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Seeding eastern Africa's maize revolution in the post-structural adjustment era: a review and comparative analysis of the formal maize seed sector

RESEARCH ARTICLE

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Abstract

Improved maize seed is instrumental to deliver an Asian-style 'green revolution' for Africa. The paper reviews and makes a comparative analysis of the maize (corn) seed sector and its evolution in Kenya, Tanzania, Uganda and Ethiopia drawing from seed sector surveys and secondary data. Enhancing farmers' access to and use of new maize varieties still presents a number of challenges in eastern Africa – not least due to a number of policy and institutional impediments to the development of the seed sector. The regional seed sectors also show some remarkable contrasts: they have evolved at different speeds and in different directions, driven by diverging agricultural growth opportunities and varying degrees of regulation, liberalization and restructuring. The paper reiterates calls for an enabling environment for private seed companies to evolve in order to serve the diverse farmer communities so that they benefit from existing and future improved maize seed opportunities.

Keywords: seed supply, seed business, corn, improved varieties, structural adjustment

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1. Introduction

The need to increase agricultural productivity to enhance food security and reduce poverty in Africa is widely acknowledged (IBRD, 2007; McArthur, 2015). Improved crop varieties play a critical role in agricultural intensification (Evenson and Gollin, 2003; Walker and Alwang, 2015) – particularly when combined with external inputs and a conducive policy environment as exemplified by the Asian Green Revolution. There has been considerable interest in an African green revolution (Byerlee and Eicher, 1997; Otsuka and Larson, 2016; Scoones and Thompson, 2011; Smale *et al.*, 2011; Toenniessen *et al.*, 2008).

Improved maize (or corn, *Zea mays* L.) varieties play a potential pivotal role to revolutionize Sub-Saharan Africa's (Africa hereafter) agriculture, enhance food security and reduce poverty. Maize is a strategically important crop for food security and economic growth in Africa. Maize is a key food crop across large swathes of Africa, and Africa's largest and most widely cultivated cereal with over 30 million ha cultivated and 50 million tons produced annually. Currently maize productivity is a major determinant of food security from the household to the regional level. Improved maize seed is a key to boost productivity so as to generate the surpluses to lift rural incomes and feed burgeoning rural and urban populations. Unlike in many other parts of the world, maize is a key staple crop across many eastern and southern African countries and fast growing in importance in West Africa. Hybrid maize seed is the key to viable seed industries, further enabled by the structural adjustment induced market liberalization and privatization. Maize seed has thereby long been viewed as instrumental to deliver an Asian-style 'green revolution' for Africa.

Yet, despite improved maize seed's promise and substantial progress made in recent years in Africa – progress has been slow, intermittent and uneven (Kassie *et al.*, 2013; Langyintuo *et al.*, 2008, 2010; Morris, 1998; Rusike and Eicher, 1997; Timothy *et al.*, 1988). Enhancing farmers' access to and use of new maize varieties still presents a number of challenges in the region – not least due to a number of policy and institutional impediments to the development of the seed sector. This is particularly important given that most of the maize in Africa is grown by small-scale farmers facing asset, institutional and policy constraints in accessing new technology and markets. A vibrant, efficient and functioning seed sector is critical in ensuring widespread distribution of new maize varieties to farmers for increasing productivity and reducing food prices for consumers. While improved seed supply is critical in many regions for improving access and use, demand is also crucial for igniting productivity change and stimulating growth in the seed industry. The institutional and policy impediments are important on both supply and demand sides of this process. The seed sector in Africa also shows some remarkable contrasts: it has evolved at different speeds and in different directions, driven by diverging agricultural growth opportunities and varying degrees of regulation, liberalization and restructuring.

The objective of the paper is to assess and characterize the maize seed sector and its evolution in Kenya, Tanzania, Uganda and Ethiopia in the post-structural adjustment era. Specifically, the paper first reviews the state of the formal maize seed sector in eastern Africa based on secondary data and the literature. The paper then makes a comparative analysis of the maize seed sector stakeholders drawing from seed sector surveys in each of the four study countries. The premise is that we need to understand seed systems in order to enable further seed sector development and a maize revolution; whereas their inherent context specificity and complexity calls for comparative analysis using a similar approach across national borders within eastern Africa. This study aims to start filling the knowledge gap given the importance of maize in the region and that of the seed sector in enhancing the development and use of improved crop varieties.

