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Enhancing Agricultural Sector Development in Ethiopia: the Role of Research and Seed Sector

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አህፅሮት

ይህ ፅሁፍ በኢትዮጵያ ውስጥ ላለፉት ከ35 ዓመታት በላይ በተካሄደው የተደራጀ የዘር ሥርዓት ዕድገታዊ ለውጥ ላይ ያሉ የመሻሻል ሁኔታዎችን አጉልቶ ያሳያል። ከ1940ዎቹ ጀምሮ በተለየ አደረጃጀትና መጠነኛ ጅምር የተጀመረው የአገሪቱ መደበኛ የዘር ሥርዓት በተለያዩ ውስጣዊና ውጫዊ ምክንያቶች በተለይም ባለፉት ሁለት ምዕተ-ዓመታት ብዙ መዋቅራዊና ድርጅታዊ ለውጦችን አካሂዷል። ከነዚህ ውስጥ ዓለማ አቀፋዊ የኢኮኖሚ ዕድገት ለውጥ (ለምሳሌ የመዋቅራዊ ማስተካከያ ፕሮግራሞች)፣ በዘር ስርዓቱ ውስጥ ተሳታፊ አካላትን በማስፋት የግል ባለሃብቶች ተሳትፎ ላይ ትኩረት/አፅንኦት በማድረግ፣ የዘር ማምረትና የዘር ቁጥጥር አካላትን በመለያየት እና ለኢ-መደበኛ የዘር ሥርዓቱ ሚና ዕውቅና መስጠት ናቸው። እነዚህ ለውጦች የብሔራዊ የዘር ሥርዓቱን ለሚመሩ ገዢ የፖሊሲ እና የዘር ቁጥጥር አውታሮች ዕድገት ላይ መሰረታዊ ለውጥ እንዲመጣ መንገድ ከፈቱ። ምንም እንኳን ከቅርብ ዓመታት ወዲህ ብዙ ለውጦች ቢመጡም፣ በኢትዮጵያ የዘር ስርዓት ውስጥ የተለያዩ ተሳታፊ አካላት በአብዛኛው ተሳታፊ ያልሆኑበትና የመንግስት አምራች ድርጅቶች የበላይነት የሚታይበት እንዲሁም የዘር አቅርቦት አማራጭም በውስንና ዋና ሰብሎች ላይ ብቻ ያተኮረ ነው። በሰብል ማሻሻያና የዘር አቅርቦት መካከል መሠረታዊ ግንኙነት እንዳለ በመግለፅ፣ ይህ ፅሁፍ በቀጣይም በአገሪቱ የግብርና ትራንስፎርሜሽን አጀንዳ ላይ የተፈጠሩ ችግሮችና ጥሩ አጋጣሚዎች ዙሪያ አይጠነተነ የግብርና ምርምር እና የአገሪቱ የዘር ሥርዓት አተገባበር በበቂ ሃብት ታግዞ በተግባር ላይ የሚውልበት ተጨባጭ ርምጃዎች ላይ ይተነትናል። በመቀጠልም በአገሪቱ ውስጥ አመቺ የዘር ፖሊሲ እና ቁጥጥር ሥርዓት መፈጠር እንደሚኖርበትና በተቀናጀ የዘር ሥርዓት ዕድገት መርህ መሠረት በዘር ስርዓቱ ውስጥ የተለያዩ ተሳታፊ አካላት ማለትም መደበኛ ስርዓት (መንግሥታዊና የግል)፣ መካከለኛ (መካከለኛ ኢ-መደበኛ) እና ኢ-መደበኛ (የአርሶ አደር ዘር፣ አርሶ አደርን መሰረት ያደረገ ዘር ብዜት) ሥርዓቶች መፈጠር እንደሚኖርባቸው ይገልፃል። ከዚህ ጋር ተያይዞም የአገሪቱ የዘር ሥርዓት ከክልላዊና ዓለም አቀፋዊ የዘር ኢንዱስትሪ ጋር በመቀናጀትና ከዚያ ከሚገኘው ዕድገት በመጠቀም ብቁና ተወዳዳሪ አገራዊ የግብርና ምርምር ለዕድገት አጀንዳ መፈጠር እንደሚገባው ያሳስባል።

Abstract

The paper highlights the evolution of the organized seed sector and the progressive changes that took place over the last 35 years in Ethiopia. From its ad hoc arrangements and modest beginning in the 1940s, the formal seed sector went through several structural and organizational changes particularly during the last two decades due to several internal and external factors. Among these are the shift in international economic development (e.g. structural adjustment programs), the need for and emphasis on diversification to allow entry of the private sector, the separation between production and regulatory agencies and the recognition of the role of informal sector. These changes led to the development of policy and regulatory framework governing the national seed sector. Although much progress has been made in recent years, the Ethiopian seed sector remains less diverse where the public sector dominates and the choice for seed supply is limited to few major crops. The paper further discusses the challenges and opportunities presented within the agricultural transformation agenda of the country and calls for concrete steps to be undertaken in the implementation of national seed sector strategy through provision of adequate resources. It argues for a more facilitative seed policy and regulatory framework recognizing the diversity of the seed sector within the concept of integrated seed sector development embracing various types of formal (public and private), intermediate (semi-informal) and informal (farmer-saved and farmer-based) seed systems. It also calls for the integration of the national seed sector to the regional and global seed industry to benefit from developments elsewhere and become more competitive to serve the national agricultural research for development agenda.

