Why do maize farmers in Ghana have a limited choice of improved seed varieties? An assessment of the governance challenges in seed supply

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Abstract

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

Keywords Seed systems · Governance challenges · Varietal development · Seed production · Seed quality · Ghana

1 Introduction

The use of improved crop varieties is essential for increasing agricultural productivity in Africa (Walker and Alwang 2015; World Bank 2007). Maize is the most important cereal crop in Sub-Saharan Africa and as such considerable attention has been paid to potential productivity gains through the use of improved varieties (Alene et al. 2009; Byerlee and Eicher

1997; Hassan et al. 2001; Smale et al. 2013). This desired outcome hinges upon an efficiently functioning seed system to ensure the delivery of these varieties to farmers (Langyintuo et al. 2008; Morris 1998; Tripp 2001). However, only a few African countries, such as Kenya and Mozambique, provide evidence of successful commercial seed sector development (World Bank 2016). It is widely accepted that a major cause of the sector's poor performance has been the combination of a public sector monopoly of seed supply and a weak capacity of the public sector organisations in charge (Tripp and Rohrbach 2001). In recent years, many African governments have liberalised their seed sectors, though to a varying extent, which has generally resulted in increased private sector participation. Nonetheless, the transition to an effective private sector-driven seed system has been hampered by a lack of complementarities in public and private investments, leading to deficiencies in the institutional linkages between the various stages of seed production, from breeding to commercial seed delivery (Langyintuo et al. 2010). These governance challenges of seed supply systems have only been partly

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addressed in the literature (see Langyintuo et al. 2010; Tahirou et al. 2009; Tripp 2000). Countries like Ghana have sought to overcome the problem of farmers having poor access to improved seed varieties by reforming the institutional framework of the commercial seed sector.

Ghana passed a new seed law, the Plants and Fertiliser Act, in 2010. The Act entailed a commitment by the state, supported by the donor community, to relegate responsibility for seed multiplication and marketing to the private sector. The main aim of liberalising the sector was to increase the availability of improved seed varieties to farmers by providing more opportunities for the private sector.¹ The most noteworthy aspects of the law are that it authorises both the development of varieties by the domestic private sector as well as access to foreign varieties produced by both public and private organisations. The law also permits the production of any class of seed by any approved entity (public or private) and leaves the door open for the possibility of privatised seed certification (GoG 2010). These changes have enabled the emergence of domestic private seed companies. By 2013, the number of indigenous private seed companies had reached ten (Tripp and Mensah-Bonsu 2013). However, a chronic lack of varietal diversity has still remained a major concern of Ghana's maize seed system. One open pollinated variety (OPV) released in 1992 called Obatanpa continues to overwhelmingly dominate commercial seed production. This is a concern because maize is the most important cereal crop in Ghana, accounting for 55% of total grain output in the country. Maize is also important for food security as it is widely consumed in all regions of Ghana and covers the largest area among the food crops produced in the country (MoFA 2015a). Apart from its traditional food uses, maize grain is also used in the food processing industry, breweries and in the poultry industry as a primary source of feed. Due to industrialisation and urbanisation, demand for maize from these sectors is also rising (Andam et al. 2015, 2017). Yet, productivity of maize has been low. Average yields reached only 1.7 metric tons per hectare in 2014 (MoFA 2015a). As further detailed in Section 3, 60% of the maize area was planted to improved varieties in 2012, and Obatanpa accounted for almost 70% of this area (Ragasa et al. 2013). Even though 18 improved maize varieties have been developed and officially released since Obatanpa was introduced in 1992, only a few of these varieties are produced as commercial seed. Hence, they are mostly not available to farmers.

A large number of technology adoption studies on maize in Africa have focused on the socio-economic and agro-ecological factors that influence farmers' decisions to adopt

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

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

The rest of the paper is organised as follows: Section 2 presents potential governance challenges of seed supply based on economic theory and the literature on seed sector development in Africa. Section 3 outlines the current state of Ghana's maize seed system. The research design and data used for the analysis are described in Section 4. Section 5 presents the results of the Process Net-Maps and expert interviews. Section 6 discusses the empirical findings and Section 7 concludes and derives policy implications.

¹ The new law repealed the Plant Quarantine Act of 1965 and the National Redemption Council Decree 100 of 1972 (Alhassan and Bissi 2006). Although the new law was already in force at the time of submitting this article in early 2017, the attendant seed regulations were at an advanced stage for ratification by Parliament following amendments to fit regional seed regulations of the Economic Community of West African States (ECOWAS).