The paper is structured as follows. The following section provides an analytical framework. The third section introduces the material and methods including the underlying seed sector surveys. The fourth section reviews the eastern Africa's maize seed sector. The fifth presents a comparative analysis of the seed sector stakeholders. The paper then discusses the associated challenges and opportunities for the sub-region's maize seed sector development, before concluding.

2. Analytical framework

Seed systems can be broadly categorized into formal and informal – with the formal referring to the organized seed sector including institutionalized seed producers and companies, be it private or public. The informal seed sector is non-institutionalized, encompassing seed saving, seed exchange and seed production by farmers and is often highly localized. The informal sector is the major source of seed of all crops in Africa (e.g. Louwaars and De Boef, 2012), with an estimated seed share above three-quarters across eastern Africa (e.g. 80% in Kenya (Wulff *et al.*, 2006), 90% in Tanzania (Ngwediagi *et al.*, 2009), 92.5% in Uganda (Kabeere and Wulff, 2008), and 96.5% in Ethiopia (Atilaw and Korbu, 2011)). The relative shares also vary by crop with the formal share being substantially higher for maize, although estimates vary considerably across eastern Africa. For instance, in the case of Ethiopia, seed from the formal sector is estimated to cover 19% of the maize area (Alemu, 2011), whereas it approximates three-quarters in Kenya (Langyintuo *et al.*, 2010).

The formal and informal seed systems can play diverging but also complementary roles (Almekinders and Louwaars, 2002), also in view of the significant market failures for seed research and development in developing countries (Kremer and Zwane, 2005). This paper purposively focuses on the formal seed sector in view of its critical role in agricultural intensification through the introduction of improved seed. The paper particularly focuses on maize seed as the formal seed sector in eastern Africa primarily revolves around maize. This reflects the role maize plays as a major staple crop in the sub-region and the inherent characteristics of maize seed. Maize is a cross-pollinating crop and thereby opened the prospects of hybridization and commercialization through the associated potential demand for recurrent seed renewal further aided by its high multiplication factor.

Seed system analysis needs to go beyond identifying the formal and informal sectors. Seed systems are complex and dynamic – not least due to inherent variations in products, supply and demand side factors and their interrelated associations with the policy environment. Various analytical frameworks have been put forward to analyze seed systems (i.e. Almekinders and Louwaars, 2002; Cromwell *et al.*, 1992; Louwaars and De Boef, 2012; Van Mele *et al.*, 2011a). Some have emphasized the dynamic nature of seed systems and perceived development paths from ‘basic’ to ‘mature’ seed systems (Morris, 1998; Pray and Ramaswami, 1991; Rusike and Eicher, 1997) with a decreasing role for the informal sector and corresponding increasing role for the formal sector and corresponding stage dependent policy implications. The associated path dependency of seed sector development from preindustrial to emergence to expansion to maturity is appealing for its simplicity and apparent logic. But others have argued that reality has proved more complex and that there is no blueprint seed policy implying that there is a need to understand seed systems in order to develop the corresponding seed policy options (Louwaars, 2002). This study builds on this premise – and seeks to understand seed systems within their local context.

The context specificity of seed systems and their inherent complexity have led to numerous case studies of (sub)national seed systems with a diversity of approaches and emphasis – with seed systems in eastern Africa being a case in point (Kenya: Misiko *et al.*, 2011; Muhammad *et al.*, 2003; Muthoni and Nyamongo, 2008; Wulff *et al.*, 2006; Tanzania: Ngwediagi *et al.*, 2009; Uganda: Kabeere and Wulff, 2008; Larson and Mbowe, 2004; Muhhuku, 2002; Van Mele *et al.*, 2011b; Ethiopia: Alemu, 2011; Alemu *et al.*, 2010; Atilaw and Korbu, 2011; Bishaw *et al.*, 2008). These diverse stand-alone case studies make it difficult to make any comparative analysis or synthesis and this challenge is further compounded by the diverging points of departure and timing and extent of liberalization. The current paper addresses this gap by providing a comparative analysis using a similar approach across national borders within eastern Africa.

3. Material and methods

The study draws on a structured questionnaire to generate data and information on the maize seed industries in eastern Africa for a comparative analysis. The questionnaire based interview included respondents representing seed companies, national research institutes, and seed traders’ associations in each of the

countries (Ethiopia, Kenya, Tanzania and Uganda). The survey was not intended as a census but aimed and succeeded to at least include all the main established stakeholders willing and able to cooperate (Table 1). The sample includes some relatively independent subsidiary seed companies as separate entries; i.e. the instrument focusing on their immediate operational domain and not on their respective parent companies. The survey was complemented with a literature review and secondary data where available. However, unless specified otherwise, data presented here were collected during the 2010 seed sector survey.