Historical Perspectives

Modern crop varieties are the backbone of a robust seed system showing a strong interface between agricultural research and seed delivery. The emergence of knowledge based agriculture including scientific plant breeding, mechanization, commercialization, diversification and specialization at various stages of agricultural development led to the emergence and progressive development of an organized seed sector in developed countries (Thomson, 1979; Groosman, 1989; Tripp, 2001). Seed remain the delivery mechanism of agricultural innovations.

In Ethiopia, the pattern of organized seed sector development follows that of many developing countries with some local variations due its political and socioeconomic context. At least three stages of seed sector development can be recognized: (a) Stage 1: emergence of organized seed sector characterized by ad hoc seed production and delivery (1940-1978); (b) Stage 2: establishment of organized seed sector and consolidation of public sector (1979-1990); and Stage Diversification and expansion of the organized seed sector and entry of the private sector (since 1991).

In stage one, from the outset seed activities were started essentially linking crop improvement and extension (Bishaw et al 2008).Early attempts made by Jimma Agricultural Technical School (1942) and Alemaya College of Agriculture (1954) and later on by the Institute of Agricultural Research (1966) and the Chillalo Agricultural Development Unit (1967) were some of the precursors of the organized seed sector in the country.

During stage two, the establishment and consolidation of Institute of Agricultural Research (1966) and attempts in modernization by emerging private estate farms in the 1960s and 1970s culminated with the establishment of the Ethiopian Seed Enterprise in 1979 (Bishaw et al. 2008; Niels and Bishaw, 2012). The expansion and establishment of large public state farms, the formation of farmer producer's cooperatives and the resettlement program sunder socialist government in the 1980s further strengthened the basis for strong centralized public seed sector.

In stage 3, following the socialist government, it was envisaged to move the agricultural sector from a command and control production and marketing system to market-driven agriculture. Since 1992, both the agricultural research and the seed sector went through several policy and regulatory reforms and institutional and structural changes to respond to the developmental challenges of economic growth and development. The reforms and liberalization of the seed sector led to the emergence of substantial number of domestic small to medium scale private seed companies and entry of limited number of foreign private seed companies.

To date we find a mix of federal and regional public seed enterprises, small to medium domestic private seed companies and large-scale foreign private seed companies and a wide range of semi-informal licensed or non-licensed small seed enterprises of different shapes and scales operated by cooperatives or farmer associations which are involved in seed supply.

Chronologies in Seed Industry Development in Ethiopia (Turner & Bishaw, 2016)

1976	National Seed Council established by the National Crop Improvement Conference
1978	Start of the FAO Seed Production and Quality Control Project
1979	Establishment of the Ethiopian Seed Enterprise under the WB project
1982	National Variety Release Committee established
1990	ESC forms joint venture with Pioneer for hybrid maize seed production
1992	National Seed Industry Policy and Strategy published
1993	National Seed Industry Agency established to handle regulatory matters
1993	Ethiopian Seed Corporation renamed as Ethiopian Seed Enterprise
1995	Policy of regionalization introduced by the new Constitution
1996	Joint venture terminated; Pioneer becomes independent PLC
2000	Seed Proclamation by MoA (206/2000)
2002	National Seed Industry Agency abolished, responsibilities transferred to newly formed National Agricultural Inputs Authority (NAIA)
2004	NAIA abolished, responsibilities transferred to the newly formed Ministry of Agriculture and Rural Development (MoARD)
2007	Ethiopian Seed Growers and Processors Association established
2008	First Regional Public Seed Enterprise established in Oromia Regional State; (and Amhara RS in 2009 and Southern Nations, Nationalities and Peoples in 2010; and Somali RS in 2014)
2009	Integrated Seed Sector Development Project established with NL funding 2010 Seed Co enters hybrid maize seed market
2010	First regional quality control bodies established
2011	Agricultural Transformation Agency established, with seeds as one key focus area
2013	New Seed Proclamation promulgated by Federal Government (2013)
2014	Strategy and road map for seed sector development published by ATA *(online in 2015)*

Current State of Agricultural Research and Seed Sector

According to Alemu (2010), Ethiopia has a strong commitment to a decentralized political-administrative system which translates to decentralized agricultural and rural development under the umbrella of national policy and regulatory framework. The country moved from a centralized to decentralized institutional arrangements in agricultural research, seed delivery and related services.

Developments in Policy, Regulatory and Institutional Frameworks

The Ethiopian agricultural sector is at cross roads supported by various high level government policy support and interventions to bring about transformational change. To date the development of the seed sector occupies center stage from federal and regional governments to regional and global development partners and donors (Alemu and Bishaw, 2015). The Agricultural Transformation Agency (ATA) was established to address some key systemic bottlenecks in the agricultural sector among which the seed sector is one of the priorities of the country. It is expected that this support will bring

greater opportunity for public and private sector investments to achieve the desired changes in the agricultural sector contributing to overall economic growth and development.

Institutional and organizational changes

Since 1990s, the Ethiopian agricultural research has been restructured into federal and regional levels. In addition to the federal agricultural research led by the EIAR, seven Regional Agricultural Research Institutes (RARIs) were established during late 1990s serving the regional states. Moreover, there are agricultural universities/faculties engaged in academic teaching and research of varying degrees in crop improvement.