2 Potential governance challenges of seed systems

2.1 Overview of the seed system

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

A formal seed system, in this paper also referred to as commercial seed system, encompasses a series of interdependent activities, which can be grouped into three major stages, as shown in Fig. 1. (1) Varietal development; (2) seed multiplication and certification; (3) seed marketing and promotion. The first step, the development of new varieties, requires breeding, which is a research activity. To ensure that farmers get access to new varieties that indeed have advantages over existing ones, the testing of new varieties is required, which is typically part of a variety release procedure. To make the new varieties available to farmers on a large scale, several stages of seed multiplication are necessary. These are typically referred to as the production of (a) breeder seed (the first generation of seed), (b) foundation seed

(the second generation of seed) and (c) commercial seed (the final product used by farmers). At each stage of seed production, quality must be assured, which is typically achieved through seed certification. Marketing and promotion activities are then required to ensure that farmers have knowledge of the improved seed varieties and can purchase them.

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

Fig. 1 Overview of governance challenges affecting seed supply

failure.” In this paper, these “failures” of the public, the private and the third sector are referred to as “governance challenges.”

The following sections examine the underlying reasons for these governance challenges in the case of seed supply. Maize is used as an example. For maize, both open pollinated varieties (OPVs) and hybrid varieties are available. As further detailed below, the governance challenges involved in the supply of OPVs, which farmers can reproduce themselves, differ to some extent from the governance challenges involved in the supply of hybrid varieties. Figure 1 gives an overview of these governance challenges.

2.2 Varietal development

2.2.1 Market failure

Varietal development is capital intensive as it requires access to germplasm, trial fields, physical equipment and the scientific expertise that is necessary to undertake an effective breeding programme. Moreover, varietal development is a long-term process. Thus, economies of scale may deter private sector investment in varietal development or allow one firm to monopolise this activity especially in very small markets (Jaffee and Srivastava 1994). Most emerging seed companies are therefore dependent on varieties that were developed by the public sector. High capital requirements are also one reason for the dominance of large multinational seed companies in private sector varietal development and explain recent takeover bids among these companies. Secondly, the payoff for this long term investment can be uncertain depending on the nature of the variety. Farmers can recycle the seed of OPVs for several planting seasons. OPVs also facilitate seed exchanges among farmers, allowing some farmers to benefit from new seed varieties without ever having to purchase them (Alene et al. 2000). This public good characteristic of non-excludability constitutes a disincentive for private companies to invest in the development of OPVs. An institutional solution would be restricting the rights of farmers to multiply their own seeds. However, such a provision is difficult to enforce and involves high transaction costs, especially in developing countries where the number of smallholders is large and infrastructure is not well developed. Accordingly, the sustained dominance of OPVs in West and Central Africa has perpetuated the lack of private sector involvement in maize varietal improvement in the sub-region (Alene et al. 2015).² Hybrids are a technical solution to the non-excludability problem as seed must be purchased every season to achieve undiminished yields. Seed companies are therefore able to fully realise

the returns from their investment in developing hybrids. Thus, the widespread diffusion of hybrids among small scale farmers in Eastern and Southern Africa has led to considerable private sector investment in maize breeding (see De Groote et al. 2015).³

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

2.2.2 State failure

The market failures described above provide the rationale for government involvement in varietal development. The non-excludability problem of OPVs has been a major reason for government-supported crop breeding programmes (Minot et al. 2007). The focus of such programmes has usually been placed on major crops that are important for food security and export. The state-run programmes mostly rely on the Consultative Group on International Agricultural Research (CGIAR) for improved germplasm, but this is only useful if it can be incorporated into a well-functioning domestic breeding programme. In the case of maize, many African countries remain fully reliant upon public sector breeding programmes as the only source of improved varieties adapted to local conditions, even after liberalisation efforts in the seed sector. However, governance problems facing the public sector affect the effectiveness of such programmes. The low capacity of public research organisations and missing linkages between research and extension result in inadequate feedback from farmers. Such feedback would be essential to inform the system about farmers’ objectives for varietal development. This deficit often leads to a considerable mismatch between the type of varieties produced by breeders and those required by farmers (Cromwell et al. 1992; Louwaars 2005).

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

² Premier Seed Ltd. in Nigeria was the only private seed company in West and Central Africa that invested in maize research with about six full-time equivalent researchers working on maize breeding in 2009 (Alene et al. 2015).

