

Chapter 6

Role and Challenges of the Private Seed Sector in Developing and Disseminating Climate-Smart Crop Varieties in Eastern and Southern Africa



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6.1 Introduction

CC poses a significant risk to crop production across sub-Saharan Africa (SSA), with ESA particularly vulnerable to the projected changes. Temperature increases are estimated to rise at a rate above the global average during the twenty-first century and it is predicted that by 2050 will significantly change the cropping duration for key staple crops (Cairns et al. 2013; Schlenker and Lobell 2010; Niang et al. 2014; James and Washington 2013; Challinor et al. 2016). Meanwhile, precipitation is projected to increase in parts of eastern Africa but decrease significantly in southern Africa. The combined heat and drought stress in parts of ESA is projected to reduce yields of staple cereals by as much as 30% within two decades (Niang et al. 2014; Lobell et al. 2008).

Smallholder, subsistence farmers constitute over 70% of the population in ESA and account for over 75% of agricultural output (AGRA 2017). They are the group most vulnerable to CC and require urgent, scalable access to CS crop varieties with adaptive characteristics that can tolerate future climates. These include; tolerance to combined heat and drought stress, waterlogging and lodging stress, post-harvest storability, maintenance of nutritive value in warmer climates, and adaptation to new and shifting incidences of pests and diseases. To deliver CS crop varieties in CC

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affected areas of ESA will largely depend on increasing the rate of genetic gain (genetic improvement through artificial selection) for CS traits and the establishment of scalable, competitive seed delivery systems that ensure improved varieties reach smallholder farmers in the shortest time (Atlin et al. 2017).

Smallholder farmers' adoption of improved crop varieties in SSA is amongst the lowest in the world (estimated to be 20% by the Alliance for a Green Revolution in Africa (AGRA) 2017), yet the formal seed sector has grown significantly following deregulation of the seed industry regionally in the early 1990s. The emerging private seed sector provides a unique and timely opportunity to promote the development and dissemination of improved, CS crop varieties through certified, scalable seed systems that can potentially impact millions of livelihoods in SSA. In this chapter, the specific roles and constraints for the private sector in ESA in developing and disseminating improved, CS crop varieties are discussed, with particular emphasis on maize (*Zea mays*), the staple food crop and primary source of daily calorie intake in the region.

6.2 The Emerging Private Seed Sector in ESA

In most of ESA, the plant breeding and seed industries were dominated by public institutions until the mid-1990s, when the seed sector was deregulated. Since then, dozens of private, local seed companies have been established, and several global multinational seed corporations have entered the ESA seed market. The primary focus of seed companies in ESA is maize, the driver of the global seed industry by virtue of acreage and potential for hybridization. The effect of deregulating the seed sector in ESA is highlighted in Fig. 6.1a, b, which show maize variety releases in Zambia and Kenya respectively. Both countries have emerged as leading centers for the seed industry in SSA and serve as important bellwethers of regional trends. In both cases, deregulation of the seed industry has led to a marked increase in the total number of seed companies and, subsequently, maize variety releases. However, the majority of these variety releases have been licensed from existing public breeding pipelines, and it is estimated that less than 25% of seed companies in the region (estimated to be 80 in total) have invested in proprietary germplasm improvement (Langyintuo et al. 2008).

Variety releases of other important staple crops in ESA have not emulated maize, in large part due to low commercialisation opportunities for the private sector. Total variety releases for maize, sorghum (*Sorghum bicolor*), common bean (*Phaseolus vulgaris* L.) and cassava (*Manihot esculentum*) are shown in Fig. 6.2a, b for Zambia and Kenya respectively. Even though variety releases of these crops have doubled since deregulation, the cumulative number of releases (for sorghum, common bean and cassava) is still less than 30% that of maize, and dominated by the public sector (over 80% of releases). In Zambia, cassava is an important secondary staple crop, yet only seven varieties (all publically bred) have been released since 1970, the latest in 2001. These crops are important components of food and