Similarly, besides ESE at federal level, four Regional Public Seed Enterprises (RPSEs) were also established in Amhara, Oromia, Southern and Somali Regional States and became operational in late 2000s. Furthermore, several small to medium scale domestic private seed companies emerged over a decade or two operating at federal and regional levels. Also technically, financially and organizationally weak about 33 private entities are operating in seed business at regional levels. There are also few foreign companies like Pioneer Hibred PLC and Seed Co which are already involved in the seed sector while some new ones have shown genuine interest to enter the seed market. This pluralism is quite new to the country, but obviously, most of these private companies mainly produce maize seed.

The Plant Variety Release, Protection and Seed Quality Control Directorate (PVRPSQCD) was reorganized as a separate entity within the Ministry of Agriculture. It became responsible to provide policy direction and coordinate variety release and protection as well as seed quality control and certification at federal level. The regional seed quality control agencies have been formed and have established seed inspection and testing laboratories to implement seed quality control under the Bureaus of Agriculture of respective regions.

Growth and transformation plan

In GTP II agriculture remains the major source of economic growth. The accelerated and sustainable growth expected to ensure food and nutritional security, provide adequate raw product to the agro-industry, contributes to foreign exchange earnings and transforming rural livelihoods. Increasing crop production and productivity is one of the main strategic objectives where detailed goals in terms of production and productivity were set for the main agricultural and horticultural crops. The expected productivity changes will not be achieved without strong demand driven agricultural research employing a combination of both conventional and modern biotechnology tools. New crop varieties which are well adapted to diverse agro-ecologies and farming systems that are farmer, industry and consumer preferred are required for competitive domestic and international markets. Moreover, new integrated crop management technologies are required which combine conservation of natural resources such as water and soil health. Seed remain a conduit to transfer of new agricultural innovation. There is greater opportunity for convergence and synergy between agricultural research and seed supply for sustainable agricultural development.

Establishment of NARC and research strategy

The National Agricultural Research Council has been created as an apex body to provide policy guidance and setting the research agenda and coordination at the country level involving both the federal and regional agricultural research institutes. The main purpose of the NARC is to facilitate rapid and sustainable agricultural development by coordinating, strengthening and guiding NARS to develop technologies and knowledge that are required for the development of the agricultural sector. It also ensures that the agricultural research complies with the scientific rigor and aligned with agricultural development policy and strategy of the country. NARC is expected to be a clearing house for agricultural research in the country. This would enable to bring together somewhat scattered and defused agricultural research system under one umbrella.

Within the national agricultural research for development agenda, EIAR has recently developed its research strategy and prioritized its national agenda. The RARIs of regional states are also expected to follow suit in developing their research strategies and priorities.

Development of seed sector strategy

Agricultural Transformation Agency has developed a strategy document of the national seed system with the broader consultation and inclusive participation of the seed value chain actors. The strategy has classified the national seed sector into three sub-sectors-formal, intermediate and informal- and has identified several systemic bottlenecks, proposed set of interventions and developed a road map for respective areas across the seed value chain. It is envisaged that the strategy is to bring comprehensive transformation of the seed sector and provide blue prints to guide domestic and international development partners in targeting priority investments to address systemic bottlenecks.

The issues raised in the strategy are not new to long-time observers of the Ethiopian seed sector, however and the interventions are related to (i) strengthening the variety development, release and registration; (ii) improving the delivery of early generation seed by NARs, (iii) strengthening the capacity of public and private sector to expand the volume of certified seed supply, (iv) developing a more reliable demand assessment and supply management system, and (v) establishing a more efficient quality assurance and certification scheme (Alemu and Bishaw, 2016).

What are unique of the proposed strategy are a series of key activities outlined and the assignment of responsibilities and institutional ownership to undertake the implementation of the strategy. However, the deficiency of the strategy is its lack of implementation plan and the resources required for the proposed interventions, which left its design and implementation to the stakeholders where its success is dependent on adequate ownership, coordination, and accountability of partners at all levels. The strategy document is available online for public comment before its final approval and endorsement by the MoANR. It remains to be seen how far the stakeholders are engaged and implement the strategy for the target year set in 2018.

National seed policy and regulatory framework

The National Seed Policy and Strategy (1992) explicitly advocated the role of the private sector in the Ethiopian seed sector. Bishaw and Louwaars (2012) stated that 'The birth pangs of diverse and pluralistic seed sector are visible with the emergence of the embryonic private sector'. However, despite the optimism the role of the private seed companies remain weak in scope and scale of their operation. On the other hand, the seed sector continues to be dominated by the expansion of the public sector. In general there is lack of clear guidelines addressing the entry of foreign private sector into the domestic seed market.

The revised Seed Proclamation (782/2013) puts the Ethiopian seed system on legal footing. It is the basic seed law of the country addressing the key issues of variety release and registration, eligibility and certificate of competence for seed producers and seed quality control and assurance. Accordingly all varieties, domestic or introduced, should be registered and all seed, produced locally or imported (including exported seed), should meet the national field and seed standards.

The national seed policy also encourages various forms of alternative local seed production by farmer seed producer's cooperatives or associations to fill the gap and expand quality seed supply. Cognizant of this fact, a Quality Declared Seed (QDS) scheme was introduced and standards developed for 35 priority food, feed and horticultural crops. The move is expected to bring some form of normality to otherwise chaotic scene of project based operations which may undermine the formal sector. While this will provide greater opportunities for less resourced local seed businesses greater effort is expected in promoting the principles and spirits of QDS where it is liable to different interpretation and misrepresentation.