³ The private sector was responsible for 53% of the maize variety releases in Eastern and Southern Africa between 2000 and 2010 (De Groote et al. 2015).

2.2.3 Community failure

Informal seed systems rely entirely on local communities, but as outlined above, they are not the focus of this paper. Communities can also play an important role in formal systems to address the problems of market and state failure identified above. “Participatory Plant Breeding” (PPB) approaches have become rather common, and they are often part of formal seed systems (Sperling et al. 2001). Depending on the type of PPB approach, communities may be involved at all stages of the formal seed system displayed in Fig. 1.

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

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

2.3 Seed multiplication and certification

2.3.1 Market failure

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

number of both foreign and domestic private sector companies involved in commercial seed multiplication, which focus particularly on hybrids (ACB 2015).

Information asymmetry is not only a problem for variety development, but also for seed multiplication. Seed producers invariably have more information than farmers about the origin and quality of commercial seed (Byerlee et al. 2007). By visual inspection, farmers can detect some aspects of seed quality (such as obvious damage), but they cannot assess important aspects such as genetic purity. Akerlof (1970) demonstrates how information asymmetry about product quality and potential fraud adversely affects market performance. This problem of market failure can also be observed with regard to seed multiplication. Farmers may opt to use seed saved from their own harvests or utilise more familiar informal seed distribution channels rather than purchase seed of unknown quality from a seed company. The majority of small scale farmers in Africa obtain their seed from these informal sources (Louwaars and De Boef 2012; McGuire and Sperling 2016). Seed certification can address this challenge, but it involves its own governance challenges, as discussed below.

2.3.2 State failure

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

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

Governments have also set up seed certification systems to address the market failure of quality assurance discussed above. These systems also face governance challenges due to resource constraints. Spatially dispersed seed production fields must be repeatedly inspected at specific stages of the

growing season. The inability to mobilise these resources often causes costly delays and losses. This invariably encourages rent-seeking and collusion between influential seed producers and officials. Most African countries operate mandatory and highly centralised government-funded seed certification systems for food crops like maize that are confronted with these challenges (Tripp and Louwaars 1997).

2.3.3 Community failure

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

2.4 Seed marketing and promotion

2.4.1 Market failure

Market failure in seed marketing and promotion can occur for a number of reasons. First, the public good feature of non-excludability arising with OPVs tends to lead to a preference for only promoting and marketing hybrid seed. While seed marketing is a particularly weak point in Africa's commercial seed sector development, dominant seed companies in a number of African countries have fairly well established distribution networks for their hybrid maize seed (Tripp 2000). Second, private companies lack the incentive to invest in the promotion of public varieties as this may prove beneficial to competing companies (Tripp and Byerlee 2000). This is an indication of the free rider problem where those benefitting from a service are not paying for it, which results in an under-

provision of the service. Third, information asymmetry about the actual content of packaged commercial seed results in the common problem of seed adulteration by seed retailers (Langyintuo et al. 2010). In addition, the high transaction cost of marketing seed to spatially dispersed smallholders in remote and low potential areas also serves as a deterrent to seed companies and agro-dealers.

2.4.2 State failure

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

2.4.3 Community failure

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

3 Ghana's commercial seed sector

Ghana's evolving commercial seed sector supplies only a small percentage of the total demand for seed. About 80% of the seed used in the country is sourced from the informal sector, which entails farmer-saved seed, seed exchanges

among farmers and purchases from local grain or seed markets (MoFA 2015b). Similar to most African countries, maize is the predominant crop in the commercial seed system. The average annual certified maize seed production between 2001 and 2014 was 2230 metric tons. This represents 60% of all commercial seed production. Between 1970 and 2010, twenty-seven improved maize varieties were released in Ghana. Table 1 shows that Ghana's varietal output is average as compared to other countries in West and Central Africa. Yet, one OPV, Obatanpa, accounts for 96% of maize seed production while newer varieties have failed to have significant commercial seed production (PPRSD 2002–2015). These unsuccessful varieties have included several hybrids (Tripp and Ragasa 2015). A comparison of the studies by Morris et al. (1999) and Ragasa et al. (2013) indicate that the total maize area planted to improved varieties in Ghana increased marginally from 54% in 1997 to 60% in 2012. However, the share of Obatanpa more than doubled over this period. In 1997, Obatanpa accounted for 30% of the maize area planted to improved varieties. In 2012, the share of Obatanpa increased considerably to approximately 70% of the maize area planted to improved varieties. It must be noted that the annual certified seed production of Obatanpa is insufficient to cover this area with fresh seed every year, given the average seed rate of 20 kg per hectare (Ragasa et al. 2013).