4. A review of eastern Africa's maize seed sector

The formal seed sector in Africa typically originated from a similar public sector dominance and till the turn of the century the commercial seed sector had generally been slow to develop (Tripp and Rohrbach, 2001). Indeed, seed sector development in Africa has long been hampered by regulatory frameworks that favored parastatal enterprises and inhibited commercial innovation (Tripp and Rohrbach, 2001). The regulatory frameworks variously emphasized control, cooperation and/or competition (Louwaars, 2002). Seed commercialization by the formal sector normally implies the need for varietal registration and seed certification in each country (GRAIN, 2005; Setimela *et al.*, 2009; Waithaka *et al.*, 2011).

Despite similar origins, in the 1990s there was already considerable variation in seed sector development across countries: e.g. in eastern Africa, only Kenya was perceived as having a rather effective and diversified seed industry, with still rather limited progress in Tanzania, Uganda and Ethiopia (Lanteri and Quagliotti, 1997). Some of the current seed sector characteristics reiterate the differential start, with Kenya being the first to have a national seed trader association, having substantially more active seed companies, more registered maize varieties, more certified maize seed sales and more adoption of improved maize varieties (Table 2). The last decade has seen on-going efforts to harmonize and rationalize the seed policy environment across eastern Africa.

Maize dominates the national formal seed sales with shares in excess of 70% in all eastern African countries, except in Ethiopia where maize comprises 38% (Table 2). Maize also dominates the national variety lists – with for instance more than a third of entries in both Kenya's national variety list and Tanzania's plant varieties officially released for commercialization between 1995-2008 (Ngwediagi *et al.*, 2009). These selected indicators however also mask further regional variations. For instance, the reported average national volumes of certified maize seed have been relatively stagnant over the last few years in Kenya and Tanzania, but have seen a steady increase in Uganda (Waithaka *et al.*, 2011).

There has also been a varying liberalization of the seed sector. Uganda stands out with the seed industry having moved from a public monopoly of seed production to a completely private seed sector in the wake of policies to liberalize and privatize the economy that started in the early 1990s (Kabeere and Wulff, 2008). Kenya liberalized the seed sector in 1996 (Wulff *et al.*, 2006) with numerous seed companies rapidly emerging in the following years to a total of 74 in 2009. However, despite the rapidly increasing number of private seed companies, the Kenya Seed Company (KSC) remains the largest company that still dominates the national seed market (e.g. nearly 75% of certified seed sales in 2005 (Wulff *et al.*, 2006)) while being publicly owned. In Tanzania, the former seed parastatal was privatized – with the private sector primarily responsible for production and marketing of certified seeds although up to recently the public Agricultural Seed Agency remained responsible for the production of basic seed of public varieties and even marketed some certified seeds (Ngwediagi *et al.*, 2009).

Table 1. Number of formal maize seed sector stakeholders interviewed, 2010.

	Kenya	Tanzania	Uganda	Ethiopia	Total
Number of seed companies	12	10	8	5	35
Number of other stakeholders	2	1	2	1	6
Total	14	11	10	6	41

Table 2. Selected characteristics of seed sector from secondary data.¹

	Kenya	Tanzania	Uganda	Ethiopia
Number of active seed companies ^a	74	31	20	30
% Share of maize seed in national seed sales ^{a,b}	87 (2009)	71 (2009)	75 (2009)	38 (2007-08)
Certified maize seed sales (×1000 ton per year) ^{a,b}	25-30 (2005-08)	7-7.5 (2005-08)	8.5 (2009)	8.6 (2007-08)
Number of registered maize varieties (year) ^c	164 (2009)	75 (2008)	36 (2010)	42 (2009)
Estimated adoption rates of improved maize varieties (% maize area) ^{d,e}				
2007	72	18	35	19
1997	71	4	9	8
Establishment national seed trader association (year) ^f	1982	2002	1999	2006

¹ Adapted from: (a) Waithaka *et al.*, 2011; (b) MoARD, personal communication; (c) data obtained from: Variety Release Committees of Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia; Kenya Plant Health Inspectorate Services (KEPHIS), Nairobi, Kenya; Ministry of Agriculture and Food Security (MAFS), Morogoro, Tanzania; Ministry of Agriculture, Animal Industry and Fisheries, Entebbe, Uganda; (d) Langyintuo *et al.*, 2010; (e) Hassan *et al.*, 2001; (f) National seed trader associations (<http://afsta.org/memberships/afsta-members>).