The Bisoafety Law is now revised and is expected to facilitate the introduction, testing and release of biotech crops, contrary to previously very restrictive law which criminalizes research on GMOs. The PBR slaw is under review to facilitate the protection of domestic and foreign plant varieties and expected to build confidence of the private sector investment in the seed sector. These laws are expected to provide greater opportunity for diversification of research and seed supply in the agricultural sector.

Performance of Agricultural Research and Seed Sub-sectors

EIAR, since its establishment in 1996, played a pioneering role in generating and transferring new agricultural technologies with significant contribution to the agricultural growth and development of the country over the last six decades. A substantial number of new improved varieties and integrated crop management technologies for major agricultural and horticultural crops were developed, released and disseminated in the country. Some of the achievements of these activities are discussed in the following sections.

Development of agricultural technologies (varieties and hybrids)

New varieties of plants are the backbone of a robust seed system and one of the fundamental technologies for sustainable agricultural development. In 2014, the Crop Variety Register contains an impressive list of 960 improved varieties of 114 crop species

including agricultural, horticultural, forage and fruit tree crops (Figure 1 and MoA, 2014). During the last four decades and half there is an increasing trend in varietal releases with the highest peak so far from 2000-2009. Since 1970s, the average annual varietal release per year is 7.8 for cereals, 3.4 for legumes and 2.6 for oilseeds. In case of individual crops the varietal release per year was 2.6 for wheat which is the highest followed by 1.6 each for barley and maize and 1.2 each for rice and haricot beans, the CGIAR mandate crops, where most of the releases are of direct or indirect origin from IARCs. This can be compared to the average annual varietal release of wheat of 14 in SSA during 1994-2014 (Lantican et al, 2015) where Ethiopia is one of the contributors in terms of varietal release.

Given variations in crop area, releases per million hectares of crop suggested as useful indicator for comparison. Accordingly, the number of varieties released per million ha of cultivated land over four and half decades is the highest for oilseeds at 105 varieties followed by legumes with 100 varieties, owing to the smaller total area under cultivation compared to cereals with 35 varieties. These numbers are slightly higher for horticultural and minor crops. Significant achievements have been registered in terms of increased agricultural productivity and production through adoption of these new crop varieties and associated agronomic technologies by farmers.

The impressive figures in varietal releases however mask serious deficiencies in many ways. First, in terms of varietal mix, cereals and legumes occupy about 36 and 20% of all varietal releases across all crops followed by that of vegetables(12%) compared to some important food security crops. Second, despite the agro-ecological variability and the diversity of farming systems in the country, there is lack of diverse set of well adapted and context specific varieties for different environments, where most released varieties are for favourable highland areas with adequate rainfall compared to moisture stress areas in the lowlands or irrigated areas. Third, grain yield and (a)biotic stress tolerance is an overriding criteria both for breeders and farmers whereas grain quality traits for industrial use (durum, malt barley) and seed size (legumes for export) appeared to be lacking for some crops. Fourth, most of varietal releases are OPPs except for maize (almost 50% for hybrids) and few for sorghum. Fifth, most varietal releases are from the public sector whereas releases from the private sector constitute less than ten per cent not withstanding hybrids of maize, rice, sunflower and cotton and vegetable crops. In total about 114varieties of wheat (2), rice (3), maize (18), sorghum (1), chickpea (1), mung bean (1), sunflower (12), linseed (1), cotton (7), foxtail (2) and vegetables (66) were released by the private sector until 2014. Six, there is a general lack of research on new technologies such as transgenic, leaving aside the controversy on biotech crops.

Alemu and Bishaw (2016) found that farmers' perceptions of attainment indices, varietal attributes demanded by farmers, is high for improved varieties compared to the local landraces. However, there is a high variability in the attainment indices among improved varieties for different attributes thus implying the need to target varieties for the different environments and circumstances.

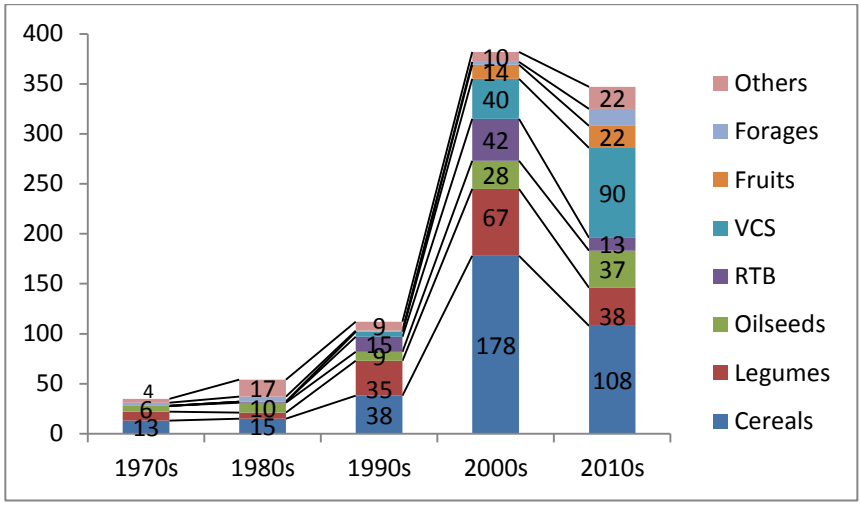


Figure 1. Varietal releases of agricultural crops in Ethiopia (1970-2015)

Performance of the seed sector

It is crucial that improved crop technologies reach the majority of farmers to bring about tangible results on the rural livelihoods. Hence generation of technology must be coupled with a robust and diverse seed system which provides farmers with adequate quantity and quality seed at the appropriate place, time and price.