Obatanpa is a medium maturity white OPV. This quality protein maize variety (QPM) was developed by the public research system in Ghana under the Ghana Grains Development Project (GGDP) and promoted extensively by the Sasakawa Global 2000 (SG 2000) programme.⁴ The variety has not only been widely adopted in Ghana but also across a number of other African countries (Badu-Apraku et al. 2004). Although Obatanpa is an improved variety,⁵ it was released over two decades ago and is therefore unlikely to play a significant role in any further commercial seed sector development (Tripp and Mensah-Bonsu 2013). The national annual average yield for maize over the past decade is 1.7 metric tons per hectare (MoFA 2015c). Based on on-station and on-farm trials, achievable yields of newer OPVs and hybrids could be between 5 and 8 metric tons/ha. The low adoption of improved technologies such as improved varieties is a major reason accounting for this yield gap (Ragasa et al. 2013). Thus, the availability of new and higher yielding improved varieties in the seed system is vital for increasing maize productivity.

Table 1 Improved maize varieties released in West and Central Africa, 1970–2010

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

Source: Alene et al. 2015

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

4 Research methods

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

4.1 Research design

The study employed a two-step data collection procedure. In the first step, the participatory mapping technique based on in-depth interviews and visualisation known as Process Net-Map was conducted with an array of purposively sampled experts in the seed supply system. The respondents were selected based on the extent of their experience and understanding of how the entire commercial maize seed system operates. Net-

⁴ This was an outcome of a joint institutional effort to improve the nutritional value of maize grain protein aimed at overcoming malnutrition in the large population of low-income groups who depend on maize as the main component of their dietary protein intake (Sallah et al. 2003).

⁵ Obatanpa has a potential yield of 4.6 metric tons/ha based on on-station and on-farm trials (Ragasa et al. 2013).

Map is a participatory mapping method developed for analysing how complex systems with multiple actors function (Schiffer 2007). Process Net-Map is a variant of the method that was developed to identify governance challenges in processes of policy-making and implementation (see Raabe et al. 2012). In this study, the tool was used to gain detailed insights into the process of commercial maize seed supply in Ghana. At the same time, the tool made it possible to identify the relevant stakeholders. A detailed description of this method is presented in Section 4.2 below. Guided by the Process Net-Maps, the second step involved in-depth interviews with selected experts from all identified stakeholder categories using purposive sampling. These respondents were selected based on their high level of experience carrying out specific activities in the seed system. Additional in-depth interviews were conducted using snowball sampling to ensure exhaustive expert information. The respondents included agricultural researchers, public officials and regulators, donors, seed producers (individual seed growers), local private seed companies, input dealers, extension agents, maize farmers and other stakeholders throughout the country. In total, 71 stakeholders were involved in this study (see Table 2). Direct observation of seed supply activities, such as maize seed processing, certification, storage and sale was also conducted. Each interview involved a series of open-ended questions and follow-up questions to best capture the respondent's expert opinion on the governance challenges in the commercial maize seed system and his views on how these challenges may be overcome. The two-step research design was complemented with an extensive review and synthesis of relevant policy and legal documents as well as project reports. The document review served as triangulation to validate the findings.

4.2 Data collection

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

Table 2 Overview of process Net Maps and expert interviews

Stakeholder category	Number of Net-Maps	Number of interviews (including Net-Maps)
CGIAR centres	1	1
Research institutions	1	4
Universities		1
Government agencies (policy, regulation, extension)	4	16
Development partners/donors	1	5
Non-governmental organisations		2
Agricultural consultants	1	1
Local private seed companies	2	8
Seed producers (individual seed growers)	1	8
Agro-input dealers (seed dealers)		9
Agro-processing companies		1
Maize farmers		15
Total	11	71

these challenges. Digitalised copies of the Net-Maps were later shared with the respondents for verification.

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

5 Results

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

5.1 Aggregated process net-map

The analysis of the eleven Process Net-Maps revealed the same basic steps for commercial maize seed supply in Ghana. While there was no contradiction, respondents provided different levels of detail for the different stages of maize seed supply. The Process Net-Map in Fig. 2 represents an aggregation of the most detailed number of steps and actors involved at each stage of the process based on the eleven maps produced. The average influence levels were reported as there was minimal variation in the respondents' perceptions of the influence of different actors (see Table 3). These influence levels were computed by summing the scores of the eleven respondents and dividing the sum by eleven. The mean scores were rounded off to the nearest whole number. They are depicted in the form of circles next to the actors in Fig. 2. The number in the circles displays the rounded mean score. The governance challenges in the system are depicted in the form of stars.