In Ethiopia, the Ethiopian Seed Enterprise is a public enterprise that still dominates the national seed market. In the 1990s, Pioneer Ethiopia was the only other operational seed company, and only in the 2000s did the number of seed companies start to increase. But Ethiopia stands out for its ambivalent attitude towards economic liberalization and the private sector (Alemu, 2011). Indeed, Ethiopia is the only case study country where the number of public seed enterprises has been increasing, with the recent establishment of regional seed enterprises with the aim of addressing the seed demand at the regional level. Private seed companies contributed only 12% to the volume of formal seed produced in Ethiopia (across all crops, 2006-08), with public seed companies contributing 79% and others (including state farms, unions, research centers) contributing 10% (Alemu *et al.*, 2010). The role of private seed companies is somewhat more substantial in the case of hybrid maize seed production (33%, *ibid.*).

5. A comparative analysis of eastern Africa's maize seed sector stakeholders

Liberalization opened the seed sector to many new entrants. The startup year of the surveyed seed companies averages late 1990s, reflecting their relatively recent nature and their increasing number, with most seed companies having worked with maize seed from their inception (Table 3). Seed typically was the core business of the surveyed seed companies contributing 89% of their gross revenue, with two-thirds of companies having an exclusive seed focus (Table 3). Most of the seed companies had a diversified seed portfolio in terms of crops, although maize seed is the most important accounting for about 64% of the gross revenue (Table 3) – reiterating the relative profitability of maize seed vis-à-vis other crops.

Ethiopia stands out for having the least diversified seed companies – reflecting that most private seed companies focus on hybrid maize seed. Surveyed seed companies in Tanzania and Ethiopia catered purely for their domestic market, whereas at least a third of the surveyed seed companies in Kenya and Uganda also reported regional cross-border operations. About half the surveyed seed companies produced publicly available maize varieties, with 29% of surveyed seed companies reporting having their own breeding unit (to develop their own varieties) and 14% relying on a breeding unit with their parent company (Table 3). In-house breeding units were markedly more common in Kenya and Uganda, implying their relatively more mature private seed sector. An increasing share of the released maize varieties now is proprietary material owned by private seed companies (Setimela *et al.*, 2009). Surveyed seed companies typically produce their

Table 3. Surveyed seed company characteristics.

	Kenya	Tanzania	Uganda	Ethiopia	Overall
Startup year (average)					
Seed company	1990	2002	2001	1998	1997
Maize seed	1995	2002	2004	1998	1999
Seed focus					
Exclusive (% seed companies (SC))	58	70	63	80	66
Share gross revenue (%)	84	87	95	95	89
Maize seed focus					
Exclusive (% SC)	8	0	0	40	9
Share gross revenue (%)	65	71	47	79	64
Geographic scope (% SC)					
Sub-national	33	20	0	40	23
National	33	80	50	60	54
Regional	33	0	50	0	23
Number of countries covered	1.9	1.0	1.9	1.0	1.5
In-house (% SC)					
Breeding unit (+ with parent Co.)	42 (+17)	10 (+10)	38 (+13)	20 (+20)	29 (+14)
Seed quality control lab	30	44	71	20	42
In-country seed multiplication (% SC)					
% irrigated	37	17	6	29	23
% area contract farmers	71	62	85	30	65

seed in-country – only a few companies bring their seed from elsewhere (Table 3). The seed multiplication is mainly rainfed and hence subject to the vagaries of weather. About two-thirds of the companies' maize seed multiplication area is contracted from seed out-growers while one third of the area is owned by the companies themselves – the latter particularly more important in Ethiopia apparently linked to the land tenure system (Table 3).