From its modest beginning in the early 1980s the formal sector went through substantial changes in recent years. During the first decade of its operations from 1980 to 1989, the ESE was distributing on average 21,162 tons of seed annually of handful of cereal and few legume crops particularly haricot bean where the major customers were the public state farms followed by MoA and some NGOs for emergency seed relief. In the second decade (1990-1999), the average yearly seed supply dropped to 14,012 tons due to reduced demand from the public state farms where the new major customers were the regional Bureaus of Agriculture and the federal Ministry of Agriculture. In the third decade (2000-2009), formal seed supply on average reached 18,632 tons although in 2010, it was more than doubled reaching 54,000 tons. The major leap in formal seed supply can be witnessed during the fourth half decade (2010-2014) with an average of 67,630 tons reaching over 105,100 tons in 2014, if the statistics is right. This is close to one third of the target planned under GTPI which was aimed at reaching 360,400 tons by the end of 2015(excluding the recycled certified seed as this is not considered seed from formal sector).

Despite over four decades of organized seed delivery in the country, there is no significant shift in the portfolio of crops and varieties in the menu of certified seed provided where cereals predominate and among these wheat and maize occupy the major share of all crops. The proportion of wheat seed supply declined quickly from over 90% at the beginning while that of maize increased rapidly from less than 10% and both crops continue to dominate the formal seed supply. In 2014, wheat and maize occupy 64 and 19% of formal seed supply, respectively but both crops occupy about 13 and 17% of

cultivated area in the same order. Moreover, a handful and sometimes old varieties dominate the formal seed supply.

Another important performance indicator is the degree of private sector involvement is seed delivery. The role of private sector in certified seed delivery is limited both in scope and scale of seed supplied. Pioneer Hi-bred Ltd started seed operation in 1990 and was the only private seed provider in the country until the emergence of a number of small to medium domestic private seed companies in 2000s. From 1998-2008, based on available data, the private sector on average provided about 1,388 tons of primarily maize seed which is about 21% of total maize seed supply or 9% of total formal seed supply across all crops. Pioneer Hibred is a major supplier among the private sector. Its share of hybrid sales increased from a little more than 500 tons in 1996 to nearly 3,000 tons in 20011(Negari and Admasu, 2011). The figure reached 4,214 tons (2012), 7078 tons (2014) and expected to hit the 10,000 tons mark in 2016 (Melaku Admasu, personal communication). Alemu et al (2010) also found a similar situation where the contribution of private sector is focused on maize seed and very limited in other crops.

On the other hand, the vegetable seed sector is dominated by the private sector where the total seed import has increased from about 2 thousand tons in 2012 to 2.5 thousand tons in 2013, and about 3.6 thousand tons in 2014 with the corresponding CIF value equivalent to USD 3.7 million, 4.6 million and 6.3 million, respectively. There is insignificant or no certified seed supply of certain legumes (except haricot bean), oilseeds, root, and tuber crops, forage and pasture crops. Certainly, the current low level productivity of these crops compared to wheat and maize and the relatively higher seed to grain price ratio may have limited or discouraged the demand for certified seed and technology of these crops.

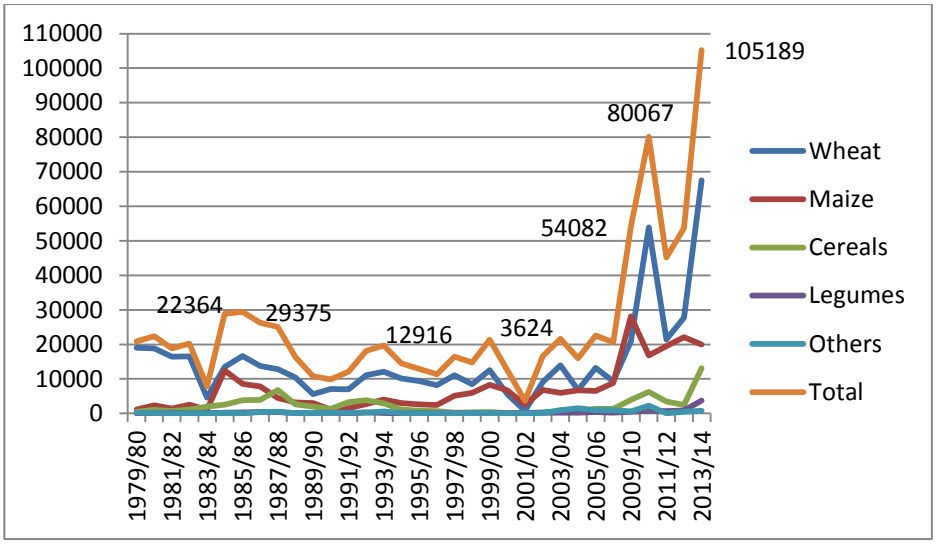


Figure 2. Certified seed supply in Ethiopia (1979-2014)

Varietal and seed replacement rates

Varietal release alone is not the measurement of success for agricultural research unless they are adopted by farmers. Varietal replacement and seed replacement rates help measure the performance of the formal seed sector and determines the extent of spatial and temporal changes in varietal use and the extent of access to quality seed by farmers. Variety replacement is the decision by farmers to change varieties already adopted whereas the decision to obtain fresh seed stocks of the same variety is termed as seed replacement. In both cases the decision to replace variety and/or seed may be due to perceived reduction in productivity of the variety and/or deterioration of seed quality due to continuous use of the same variety or seed.