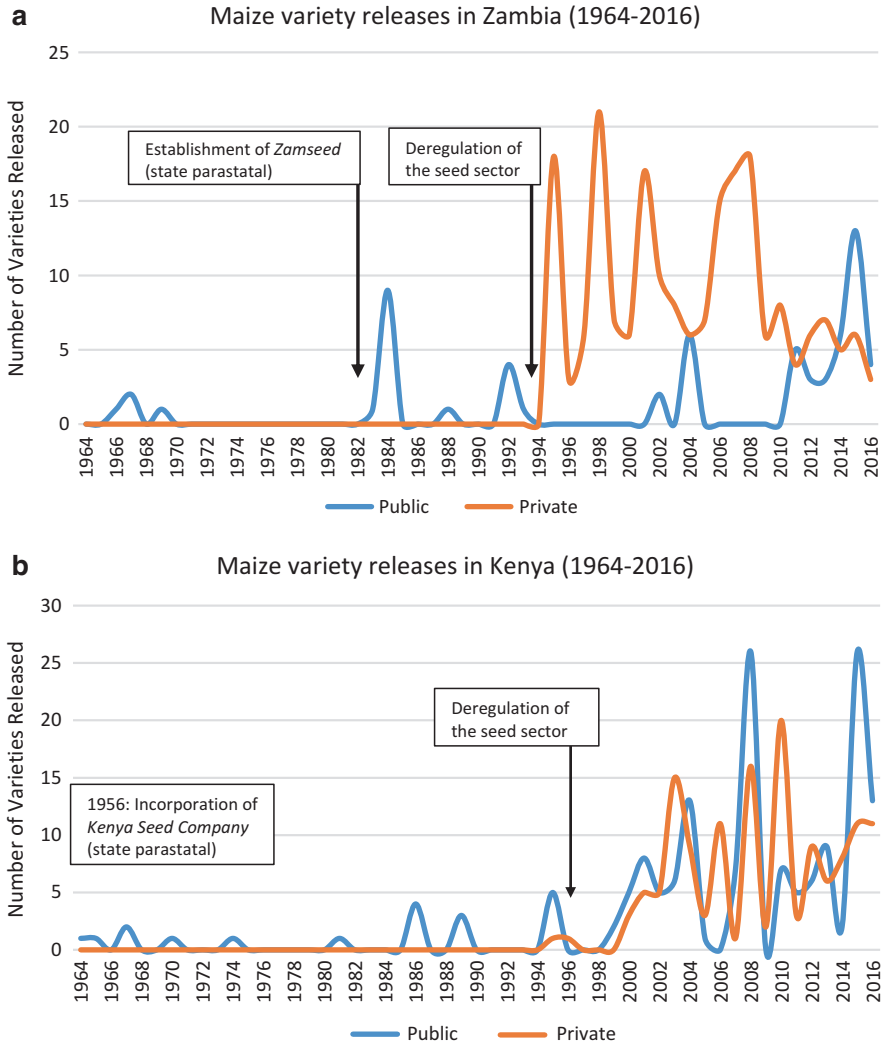


Fig. 6.1 (a) Maize variety releases in Zambia (1964–2016) by the public and private sectors. (Source: SCCI 2017). (b) Maize variety releases in Kenya (1964–2016) by the public and private sectors (KEPHIS 2017)

nutritional security in ESA, where they will play a critical role in diversified, CS agricultural systems. Market incentives are urgently required to better integrate these open pollinated and vegetatively propagated crops into scalable, certified seed systems in the region.