The surveyed seed companies reported an average portfolio of five current maize varieties (Table 4). The maize portfolio is heavily biased towards hybrids in Kenya and Ethiopia whereas open pollinated varieties (OPV) still dominated in Tanzania and Uganda at the time of the survey (Table 4). The volume of maize seed sold in the domestic market averages 1,500 tons per surveyed company, with Uganda and Tanzanian companies selling half that and Kenyan companies selling nearly two times the average (2,700 tons; Table 4). These country averages are, however, influenced by the small sample size and the substantial volumes handled by the large public seed companies. Indeed, across the region the surveyed seed companies are primarily small private seed companies with seed volumes below 1,500 tons per year. On average, a quarter of the seed volume handled by each company was classified as short duration and 22% as drought tolerant (Table 4). These two categories overlap to some extent but typically reflect maize seed targeted for the drier drought prone environments. The retail price for maize seed averaged 1.8 and 1.1 US\$/kg for hybrid and OPV, respectively (Table 4). As expected, OPV seed was substantially cheaper than hybrid maize, although it was relatively expensive in Kenya in part associated with the limited OPV volumes handled and correspondingly small sample size. Both types of maize seed were relatively cheap in US\$ terms in Ethiopia compared to the region as whole; whereas hybrid maize seed was relatively expensive in Tanzania. The maize seed prices expressed relative to the rural grain prices oscillated around 8 for hybrid and 5 for OPV maize seed (Table 4).

Maize seed is primarily targeted at small-scale farmers and is thus predominantly marketed in small bag sizes with the 2 kg bag being the most common (Table 5). A notable exception is Ethiopia where all maize seed was sold in mandatory 12.5 kg bags at the time of the survey. Maize seed is mainly sold through independent private retail outlets (or agro-dealers, especially in Kenya and Tanzania), with smaller shares reported as

Table 4. Seed company seed portfolio.

	Kenya	Tanzania	Uganda	Ethiopia	Overall
Maize seed portfolio					
Number of current varieties	5.2	5.0	4.3	5.4	4.9
% hybrid entries	91	17	42	92	58
Average maize seed volume sold in domestic market (× 1000 ton per year)	2.7	0.7	0.8	1.6	1.5
% hybrids	89	17	26	94	55
% short duration	28	24	36	3	25
% drought tolerant	22	36	16	4	22
Retail prices (US\$/kg)					
Hybrid maize seed	1.91	2.22	1.69	1.27	1.77
OPV ¹ maize seed	1.84	1.08	0.85	0.44	1.05
Maize grain price (US\$/kg)	0.25	0.23	0.20	0.16	0.22
Relative seed price (seed:grain)					
Hybrid seed	7.8	9.8	8.6	8.0	8.1
OPV seed	7.5	4.8	4.4	2.7	4.8

¹ OPV = open pollinated varieties.

Table 5. Seed company maize seed distribution.

	Kenya	Tanzania	Uganda	Ethiopia	Overall
Main bag sizes maize seed (in kg, % SC reporting)¹					
0.5-1	27	10	25	0	18
2	100	90	88	0	79
5	18	40	75	0	35
10-12.5	36	20	63	100	47
25-50	36	0	13	0	15
Maize seed distribution outlets (% share sales per year)					
Private retail	76	76	46	1	57
Own seed company retail	0	8	25	0	8
Direct sales	14	16	29	3	17
Other sales network	10	0	0	96	18

¹ Columns may not sum 100% as multiple responses are possible; SC = seed companies.

direct sales (usually larger volumes sold directly by the seed company to individuals and/or institutions) or sales through the seed companies own retail outlets (Table 5). Ethiopia is an exception again that seed sales are centrally organized and maize seed demand is first estimated and maize seed subsequently distributed through farmer cooperatives and unions.

The surveyed formal maize seed sector stakeholders were queried on their perceptions of the seed policy environment – with about a third perceiving an overall increase in seed regulatory processes in their respective countries (Table 6). The time to release a new variety was generally perceived to have decreased to an average of 2.7 years. The decrease was generally associated with the harmonization efforts and the average was relatively uniform across the case study countries. After release it would take on average an additional two years to have the seed available in ‘significant quantities’, although this showed more regional variation depending on the seed company and country specificities. Kenya’s seed certification system is relatively well developed and used as a model for the other case study countries. As a result, most stakeholders in Kenya

Table 6. Perception on seed policy environment by surveyed formal maize seed sector stakeholders (2010).¹

	Kenya	Tanzania	Uganda	Ethiopia	Overall
Perceived increase in seed regulatory processes (% SC, n=34)	23	13	50	33	29
Time to release new variety (yrs, n=33)	2.9	2.8	2.6	2.3	2.7
Perceived decrease in duration varietal registration (% SC, n=34)	57	63	67	67	62
Time to have seed available (yrs from release, n=33)	2.8	1.3	1.5	2.5	2.1
Perceived change in strictness of seed certification (% SC, n=40)					
Decrease	0	10	50	33	20
Same	79	20	30	50	48
Increase	21	70	20	17	33
Public support to private seed companies	(+)		+	++	
Maize seed sales					
Price controls	(+)			++	
Subsidies	+	+	(R)		
Sales restrictions				++	

¹ SC = seed companies; ++ = substantial; + = some; () = only selected; R = relief.

did not report any perceived change in strictness of seed certification, whereas in Tanzania most perceived it to have increased.