Varietal replacement: The rate of varietal replacement is estimated by the age of varieties in farmers' fields, measured in years since releases and weighted by the area under each variety (Brennan and Byerlee, 1991).Low average age of varieties indicates higher rates of varietal turnover and earlier access to new crop varieties and associated with better productivity.

In Ethiopia, several studies were conducted on adoption of improved varieties of cereals (wheat, barley, sorghum, etc) and grain legumes (faba bean, chickpea, lentil, haricot bean, etc). Arguably all studies, some at local or regional levels, have found high adoption rates of improved varieties and associated technologies such as fertilizers and herbicides among small-scale farmers in Ethiopia. Yirga et al (2015) found that 65.2% of farmers (0.9% durum wheat) used improved wheat varieties on 59.8% of the area (0.31% durum wheat) across different ago-ecologies and regions of Ethiopia. They defined adoption as use of seed of improved variety for five consecutive years which is problematic as farmers may access seed from informal sources. However, one of the striking findings was the weighted average age of varieties which was 19.3 years showing the predominance of older varieties and low varietal replacement rate among farmers. Accordingly old varieties such as Kubsa (1995), Galema (1995), Dashen (1984), and Tusie (1997), respectively occupy 19.6%, 7%, 5.4% and 5.3% of the area (62.2% of improved wheat area). This situation may change slightly following the yellow rust epidemics of 2010 and stem rust recurrent in 2013 and 2014 crop seasons.

Yigezu *et al.* (2015) found that adoption of improved varieties varies from 39% for barley, 19% for chickpea, 15% for lentil,11% for faba bean to 2% for field pea in Ethiopia. They found significant variation in adoption between geographic regions and high and low potential areas. In case of chickpea, adoption based on national survey showed that 17.4% of farmers planted improved varieties on 19.4% of the cultivated chickpea area. Among adopted varieties, Arerti, Habru and Shahso occupy almost 89% of area covered by improved varieties (Yirga et al 2015). Muthoni and Andrade (2015) estimated that 44% of bean area is covered by improved varieties in 2010 and among them improved varieties Nasir, Teshale and Awash 1 covered about 12 and 10% of the area under bean production. Adoption of improved potatoes estimated at 22.6% of the area where varieties such as Jalene (7.51%), Gudene (4.9%), Menagesha (2.91%) and Bule (2.6%)collectively cover 17.92% of the area (Labrata, 2015).

Table 1. Adoption of improved crop varieties in Ethiopia

Crop	Varietal adoption		Seed supply		
	Farmers (%)	Area (%)	Farmers (%)	Reference	Remarks
Wheat	65.2	59.8	16	Yirga et al 2015; Alemu & Bishaw, 2015	WAA (19.3 years)
Barley (malt)	32.8 (96)	40.78	8.4 (39)	Alemu & Bishaw, 2016	Including partial adopters
Maize	57.1	39	58	Jeng et al 2013; Benson et al 2014;Gierend et al 2014	Including partial adopters WAA (15.74 years)
Sorghum	<5	8		Gierend et al 2014	
Faba bean	27.5	22.38	6	Alemu & Bishaw, 2016	Including partial adopters
Chickpea	17.4	19.4		Yirga et al 2015	
Lentil		10.4%		DIIVA, 2009	
Haricot bean		43		Muthoni and Andrade, 2015	2009 national data
Potatoes		22.6		Labrata, 2015	National

Seed replacement

For seeds , the rule of thumb requires replacing seed every year for hybrids, two to three years for cross pollinated varieties and four to five years for self-pollinated crops because the extent of yield loss due to use of recycled seed is comparatively higher for hybrids compared to seed of self-pollinated crops.

There is substantial increase in the amount of certified seed supply in recent years. In 2014/15 crop season, a total of 95 varieties of cereals (9 species), 41 varieties of grain legumes (7 species) and 14 varieties (4 species) of oilseed crops were produced during the season. The total formal seed supply was 88,603 tons for cereals, 3129 tons for grain legumes and 591 tons for oilseeds by the federal and regional public seed enterprises and the private sector (Pioneer Ltd with 5,706 tons of maize seed). This is sufficient to meet 84.4% of certified seed demand of cereals, 21.2% of grain legumes and 52.5% of oilseed based on actual demand figures from regional states with an overall performance of 76.3% across all crops. Formal seed supply met 96% of wheat, 71% of maize and 23.6% of barley (46% for malt) of actual seed demand.

Taking into account the potential seed demand of the country and the recommended seed replacement rates, the overall performance of the formal sector appears satisfactory for some crops than for others. For cereals, the certified seed supply reached 17% seed replacement rate although it varies from 0.2% for food barley and durum wheat to 28.8% for bread wheat and 50% for hybrid maize. For legumes and oilseeds, the seed replacement rate is 15% and 13%, respectively although it differs across crops and does not include some crops where there is no certified seed supply such as grass pea and noug.