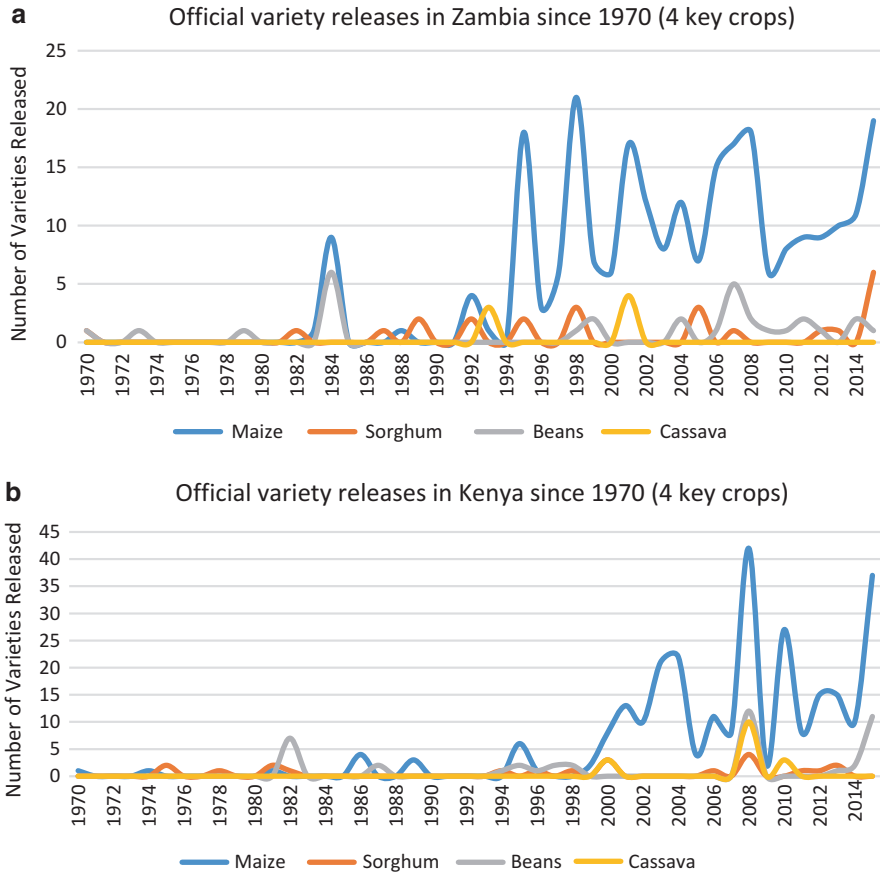


Fig. 6.2 (a) Annual releases for maize, sorghum, common bean and cassava varieties in Zambia since 1970. (Source: SCCI 2017). (b) Annual releases for maize, sorghum, common bean and cassava varieties in Kenya since 1970 (KEPHIS 2017)

6.3 Low Rates of Variety Turnover and Agricultural Research and Development Investment in ESA

Despite the growth of the seed industry in ESA since the 1990s, rates of variety turnover remain slow, and investment into agricultural research and development is extremely low. A handful of established varieties also continue to dominate markets in most countries (Abate et al. 2017). In Kenya, H614D (a variety released in 1986 by the state parastatal) accounts for over 40% of area cultivated to improved maize varieties while in Zambia, the three most widely grown maize varieties were released almost two decades ago, shortly after the deregulation of the seed sector (Smale and Olwande 2014; Smale et al. 2015). The average age of commercial

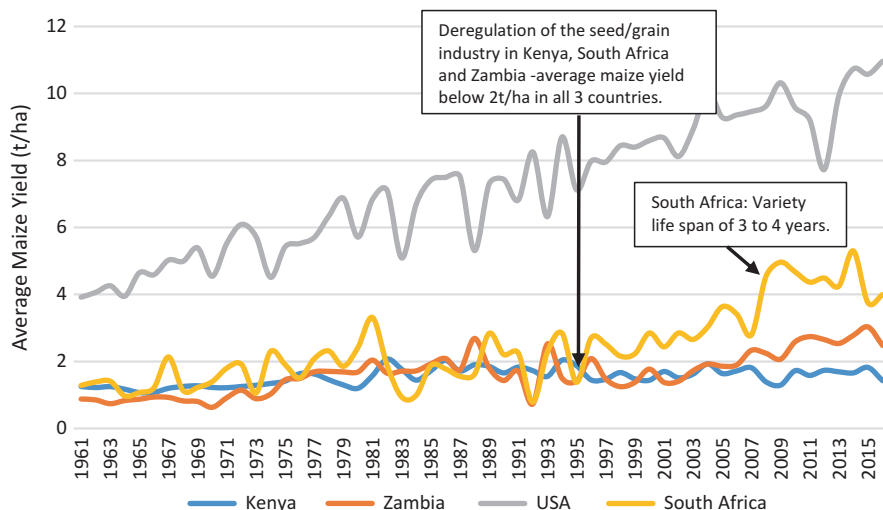


Fig. 6.3 Average maize yields (1961–2016) in Kenya, Zambia, United States and South Africa (FAO 2018)

maize varieties in ESA is estimated to be 13 years. South Africa is an exception; with the most competitive seed industry in the region, the life of the typical maize variety here spans 3–4 years, similar to the United States. Most smallholder farmers in ESA are therefore not cultivating the best available varieties for their environment, and in many cases are persevering with obsolete cultivars that were developed under climatic, agronomic and pest conditions distinct from current and future climates. This has contributed to modest yield gains for maize in many countries in ESA (Fig. 6.3).