Earlier studies have called for a greater emphasis on regional strategies for public plant breeding and private seed marketing (Tripp and Rohrbach, 2001). The import and export of maize germplasm and seed is generally possible in the sub-region provided the regulatory procedures are followed – including phyto-sanitary and other bureaucratic procedures (e.g. in Uganda germplasm imports require permission from National Agricultural Research Organization (NARO)). Imported seed also needs to have been registered in the importing country and excludes genetically modified material. Occasionally, additional ad-hoc barriers are imposed. For instance, in Kenya it was reported that in times of domestic seed shortage seed export certificates may not be issued in time, or in times of grain shortage grain exports may be banned and exporters need to prove that the product really is seed. In Uganda, there were reports of earlier restrictions on seed imports/exports, but these have subsequently been eased. In general, imports/exports seem to have benefitted from the regional harmonization, although some non-Kenyan stakeholders reported the difficulty of meeting Kenya's stringent requirements, resulting in largely one-way seed flows out of Kenya to Uganda and Tanzania.

Surveyed stakeholders generally acknowledged the generic public support to private seed companies through the public role in germplasm development/access and certification services. There was however considerable divergence in terms of the perceived specific public support, in part associated with the relative roles played by the public and private sector. Only in Ethiopia was such public support perceived as substantial (e.g. in terms of land access) and to a lesser extent in Uganda (e.g. in terms of training and information). In the case of Kenya public support was perceived to be primarily directed towards KSC. The maize seed sales were perceived to be most heavily regulated in Ethiopia, both in terms of price controls and sales restrictions. In Kenya, only the seed prices of KSC are controlled, but being the largest player this has a marked influence on overall seed prices. Such price controls for the public sector tend to become particularly prominent in times of seed shortage like in the aftermath of a drought. At the time of the survey, subsidy schemes with targeted seed vouchers were operational in both Kenya and Tanzania. In Uganda, no subsidy scheme was operational as such, but there were reports of institutional agents like NGOs distributing free relief seed in selected target areas. Market based voucher instruments are now generally preferred over the distribution of

large amounts of free or subsidized seed that undermine seed enterprise development (Tripp and Rohrbach, 2001). However, voucher-based subsidies can still ‘crowd out’ the private sector and be fiscally unsustainable (Smale *et al.*, 2011). In Ethiopia, no subsidies were reported – but the seed sector regulation and price controls did imply the lowest retail prices for maize seed in US\$ terms in the study region.

There is a general lack of reliable maize seed market data across the region – be it in terms of potential market demand (e.g. maize area and its characteristics like maize ecologies and drought incidence), actual market demand (e.g. maize varietal use and seed renewal) and supply (e.g. maize seed volumes produced/traded). Most of the surveyed stakeholders did not have such information when queried and thus have corresponding difficulties in assessing their relative market shares or identifying market opportunities. Although an individual seed company’s seed volumes may be guarded as a trade secret, the overall maize seed sector would benefit from reliable aggregate market indicators. For instance, whereas formal maize seed tends to be certified – the actual aggregate national volumes of certified maize seed per year are not systematically reported in the public domain nor otherwise easily available. It would thereby be a relatively simple but beneficial step to annually publish the certified seed volumes of maize (and other crops) on the internet.

A number of additional market failures hamper maize seed markets in the sub-region. Although some seed companies have developed their own or market proprietary maize varieties, most emerging private seed companies still rely on public maize varieties. With these public varieties being public goods, the companies have limited incentives to invest in marketing/promoting them. Public support and investment in the promotion of public varieties may thus be needed as well as help to stimulate commercial seed production (Tripp and Rohrbach, 2001). Such generic market failures are further compounded by country specific aspects. In the case of Tanzania the public Agricultural Seed Agency was the only authorized producer of foundation seed for public varieties up to the time of the seed sector survey. As a result, the surveyed companies variously complained about the insufficient availability of foundation seed to meet their needs and having their seed portfolios dictated by foundation seed availability and not actual market demand. In the subsequent years some seed companies started to circumvent these restrictions by releasing their own proprietary varieties. The case of Ethiopia is extreme with all but one company producing and emphasizing the same narrow portfolio of public material at the time of the survey (including a few popular public hybrids). At the time any incentive for seed companies to invest in the marketing of their products was further curtailed by Ethiopia’s attempt to centrally compile seed demand through cooperatives/farmer unions and centrally distribute seed accordingly. Central planning of seed markets also can only go so far, with Ethiopia moving from a severe structural shortage of maize seed to a maize seed glut in the aftermath of a program to stimulate seed production in 2009/10 (Atilaw and Korbu, 2011). Such market failures pose serious constraints to the effective development of the private maize seed sector. At the same time they impose significant barriers to the introduction of innovations such as promising new drought tolerant maize germplasm.