Table 2.Performance of formal sector in 2014/15: actual demand and supply (q)

Crop	No of varieties	ESE supply	RPSE supply	Total seed supply	Total seed demand	Gap (q)	% Supply
Bread wheat	21	150707	452861	603569	631031	-27462	95.6
Durum wheat	4	0	894	894	150	744	596.0
Total	25	150707	453755	604463	631181	-26718	95.8
Food barley	7	1275	976	2251	48335	-46084	4.7
Malt barley	9	7209	11590	18799	40966	-22167	45.9
Total	16	8484	12566	21050	89301	-68251	23.6
Tef	11	20316	52368	72684	57681	15003	126.0
Rice	5	20	550	570	2032	-1462	28.0
Maize	26	94996	89982	184978	261792	-76814	70.7
Sorghum	10	478	1340	1818	7388	-5570	24.6
Millets	2	328	135	463	877	-414	52.8
Cereals	95	275329	610696	886025	1050252	-164227	84.4
H. bean	8	6687	9382	16069	83530	-67461	19.2
Faba bean	11	365	2633	2998	32122	-29124	9.3
Field pea	2	324	2758	3082	15378	-12296	20.0
Chickpea	9	1857	1781	3638	14983	-11345	24.3
Lentil	3	1684	2173	3857	1053	2804	366.3
Soya bean	7	1292	343	1635	780	855	209.6
Mungbean	1	9	0	9	0	9	
Legumes	41	12218	19070	31288	147846	-116558	21.2
Ground nut	5	31	0	31	137	-106	22.4
Rape seed	1	4007	0	4007	800	3207	500.9
Linseed	3	88	457	545	1332	-787	40.9
Sesame	5	518	812	1330	8992	-7662	14.8
Oil seeds	14	4644	1269	5913	11261	-5348	52.5
Total	150	292,191	631,035	923,227	1,209,359	(286,132)	76.3

The formal seed supply figures however mask some important deficiencies in terms of varietal choices and age of the varieties in the farmers' fields. Interestingly, a handful and sometimes old varieties dominate the formal seed supply. For example, from 21 bread wheat varieties under multiplication in 2014/15, three old varieties Digalu (2005), Kubsa (1995) and Pavon (1982) occupy 30% and two new varieties Danda'a and Kakaba occupy 63% which is collectively almost 93% of formal wheat seed supply. Among 26 maize hybrids/varieties, two old varieties BH660 (1993) and BH540 (1995) occupy 37% and two relatively new varietiesBH661 (2011) and Shone (2006) occupy 28%, which is collectively 65% of formal maize seed supply.From 16 barley varieties Holker (1979) occupy almost 78% of barley seed supply.

During, 2002-2010, the share of hybrids to total maize seed sales reached 86.9% and the three hybrids BH660, BH540 and BH140 covered 95.1% of hybrid seed sales whereas for the OPPs, the two old varieties A511 and Katumani covered 86% of OPPs sales of ESE (Sahlu and Beshir, 2011). For seed production nine local hybrids and seven OPVs were included in the certified seed production by ESE where 85% were hybrids and among these three hybrids, BH660, BH540 and BH140 accounted for more than 92% of the total hybrid seed produced by ESE (Sahlu and Beshir, 2011). All the OPPs were releases from 1970s.

Table 4. Performance of formal seed supply in 2014/15: Potential demand and actual supply

Crop	Cultivated area in ha	Potential seed required (t)	CS required (t)	CS supplied (t)	% CS	% potential (total) seed
Bread wheat	1397630	209645	52411	60357	115.2	28.8
Durum wheat	266215	39932	9983	89.4	0.9	0.2
Total	1663846	249577	62394	60446	96.9	24.2
Food barley	843939	105492	26373	225	0.9	0.2
Malt barley	150000	18750	4688	1880	40.1	10.0
Total	993939	124242	31061	2105	6.8	1.7
Tef	3016063	90482	22620	5768	25.5	6.4
Rice	46832	4683	1171	203	17.3	4.3
Maize	2114876	52872	52872	26179	49.5	49.5
Sorghum	1834651	27520	6880	739	10.7	2.7
Millets	453909	11348	2837	88	3.1	0.8
Cereals	10124115	560724	179835	95528	53.1	17.0
Haricot bean	323327	38799	9700	1607	16.6	4.1
Faba bean	443108	110777	55388	300	0.5	0.3
Field pea	230667	28833	7208	308	4.3	1.1
Chickpea	239755	23976	5994	364	6.1	1.5
Lentil	98869	7415	1854	386	20.8	5.2
Soya bean	35260	2116	529	164	30.9	7.7
Mungbean	14562	728	182	1	0.5	0.1
Legumes	1385549	212644	80855	3129	3.9	1.5
Ground nut	64649	8081	2020	3	0.2	0.0
Rape seed	30083	361	90	401	444.0	111.0
Linseed	82326	2470	617	55	8.8	2.2
Sesame	420495	2102	526	133	25.3	6.3
Oilseeds	597553	13014	3254	591	18.2	4.5
Total	12107217	786382	263944	99248	37.6	12.6

Trends in crop area, production and productivity

In Ethiopia, the trends in cultivated area, grain production and productivity are as shown in Figure 4a-c. According to CSA data in 2014, the cultivated area of cereals is 10,144,252 ha (80.78%) followed by legumes at 1,558.442 ha (12.41%) and oilseeds at 885,750 ha (6.81%). There is a progressive increase in harvested area, crop production and productivity of major agricultural crops over the last two decades (FAO, 2015; CSA, 2014).