Reasons for slow rates of maize variety turnover in ESA are several and complex. The majority of smallholder farmers in the region grow maize in unpredictable, rain-fed conditions, and are risk averse to investing in inputs and new technologies. Average yields throughout the region are low and genetic gains in yield through crop improvement (usually 1% per year in well managed breeding programmes) are frequently overshadowed by seasonal variations in on-farm climatic conditions and crop management. The incentive for smallholder farmers to invest in new agricultural technologies is further reduced by limited access to grain markets, poor storage and transport infrastructure, as well as counterfeit seed and fertilizer. Without strong demand for new varieties, seed companies are reluctant to withdraw established, well-known varieties and invest in launching and marketing new products.

In addition to low rates of variety turnover, investment in agricultural research and development is very limited in ESA. Low income countries (including most of those in ESA) account for less than 3% of global agricultural research and development expenditure, despite being some of the most vulnerable to CC (Pardey et al. 2016). Of this expenditure in ESA, 90% is by the public sector, which continues to

dominate the development of new technologies, including crop varieties (Beinteman and Stads 2011). By comparison, private sector investment in agricultural research and development in member countries of the Organization for Economic Co-operation and Development (OECD) regularly accounts for over 70% of total expenditure (OECD 2018) and the role and costs of developing new agricultural technologies has been assumed by a vibrant private sector, driven by competition for market share. Private sector investment in agricultural research and development remains low in ESA in part due to small, fragmented markets and a lack of commercial incentive in the region. Given the projected impacts of CC in ESA, increased investment in crop improvement is vital, as are mechanisms to drive faster rates of variety turnover to ensure farmers have sustained access to the latest genetics.

6.4 Driving Genetic Gain for CS Traits Through Public-Private Partnerships (PPP)

Increasing rates of genetic gain will be fundamental to ensuring plant breeders are able to react quickly to changing dynamics caused by CC, many of which are difficult to predict (e.g., shifting incidence and severity of pests and disease). Driving genetic gain for CS traits will require access to appropriate germplasm, reliable phenotyping platforms for traits of interest, and adoption of modern breeding methods that reduce breeding cycle time. Given the current levels of investment in agricultural research and development in ESA, driving genetic gains for CS traits is unlikely to be achieved in the near term without the combined efforts of PPPs.

Effective PPPs will utilize the public sector's experience and capacity in the region whilst exploiting the emerging private sectors access to regional markets and expertise in commercial plant breeding, particularly in the case of regional or international companies. Public research institutions in ESA, for example, have developed germplasm adapted to local conditions and are strategically positioned to establish long term regional phenotyping networks for key CS traits, such as drought or emerging disease tolerance (e.g., the maize lethal necrosis (MLN) screening facility in Kenya, developed by the Kenya Agricultural and Livestock Research Organization (KALRO) and the International Maize and Wheat Improvement Center (CIMMYT)).

Conversely, the emerging private sector offers a sustainable route to market whilst assuming the costs and responsibility for seed production, quality, purity and distribution. Currently, most small and medium scale enterprise (SME) seed companies in ESA rely on this model to license and commercialise publically developed varieties, although significant bottlenecks persist in accessing foundation seed and legal services to enter mutually beneficial licensing agreements (Cramer, this volume).

The entry of multinational corporation (MNC) seed companies into the ESA seed market provides an additional opportunity to develop PPPs around technology

Table 6.1 Strength rating (low, medium or high) of selected drivers of genetic gain within the private and public sectors in ESA

Drivers of genetic gain in maize in ESA	Relative strengths	
	ESA public pipeline	MNC pipeline
Germplasm		
Locally adapted germplasm	High	Medium
Access to commercial, global germplasm	Medium	High
Phenotyping		
Establishment of regional phenotyping platforms for CS traits	High	Low
Phenotyping technology (high throughput precision screens, remote sensing, electronic data capture, etc.)	Medium	High
Access to modern breeding technology		
Double Haploids	Medium	High
Marker assisted selection, genomic selection	Medium	High
Data management systems	Low	High
Mechanisation of breeding programmes		
Seed inventory management, tracking and processing	Medium	High
Planting, harvesting, seed drying and storage	Low	High
Market orientated breeding programme		
Development of target product profiles	Medium	Medium
Cost of goods and production research	Low	High
Adoption of new technology through extension	High	Low