The surveyed seed companies were queried as to their business model expectations for the next five years (Table 7). The majority of seed companies see the importance of maize in their respective countries increasing – often in relation to population growth and maize being a competitive staple food. Worryingly though, an even larger majority expects the incidence of drought to increase in their respective countries, except amongst those surveyed in Ethiopia who already reported a widespread incidence of drought. The expected drought increase is often associated with climate change and increasingly erratic rain patterns. Reflecting the drought incidence expectations, the majority of seed companies across countries expected drought tolerant maize to play an increasing role in their maize seed portfolio. Indeed, all surveyed seed companies saw drought tolerant maize as an opportunity, be it in relation to agro-ecological changes/opportunities, market opportunities/farmer demand, maize areas already being drought prone or technological characteristics of drought tolerant maize varieties. However, at the same time nearly all seed companies listed potential constraints linked to drought tolerant maize. The constraints for drought tolerant maize comprised a diverse set, but most widely reported were seed market/regulation issues.

Table 7. Business model expectations for the next five years by surveyed seed companies (% seed companies reporting, 2010).

% seed companies	Kenya	Tanzania	Uganda	Ethiopia	Overall
Increase in country scenario					
Importance of maize	50	80	63	80	66
Incidence of drought	75	90	88	0	76
Increased role in seed portfolio					
Drought tolerant maize	83	80	88	80	83
Hybrid maize	25	90	88	40	60
Maize (vs other) seed specialization					
Decrease	58	10	25	0	29
Same	17	80	25	80	46
Increase	25	10	50	20	26
Seed (vs non-seed) specialization					
Decrease	0	30	63	40	29
Same	67	40	38	60	51
Increase	33	30	0	0	20

Seed companies, particularly in Tanzania and Uganda where OPVs still play a prominent role in current portfolios, also expect to increase (or maintain) the role of hybrids in their maize seed portfolio (Table 7). Surveyed seed companies were somewhat divided in terms of their future planned maize seed specialization vis-à-vis other crops (Table 7). Most commonly they expected to maintain the current dominant role of maize seed – particularly in Tanzania and Ethiopia. In Kenya, there was an inclination towards diversifying seed away from maize – reflecting the relatively mature maize seed market. In contrast, in Uganda inclinations were towards increasing maize seed specialization reflecting the rapid recent growth in maize seed markets relative to other seed. The seed companies were also somewhat divided in terms of their future seed specialization vis-à-vis non-seed business, although most commonly they expected to maintain the current seed specialization, except in Uganda where there was a preference towards diversifying with non-seed business (e.g. other agro-inputs such as fertilizer (Table 7)).

6. Discussion: challenges and opportunities for maize seed sector development

Seed sector development in Africa has long been a challenge. Indeed up to the turn of the century, progress has often been very limited in spite of substantial investments and assistance (Lanteri and Quagliotti, 1997). The foregoing sub-regional review and comparative analysis thus helps to identify both country specific and wider lessons for seed sector development and some of the associated policy implications. It is now widely and increasingly acknowledged that the private sector can effectively carry out many seed production and distribution activities in the sub-region – but this requires a favorable policy environment, including (1) a clear regulatory framework; (2) fair competition; (3) access to germplasm from national or international research centers; and (4) limits on the distribution of free emergency seed (Minot *et al.*, 2007). Fair competition includes the assurance that private seed companies will not have to compete with subsidized public enterprises – an issue that still hampers the Kenyan and Ethiopian seed sectors and to a lesser extent Tanzanian. Ethiopia also stands out as most reliant on public seed enterprises and having an overly regulated environment that reduces flexibility and business viability as well as raising barriers to entry.