5.2 Actors and their roles in commercial maize seed supply

The results show that two national agricultural research institutes (NARIs) have been solely responsible for all locally developed improved maize varieties in Ghana: the Crop Research Institute (CRI) and the Savannah Agricultural Research Institute (SARI). CRI has the mandate for crop research in the coastal savanna, the forest belt and the forest-savanna transition agro-ecologies of Ghana while SARI handles crop research for the Guinea savanna and the Sudan savanna agro-ecologies. Both NARIs belong to the Council for

Scientific and Industrial Research (CSIR). They determine breeding priorities to overcome current production and post-harvest challenges in consultation with farmers as shown in Steps 1 and 2 of Fig. 2. Subsequently, they obtain germplasm from collaborating international research centers, particularly from the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA). Indigenous landraces are also occasionally sourced from the Plant Genetic Resources Research Institute (which also belongs to CSIR) to address specific adaptability and utilisation issues. The Plant Genetic Resources Research Institute is the national genetic resources agency and operates a national gene bank. Some public universities have established breeding programmes as well, but they are yet to release any improved maize varieties. Under the new seed law, varieties developed by the private sector from both domestic and foreign sources are also permitted.

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

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

Fig. 2 Aggregated process Net-Map of commercial maize seed supply in Ghana

registered in a national catalogue for crop varieties managed by the Crop Services Directorate of MoFA (Step 8).

Upon initial approval of the variety by the NVRRC, the responsible research institution commences breeder seed production so that at the time of official release, breeder seed will be available (Step 9). Under the new law, all classes of seed must be certified by the Ghana Seed Inspection Division (GSID) of the Plant Protection and Regulatory Services Directorate (PPRS) of MoFA.⁶ This certification process

starts with breeder seed certification (Step 10). Certified breeder seed is supplied to the Grains and Legumes Development Board (GLDB), a parastatal of MoFA, as well as directly to local private seed enterprises (Step 11). Prior to the new law, GLDB was the only institution mandated to produce foundation seed.⁷ As indicated above, ten domestic seed companies have emerged, which have started to produce the foundation seed they require for the production of commercial hybrid maize seed. GLDB still produces and

⁶ The Plant Protection and Regulatory Services Directorate is the institution sanctioned to regulate and coordinate all plant protection services. It is subdivided into four divisions which includes the Ghana Seed Inspection Division.

⁷ GLDB assumed the task of foundation seed production after the collapse of the government-owned Ghana Seed Company (GSC) in 1989. GLDB inherited some of its infrastructure (Lyon and Afikorah-danquah 1998).

Table 3 Mean and range of influence scores of actors

Actors	Mean influence level	Range
Public extension services	8	1
Crops research inst./ Savannah agricultural research Inst./ public universities	7	1
Ghana seed inspection division	7	1
Certified seed producers	6	1
Agro-input dealers (seed dealers)	6	2
Grains & legumes development board	5	2
Local private seed companies	5	2
National variety release & registration committee	4	3
Farmers	3	1
Non-governmental organisations	3	2
National seed council	2	1

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

processes the bulk of foundation seed using contract growers (Step 12). Foundation seed produced by GLDB and seed companies is inspected and certified by GSID (Step 13).

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

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

5.3 Influence level of actors

As described above, the respondents were asked to score the influence of the actors on the desired outcome that farmers

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

commendable, were perceived to have limited scope. Indeed, most seed sector activities by NGOs are concentrated in Northern Ghana. The National Seed Council had the lowest influence level on the outcome (influence level = 2) because the newly formed council was perceived as essentially following the recommendation of the NVRRC in releasing a new variety.

5.4 Governance challenges of the commercial maize seed system

This section presents the empirical analysis of the governance challenges affecting the different stages of the seed supply system. The theoretical considerations presented in Section 2 are applied here. Figure 2 highlights the identified governance challenges in the form of stars.