transfer and optimisation of breeding pipelines. MNCs have led the global development of applied breeding technology in genomics, phenomics and mechanisation, and can therefore complement ongoing public breeding efforts with modern technology to drive genetic gain. Technologies such as doubled haploids,¹ marker assisted selection,² precision phenotyping tools and data management platforms have transformed plant breeding in mature seed markets to develop products quickly in response to customer requirements. MNCs also have access to global sources of elite germplasm for a range of traits that will become more important in ESA as a result of CC (in terms of tolerance to drought, new pests and diseases). PPPs between public institutions and MNCs are likely to focus on germplasm exchange, the creation and release of joint products, the provision of technological services, and shared phenotyping platforms. The relative strengths of MNCs and public breeding pipelines in ESA in terms of driving genetic gain are shown in Table 6.1.

¹Artificial doubling of haploids to develop homozygous lines in one generation rather than six generations as required by conventional breeding

²Use of genetic markers to drive selection for a trait of interest

6.5 Enhancing the Delivery of CS Maize Varieties: Harmonising Seed Laws and Promoting Adoption

In addition to increasing the rate of genetic gain for CS varieties, regional bottlenecks in releasing, disseminating and adopting new varieties in ESA must be addressed in order to incentivise the private sector to invest in crop improvement, to reduce product life cycles, and to ensure certified seed of CS varieties reach small-holder farmers. ESA presents an attractive maize seed market (currently 20% that of North America) and many countries share common agro-ecologies which eases regional scaling of competitive varieties (Fig. 6.4). The reality, however, is nearly twenty individual nation states with distinct laws, regulations and trade agreements, making ESA a fractured and challenging seed market.

For over 20 years regional, intergovernmental bodies such as the Common Market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) have strongly recommended the harmonisation of seed laws governing variety release, the protection of plant breeder rights and cross border movement and sale of certified seed in ESA (personal communication). For example COMESA's Seed Trade Harmonization Regulations Programme (COMSHIP) calls for the harmonization of release processes across member countries and the development of a regional variety list, where varieties that have been released in two countries can be sold in similar agro-ecologies in all other COMESA member nations (COMESA 2014). However, actual adoption of these recommendations has been slow and most nations maintain separate release processes and laws. As a result, of the hundreds of improved maize varieties that have been released in

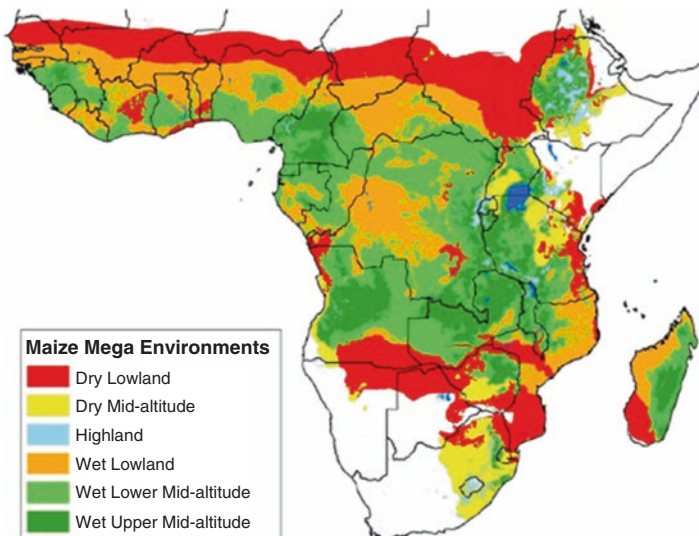


Fig. 6.4 Maize agro-ecologies in SSA. (Adapted from Hodson et al. 2002)

ESA since the 1990s, less than 5% have been successfully released and marketed in more than one country (Abate et al. 2017).

A formal variety release process remains essential in emerging seed markets such as ESA, to protect both farmers and the nascent seed industry from the entry of substandard products on to the market. However, the current regulatory environment in ESA is widely acknowledged to be costly and cumbersome for the seed industry (Bett 2017). Table 6.2 shows the current status of variety release processes in six ESA countries; the intercountry variations that exist throughout the variety release process are limiting market opportunities for seed companies and complicating both stock inventory and the consolidation of production bases.