It is also increasingly clear though that there is no blue-print to seed sector development in the sub-region and each country would do best in being open minded in assimilating the best-practices appropriate to their respective situation. This calls for an inclusive seed policy debate amongst the numerous stakeholders (Louwaars, 2002). Indeed, debates on technological and/or market dimensions of seed sector development can easily miss-out on the political economy dimensions – whereas an examination of the latter can reshape

the terms of the debate and open up alternative pathways to more sustainable and socially just seed systems (Scoones and Thompson, 2011). Political economy dimensions can indeed have far reaching consequences for Africa's agricultural development – be it in terms of undermining Kenya's 2004 strategy for revitalizing agriculture (Poulton and Kanyinga, 2014), determining the roles of Ethiopia's extensive agricultural extension program (Berhanu and Poulton, 2014), and shaping Malawi's farm input subsidy program (Chinsinga and Poulton, 2014) and southern Africa's seed industry (Kassie *et al.*, 2013).

The overarching vision should be to create an enabling environment for private seed companies to evolve and thrive and thereby service the diverse farmer communities for them to be able to adopt and benefit from existing and future improved maize seed opportunities. Indeed, it is common knowledge that private seed companies pursue market opportunities – with a corresponding bias towards the higher potential agricultural areas (Odame and Muange, 2011). Targeted policies could help incentivize a more comprehensive coverage of lower potential areas, including drought prone maize environments. For instance, policies could strengthen farmers' capacities to assess new varieties and to be effective consumers of commercial inputs (Tripp and Rohrbach, 2001); policies could support the development of new varieties appropriate for less potential areas; and/or policies could enhance the demand for such varieties through the targeted use of seed vouchers for cash strapped small holders.

The seed sector in eastern Africa features unprecedented growth in private enterprise and the popularization of hybrid maize. Still, the contrasting seed sector landscape presents different implications for seed business management (MacRobert, 2009). The domestic market still presents a major determinant for further seed business investments and growth. Kenya thereby presents the most developed seed sector but also is the most crowded. Ethiopia presents the strongest public sector interference. Uganda presents the most liberal sector but it is landlocked with a relatively small maize seed market. Tanzania has the biggest untapped growth potential, but also presents some of the biggest operational challenges. The regional market offers potential beyond the domestic market base, but has been hampered somewhat by the diversity and slow harmonization progress – with Kenya still as the most likely base for seed businesses with regional aspirations.

Despite the challenges for seed sector development it is promising to note that new products like drought tolerant maize have successfully entered the market and present growth opportunities across the region (Fisher *et al.*, 2015). Still the contrasting outcomes across the region pose particular challenges. Indeed, Kenya despite having the most developed seed sector and wide-spread improved maize adoption has seen relatively stagnant national maize yields. This shows that maize seed sector development may be a necessary but not sufficient condition for Africa's maize revolution. Indeed, there is a need to complement the provision and use of improved maize seed with complementary crop management practices and functional market linkages (both input and output markets – e.g. Dixon *et al.*, 2007). In the post-structural adjustment era it is perhaps somewhat surprising that Ethiopia – despite its public sector dominance – has made significant strides in realizing its maize revolution over the last decades (Abate *et al.*, 2015; Zeng *et al.*, 2015). Ethiopia stands out as a maize revolution success story country with increasing national maize yields and with maize having become the largest staple in terms of production – reiterating the need for improved maize seed to be complemented with improved crop management and functional markets.

7. Conclusions

Despite the prevalence of maize seed as the core business for seed companies in eastern Africa, the sub-regional seed sector also shows some remarkable contrasts between the case study countries. Although each country comes from a similar public sector dominance of the seed sector, they have evolved at different speeds and in somewhat different directions and present different seed business management challenges and growth opportunities. Driving the seed industry dynamics are diverging agricultural growth opportunities and varying degrees of regulation, liberalization and restructuring of the seed sector.

Diverging policy implementation between countries has resulted in varying degrees of market concentration and public-private sector roles. In Ethiopia the seed sector remains dominated by the government. Kenya has a well-developed and virtually saturated market, but with a single public enterprise still dominating the national seed market. In Tanzania and Uganda the policy environment has allowed the private seed sector to become the main producer and marketer of maize seed, albeit still largely dependent on OPVs. Despite the regional diversity, there are also some similarities including a proliferation of private seed companies, an increasing emphasis on hybrid maize seed and the emergence of national seed traders' associations to help organize the increasingly complex and evolving maize seed sector. There is, however, no blue-print to maize seed sector development in the sub-region and each country would do well in being open minded in assimilating the best-practices appropriate to their respective situation. The overarching vision should be to create an enabling environment for private seed companies to evolve in order to service the diverse farmer communities for them to adopt and benefit from existing and future improved maize seed opportunities.

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