5.4.1 Varietal development

As discussed in Section 2.2, market failure in varietal development can stem from high entry costs. Concordantly, private investments by local seed companies in developing proprietary breeding programs in Ghana have mainly been hindered by the cost outlay of varietal development. The interviews revealed that the absence of a plant variety protection law is also an obstacle.⁸ Thus far, there has been no private sector involvement in maize varietal development in Ghana. Public breeding programs serve as the sole source of maize varieties, as depicted in Steps 1 through 8 of Fig. 2. According to the information collected for this study, researchers in the NARIs' breeding programs only involve farmers at the later stage of on-farm trials. At the initial planning stages of varietal development, farmer input is largely absent. A NARI maize breeder noted;

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

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

state failure in setting breeding priorities, as mentioned in Section 2.2. A former MoFA official observed;

“The RELCs produce priorities that are not necessarily what the farmers want because the committees are not representative of the everyday smallholder.”

The NARIs seem to be unable to match the success of Obatanpa in satisfying farmers' needs across the country's varied maize production zones. There are instances where varieties have failed to meet farmers' preferences with regard to criteria such as grain size and milling quality. Furthermore, while many of the newer varieties are also quality protein maize varieties, almost all of the newer OPVs are early maturing (75–90 days to anthesis), which invariably results in comparatively lower yields.

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

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

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

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

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

5.4.2 Seed multiplication and certification

As mentioned in Section 2.3, public sector seed multiplication and certification can lead to capacity and inefficiency problems. In the current system, the NARIs sell breeder seed upon

⁸ At the time of submitting this article in early 2017, a draft plant breeders' rights bill intended to provide ownership and protection for new varieties developed by any public and private entities is awaiting parliamentary approval.

request to GLDB as well as to private seed companies, as shown in Step 11 of Fig. 2. The price at which the NARIs have to sell breeder seed to GLDB is subject to a pricing ratio (1:2:4) set by the NVRRC,⁹ which starts with the determination of the commercial seed price.¹⁰ The foundation seed price is set at double that of commercial seed, and breeder seed price four times that amount. According to interview information, this pricing system does not cover the cost of breeder seed production. Moreover, GLDB often delays payments. Some local private seed companies have signed a memorandum of understanding with the NARIs to obtain inbred lines for hybrid seed production at a price that allows the NARIs to recover their costs. Given the capital-intensive nature of breeder seed production,¹¹ the NARIs are often unable to supply adequate quantities of breeder seed. Related to this problem is the maintenance of breeder seed. The need to maintain a large number of different varieties also involves considerable costs, since the seeds must be stored under climate-controlled conditions. Therefore, breeder seed of a number of the older maize varieties is no longer available. The research institutions cite financial and physical resource constraints as the main reasons for this problem. A NARI maize breeder expressed this concern as follows;

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

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

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

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

The systemic problem of seed quality, which has been discussed in Section 2, is very much present at this stage of seed production as well. Seed producers have intermittently raised issues regarding the quality of foundation seed. This is obviously the consequence of the low capacity and antiquated seed conditioning equipment and facilities.

GSID has the sole responsibility of quality assurance at all stages of seed production (Steps 10, 13 and 16 of Fig. 2). GSID is tasked with field inspections, monitoring of conditioning sites and undertaking seed tests.¹² Under the new law, mandatory seed certification extends to foundation and breeder seed. Similar to GLDB, GSID is greatly under-resourced. As an industry expert revealed;

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

As a consequence of this limited capacity for seed regulation, GSID’s regulatory oversight of source seed production (breeder and foundation seed) has become a mere formality. Interview information suggests that field inspectors readily certify breeder seed without proper testing. The NARIs are seen to be fully competent and well equipped with the expertise to ensure high breeder seed quality. However, even with the experience and expertise of the NARIs, the absence of effective regulation can lead to complacency. Quality assurance of foundation seed production by GLDB faces a similar challenge. The National Seed Council has the authority to sanction private seed companies to produce foundation seed for sale. However, GSID has concerns with authorizing dispersed companies to commercially produce foundation seed

⁹ The NVRRC essentially doubles up as the Seed Advisory Technical Committee which oversees seed pricing due to identical stakeholder representation on both committees.

¹⁰ The seed producers association of Ghana (SEEDPAG) presents their cost of production at an annual stakeholder forum to set a standard seed price for OPVs and hybrids that is not mandatory but generally adhered to.

¹¹ Breeder seed production is an expensive process due to high production, testing and storage costs of ensuring varietal purity.

