *Land Use Policy* 95:104622. doi: 10.1016/j.landusepol.2020.104622
- McGuire, S., and Sperling, L. (2016). Seed systems smallholder farmers use. *Food Secur.* 8, 179–195. doi: 10.1007/s12571-015-0528-8
- Ministry of Food and Agriculture, G. (2017). *Planting for Food and Jobs Roadmap*. Accra: Ministry of Food and Agriculture.
- Ministry of Food and Agriculture, Ghana (2015). *Catalogue of Crop Varieties*. Accra: Ministry of Food and Agriculture.
- Mitchell, J., Coles, C., and Christopher, C. (2014). *Markets and Rural Poverty Upgrading in Value Chains*. Ottawa, ON: International Development Research Centre.
- MoFA (2010). *Ministry of Food and Agriculture: Plant and Fertilizer Act, 803*. Accra: Government Printer, Assembly Press
- MOFA, Ghana (2016). *Agriculture in Ghana*. Accra: Ministry of Food and Agriculture.
- MoFA—Statistics, Research and Information Directorate (SRID) (2016). *Fact and Figures*. Accra: Ministry of Food and Agriculture.
- Monela, A. G. (2014). *Access to and adoption of improved seeds by smallholder farmers in Tanzania: cases of maize and rice seeds in Mbeya and Morogoro regions (Doctoral dissertation)*. Sokoine University of Agriculture.
- Nyantakyi-Frimpong, H., and Kerr, R. B. (2015). A political ecology of high-input agriculture in northern Ghana. *Afr. Geogr. Rev.* 34, 13–35. doi: 10.1080/19376812.2014.929971
- Poulton, C., and Chinsinga, B. (2018). *The political economy of agricultural commercialisation in Africa*. Working Paper-Agricultural Policy Research in Africa (APRA).
- Prasanna, B. M., Cairns, J. E., Zaidi, P. H., Beyene, B., Makumbi, D., Gowda, M., et al. (2021). Beat the stress: breeding for climate resilience in Maize for the tropical rainfed environments. *Theor. Appl. Genet.* 134, 1729–1752. doi: 10.1007/s00122-021-03773-7
- Pritchett, L., Woolcock, M., and Andrews, M. (2013). Looking like a state: techniques of persistent failure in state capability for implementation. *J. Dev. Stud.* 49, 1–18. doi: 10.1080/00220388.2012.709614
- Quarshie, P., and Abdulai, A.-R. (2021). *The Enduring Intensification Dilemma of Africa's Rural Farmer.pdf [USAID FtF Project]*. AGRILINKS.
- Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A. N., Chapoto, A., Asamoah, M., et al. (2013). Patterns of adoption of improved rice technologies in Ghana. *Int. Food Policy Res. Inst. Work. Pap.* 35, 6–8.
- Scheyvens, R. (2014). *Development Field Work: A Practical Guide*. Thousand Oaks, CA: SAGE Publications, Ltd.
- Schinke, R.J., and Blodgett, A.T. (2016). "Embarking on community-based participatory action research: a methodology that emerges from (and in) communities," in *Routledge Handbook of Qualitative Research in Sport and Exercise*, eds B. Smith and A. C. Sparkes (London: Routledge), 88–99.
- Scoones, I., and Thompson, J. (2011). The politics of seed in Africa's green revolution: alternative narratives and competing pathways. *IDS Bull.* 42, 1–23. doi: 10.1111/j.1759-5436.2011.00232.x
- Smale, M., Byerlee, D., and Jayne, T. (2013). "Maize revolutions in sub-Saharan Africa," in *An African Green Revolution* (Dordrecht: Springer), 165–195.
- Smale, M., and Mason, N. (2014). Hybrid seed and the economic well-being of smallholder maize farmers in Zambia. *J. Dev. Stud.* 50, 680–695. doi: 10.1080/00220388.2014.887690
- Smith, B. (2018). Generalizability in qualitative research: Misunderstandings, opportunities and recommendations for the sport and exercise sciences. *Qual. Res. Sport Exerc. Health* 10, 137–149. doi: 10.1080/2159676X.2017.1393221
- Stringer, L. C., Fraser, E. D. G., Harris, D., Lyon, C., Pereira, L., Ward, C. F. M., et al. (2020). Adaptation and development pathways for different types of farmers. *Environ. Sci. Policy* 104, 174–189. doi: 10.1016/j.envsci.2019.10.007
- Sumner, A., and Tribe, M. (2008). *International Development Studies: Theories and Methods in Research and Practice*. Thousand Oaks, CA: SAGE Publications Ltd.
- Technical Centre for Agricultural and Rural Cooperation (1996). *Sasakawa and Maize Production in Ghana. News item, spore* 66. Wageningen: Technical Centre for Agricultural and Rural Cooperation.
- Tilman, D., Balzer, C., Hill, J., and Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proc. Natl. Acad. Sci. U.S.A.* 108, 20260–20264. doi: 10.1073/pnas.1116437108
- Trienekens, J. H. (2011). Agricultural value chains in developing countries; a framework for analysis. *Int. Food Agribusiness Manag. Rev.* 14, 51–83.
- Tripp, R., and Ragasa, C. (2015). *Hybrid maize seed supply in Ghana (No. 40)*. International Food Policy Research Institute (IFPRI).
- UN-Food and Agriculture Organization (2017). *www.fao.org*. Available online at: <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/seed-sys/en/> (accessed May 15, 2020).
- van Ittersum, M. K., van Bussel, L. G. J., Wolf, J., Grassini, P., van Wart, J., Guilpart, N., Claessens, L., et al. (2016). Can sub-Saharan Africa feed itself? *PNAS* 113, 14964–14969. doi: 10.1073/pnas.1610359113
- Vercillo, S., and Hird-Younger, M. (2019). Farmer resistance to agriculture commercialisation in northern Ghana. *Third World Q.* 40, 763–779. doi: 10.1080/01436597.2018.1552076
- Vercillo, S., Kuire, V. Z., Armah, F. A., and Luginaah, I. (2015). Does the new alliance for food security and nutrition impose biotechnology on smallholder farmers in Africa? *Glob. Bioethics* 26, 1–13. doi: 10.1080/11287462.2014.1002294
- Vercillo, S., Weis, T., and Luginaah, I. (2020). A bitter pill: smallholder responses to the new green revolution prescriptions in northern Ghana. *Int. J. Sustain. Dev. World Ecol.* 27, 565–575. doi: 10.1080/13504509.2020.1733702
- WACCI (2017). *WACCI Releases Three New Hybrid Maize Varieties [Text]*. WACCI. Available online at: <https://wacci.ug.edu.gh/content/wacci-releases-three-new-hybrid-maize-varieties> (accessed May 6, 2020).

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2021 Quarshie, Abdulai and Fraser. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.