Currently, very few variety release committees (VRCs) in ESA explicitly consider CS traits for variety release (Table 6.2). Given the extra investment and effort required to develop CS varieties, it is necessary to prioritise the release of varieties with these traits to secure private sector interest and commitment. The recent decision by the Kenya Plant Health Inspectorate Service (KEPHIS) to fast track the release of varieties tolerant to maize lethal necrosis (MLN) in Kenya is an example of engaging seed sector support to address an urgent challenge for smallholder farmers. The current outbreak of fall armyworm (*Spodoptera frugiperda*) throughout Africa provides another opportunity to prioritise a trait that is likely to become more relevant as temperatures increase in ESA as a result of CC.

Developing a brand around a CS trait such as drought tolerance represents a major commitment by a seed company to accept a certain degree of responsibility for varietal performance. To support the private sector to assume these risks, regulatory bodies in ESA need to provide a solid framework to protect intellectual property and clamp down on counterfeit seed that can damage farmer confidence in improved varieties. In recent years, there has been growing concern about the prevalence of counterfeit seed on sale in ESA and inadequate efforts by governments and regulatory authorities to address the problem (Mabaya et al. 2017; Bold et al. 2015). In Uganda for example, it is estimated that up to 50% of seed sold as certified seed is either fake or of substandard quality (AGRA 2011; Bold et al. 2015). Joining the International Union for the Protection of New Varieties of Plants (UPOV) and adopting global plant variety protection standards will increase private sector confidence in intellectual property protection and seed quality in ESA, though only Kenya, Tanzania and South Africa are currently members in ESA (Table 6.2).

Replacing old varieties with new, improved varieties will be a key pillar to driving agricultural productivity in ESA in the coming years, as it has in other parts of the world (Atlin et al. 2017). The benefits of cultivating improved, CS varieties need to be promoted (via extension services) to smallholder farmers who are operating in rain-fed, suboptimal environments at risk from CC. To drive uptake, the withdrawal of obsolete mega varieties should be encouraged and varieties with CS traits should be prioritised in farmer demonstrations and seed distribution programmes.

Table 6.2 Variety release regulations in six countries in ESA

	Zambia	Zimbabwe	Tanzania	Kenya	Malawi	South Africa
1	Number of seasons of Official National Performance Testing (NPT)	2	0 (preceded by 2 years of company trialing +1 year DUS)	1 (preceded by 1 years of company trialing +1 year DUS)	2	3
2	How many locations are NPT trials conducted in?	6	5 sites for company trialing	3 per agro-ecology	6–12	6–12
3	Is Farmer evaluation necessary for release?	No	No	Yes	No	No
4	What are the release criteria?	Must be DUS and have VCU	Must be DUS and competitive	Must be DUS and competitive	Superior yield to checks by 5–10% or special attribute(s)	Superior to checks with proven VCU
5	Are CS traits (e.g., drought) considered and tested during release?	Considered, but not tested	Considered, but not tested	Considered, but not tested	Yes, tested	Yes for Biotech traits
6	Is the country a member of UPOV*?	No	No	Yes	Yes	No
7	Can releases from neighbouring countries be sold?	No	No	No	No	No
8	Does certified seed have to be produced in-country?	No	Varies	No	No	Yes if Variety List is Open for Crop
9	Average age of commercial hybrids	10 years	13 years	14 years	14 years	11 years
10	Maize hybrid adoption rate	65%	95%	20%	80%	15%
						4 years
						98%

Source: Abate et al. (2017)
 * UPOV stands for International Union for the Protection of New Plant Varieties

6.6 Implications for development

The emerging private seed sector in ESA provides a significant opportunity to develop partnerships with established public plant breeding programmes, to accelerate the development of improved varieties with CS traits and their subsequent distribution through scalable, certified seed systems. Some 50% of yield gains in most global regions are commonly attributed to genetic gains made through plant breeding. Providing smallholder farmers in ESA with access to the latest, improved germplasm can therefore play a major role in adapting agricultural systems in ESA to CC. The promotion of an enabling regulatory environment for the release and adoption of improved varieties with CS traits will further stimulate private sector interest and investment. This is particularly applicable to the smallholder maize seed market, which is the primary basis for the growth of the emerging seed industry and the foundation of regional food security in ESA.

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