¹² Ghana applies the International Seed Testing Association (ISTA) rules for seed testing.

as this will increase GSID's regulatory responsibilities. The following statement of a respondent reflects this concern;

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

GSID is most active at the commercial seed stage of the production chain. Field inspectors are required to visit all the production fields of seed producers and seed companies at least five times during the certification process.¹³ However, this goal is seldom achieved. The small number of inspectors is simply unable to monitor all the dispersed seed production fields. Very often, the seed producers and local seed companies have to incur the cost of transportation of inspectors to ensure field visits. Seed producers and seed companies are already charged for each inspection. Thus, many seed producers operate with minimal supervision and quality assurance at the production stage. Another major concern is the conflict of interest arising from some GSID inspectors engaging in commercial seed production. This is forbidden by law, but not strictly enforced. A seed producer expressed concerns as follows;

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

Notably, this conflict of interest is an empirical finding of state failure in seed multiplication and certification that is not covered under the theoretical considerations presented in Section 2.

5.4.3 Seed marketing and promotion

With reference to Section 2.4, market failure in seed marketing and promotion can be caused by seed adulteration, a free rider problem, and high transaction costs. State failure can also occur due to the transaction intensity and discretionary nature of these activities.

A key duty of inspectors after seeds are produced is to supervise the filling and sealing of seed bags by seed producers and local seed companies. Certified maize seed is packaged in 1 kg polythene bags, which are subsequently placed in 45 kg bags. The 1 kg seed bags are produced in response to the small quantities of commercial seed purchased by most small

scale farmers. Standard packaging material issued by GSID is used, except for five seed companies who use their own brands. This generic packaging material has proved easy to imitate, a practice motivated by the fact that the price of certified commercial seed is approximately twice the price of maize grain for OPVs and five times the price of grains of hybrids. Thus, it is common that merchants sell maize grain packaged as certified seed. Field inspections at the time of harvest determine the number of packages issued to a producer. This could also lead to seed adulteration as the number of field inspectors is rather limited. However, unregistered seed dealers appear to be the main source of fraudulent commercial seed, rather than seed producers or even collusions between seed producers and merchants. This is reflected in the following statement by the owner of a local seed company;

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

There have been a number of cases where farmers who purchased sub-standard maize seed have lodged complaints with GSID. Yet, there is still no formalised procedure in place for addressing such complaints. The new law provides severer penalties for duplicitous activity in the commercial seed sector. There have been a few confirmed cases of incarcerations for seed adulteration following the passing of the new law. However, the monitoring system of seed dealers is rather limited, as GSID lacks the resources to implement effective regulation at sales points (Step 18 of Fig. 2).

In terms of varietal promotion, seed dealers usually lack sufficient information about the characteristics and management of varieties to effectively promote them. Many farmers do not even have access to these seed dealers whose marketing channels fail to extend to most rural areas.¹⁴ Local seed companies and seed producers are also reluctant to invest in the promotion of products that can be sold by direct competitors, given the non-exclusivity rights of varieties developed by the NARIs. As a consequence, other than public sector AEAs, only NGOs have engaged in any significant varietal promotion.

The commercial seed sector mainly depends on MoFA's AEAs to promote the use of improved seed varieties amongst farmers (Step 19 of Fig. 2). Yet, similar to GLDB and GSID, public extension services are so grossly under-resourced that they are not able to effectively perform this function. The current extension-farmer ratio in Ghana is 1:1500 as opposed

¹³ Field inspections are to be done as part of the initial application process to become a registered seed producer/company; followed by a pre-planting inspection; two inspections at the pre-flowering and post flowering stages; and a final inspection during harvesting.

¹⁴ Krausova and Banful (2010) identified a total of 3425 agricultural input dealers in Ghana in 2009 ranging from small transient retailers to large input wholesalers. Most input dealers were concentrated in urban and peri-urban areas with 59% of them selling seed.

to the recommended ratio of 1:500 (MoFA 2015c). This human resource problem is coupled with a lack of logistics such as vehicles and working gear, as well as operational funds to carry out demonstrations, field days and farmer field schools.

6 Discussion

This study aimed to contribute to the literature on the governance challenges of developing seed systems in Africa, taking the chronic lack of varietal diversity in Ghana's commercial maize seed system as an empirical example. From the theoretical considerations presented in Section 2, it is evident that each sector has its own governance challenges in seed supply. State failure in seed supply systems has motivated the liberalisation and restructuring of the African seed industry. However, our case study of Ghana suggests that these efforts have not been sufficient in ensuring an effective seed supply system. The reasons are discussed in the following subsections.

6.1 Breeding strategies

In spite of privatisation efforts, maize varietal development in Ghana has remained a purely public sector activity. The number of improved varieties that the public system released is comparable to that of other countries in the sub-region (Table 1). Yet, only Obatanpa remains popular among maize farmers. The demand for improved varieties is invariably linked, at least in part, to the performance of the research system. This is reflected in the high average influence level (influence level = 7) assigned to the research system in the Net-Map exercise. This study indicates that the state failure of deficient farmer participation in the NARIs' breeding strategy has resulted in instances where varieties failed to meet farmers' preferences. Some preferences were correctly identified; most notably increased yield and storability, but the new varieties did not outperform Obatanpa in these respects. This presumptive breeding approach has made maize varietal development a "hit or miss" exercise. However, without survey data on farmers' evaluations, there is limited scope to accurately estimate the extent to which wrong priorities versus inefficiency in meeting priorities account for breeding shortfalls. Private sector involvement in varietal development can lead to more efficient outcomes as evidenced by the maize breeding efforts of domestic companies in countries like Kenya and Zambia (see De Groote et al. 2015). However, state-managed breeding programmes which emphasise participatory breeding strategies could also produce the varieties that farmers desire. Collective action by farmers can make such programmes more accountable (cf. Sperling et al. 2001).

6.2 Managing seed multiplication

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

GLDB mirrors the resource constraints of the NARIs in the production of foundation seed. The state failures of capacity and inefficiency problems have resulted in a focus on bulking a select number of OPVs that are comparatively cheaper to produce than hybrids and have significantly higher market demand. The influence level of 5 that was assigned by respondents to GLDB reflects the parastatal's monopoly of this stage of seed multiplication. In many African countries, breeder seed will mostly come from the public sector, but there is no reason why private entities should not produce and market foundation seed, provided that the demand for commercial seed is sufficient to allow for full cost recovery of foundation seed production (Tripp 2000). In Zambia, for example, foundation seed is produced entirely by the private sector (World Bank 2014). Despite the potential quality and efficiency gains of privatised foundation seed production as evidenced by Zambia's seed system, this study finds that in Ghana, there is a reluctance of the public sector to relinquish control over this stage of seed production. This resistance appears to be stemming mainly from the increased regulatory responsibilities that would follow from foundation seed production by the private sector. There is also a need to better understand the political economy of this resistance, as there may be vested interests as well.

6.3 Quality assurance

Another key issue in the commercial seed system has been quality assurance. The mandatory certification of all classes of seed under the new law places GSID in a very influential position, as reflected in respondents' perceptions (influence level = 7). However, the findings reveal that this extended regulatory oversight does not appear to have substantially improved maize seed quality in Ghana. GSID is yet another government agency that is overburdened and under-resourced. As a consequence, GSID's limited regulatory

resources are mainly dedicated to commercial seed inspection and certification. Less attention is paid to source seed quality assurance and retail inspections. Previous studies have established the chronic market failures of poor quality commercial seed, seed adulteration and the regulatory challenges thereof (Langyintuo et al. 2010; Tahirou et al. 2009; Tripp and Louwaars 1997). This paper further highlights the state failure of major seed quality issues with source seed production which invariably contributes to poor quality commercial seed. Charging official fees based on the costs of mandatory government-run seed certification can help to overcome the regulatory challenge of limited resources (World Bank 2016). Another viable approach is finding an effective means by which public sector agencies share regulatory responsibilities with private seed companies. This could take the form of seed companies that are accredited to assume some certification responsibilities, as practised in Zimbabwe where several seed companies are licensed to certify seed. Other options include a Quality Declared Seed System¹⁵ as practised in Tanzania and Zambia, and authorising the sale of “truthfully labeled seed”¹⁶ (Tripp 2000; van Gastel et al. 2002).

6.4 Varietal promotion efforts

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

varieties to seed companies provides an incentive for private sector investment in seed promotion. Such licensing would solve the market failure of a free-rider problem in seed promotion.

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

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

7 Conclusions

In this paper, the governance challenges involved at the different stages of formal seed supply systems were analysed from a theoretical and an empirical perspective. Ghana's commercial maize seed sector was used as a case study. The analysis, which was based on Process Net-Map and expert interviews, revealed that a combination of market and state failures account for the lack of varietal

¹⁵ Under the system design, seed producers are tasked with meeting set quality standards. The system is particularly suited to countries with limited regulatory resources as it relies on randomised field and sales point inspections rather than general mandatory inspections (FAO 2003, 2006).

¹⁶ The seed producer must ensure that the seed is tested and the results indicated on the label. Seed producers are legally liable for stated seed quality.

diversity in commercial seed provision. The theoretical concepts and the empirical findings provide instructive insights for seed system development, which are likely to be relevant for other African countries.

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

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

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Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

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