For major agricultural crops- cereals, legumes and oilseeds- area increased from 7.6 million ha in 1994 to 12.7 million ha, an increase of 68% or combined annual growth rate of 3%. Cereal area has increased from 5.7 million ha in 1994 to 9.8 million ha in 2014, an increment of 71%, an annual growth rate of 4%. Similarly, for legumes, the increment was from 1.5 million ha to 2.0 million ha, about 35% in area (2% growth rate per year) whereas for oilseeds, substantial increment was observed from 0.3 million ha to 0.8 million ha which is more than doubled (an increase of 153% or annual growth rate of 8%).

Agricultural production followed the same trend where total grain production has increased during the same period from 7.5 million tons in 1994 to 25.4 million tons in 2014, an increase of 242% or combined annual growth rate of 12%. Cereal production has increased from 6.2 million tons in 1994 to 21.6 million tons in 2014, an increment of over

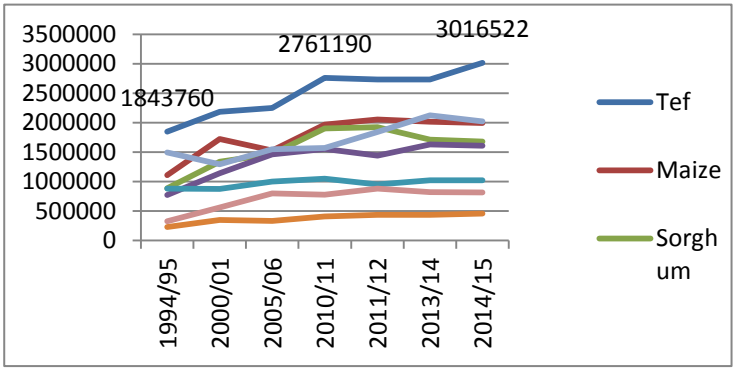
threefold (an increase of 251% or annual growth rate of 13%). For legumes, the increment was from 1.2 million tons to 3.2 million tons, more than doubled ((an increase of 167% or annual growth rate of 8%) whereas for oilseeds, the increment was from 109 thousand to 711 thousand tons which is more than fivefold (an increase of 552% or annual growth rate of 28%).

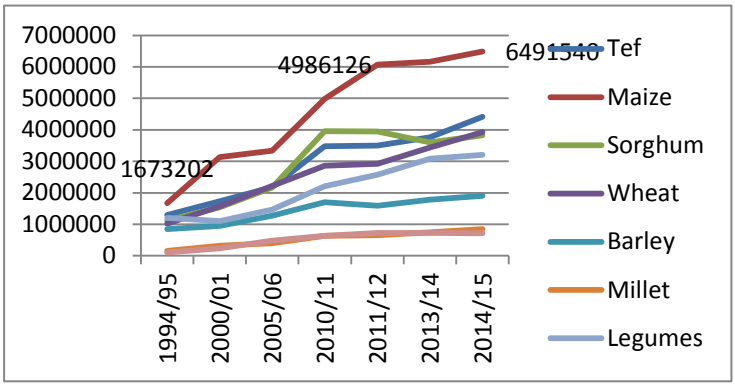
While substantial increase in area contributed to significant increases in production, the increase in productivity remains modest due to low average national yield of all crops. However, substantial increases in yield have been reported in localized areas which are an outcome of adoption of improved varieties and associated integrated crop management technologies. Among cereals, maize and wheat, has shown higher productivity gain during the last two decades. For example plot level yield changes have been reported in the range of 48-63% due to adoption of new varieties in Ethiopia (Zeng *et al*. 2015). Grain legumes have shown the highest productivity increase across the major crops such as faba bean, field, chickpea, lentil and soya bean. Similar results have been observed for oilseeds.

Yield gaps in major crops

Whilst there is good evidence that genetic improvement contributes to yield improvement there is good body of literature where contribution of advances in agronomy to increases in yield is well documented. Crop productivity and use of production enhancing technologies such as fertilizers, herbicides, etc are low in Ethiopia by any African or global standards. Ethiopian varietal release lack specific recommendation and generic in terms of agro-ecological adaptation (altitude, rainfall pattern and soil fertility gradient), fertilizer application (urea and DAP), though recent attempts try to address fertilizer application with soil fertility tests.

There is a tremendous yield gaps between yields on research centres, demonstration plots and farmers' fields. For example, this variation in yield gaps can be demonstrated using barley and faba bean. During 2004-2014, the average national yield for barley is 14.9 ton/ha whereas yields under farmers practice on average is 20.18 ton/ha. However, barley yields under improved management practices on the farm can reach up to 2.7 tons/ha whereas yields on research station on average can be 3.8 tons/ha (Alemu and Bishaw, forthcoming). A similar situation can be observed for faba bean where national average yield per ha is 1.5 ton during the same period and this can reach 1.9 ton under farmer management, 3.2 tons in demonstration plots and 3.8 tons per ha on research stations. Agro-ecology based recommendations are required to reduce yield gaps not only in provision of seed of improved varieties but of complementary inputs and information to farmers.





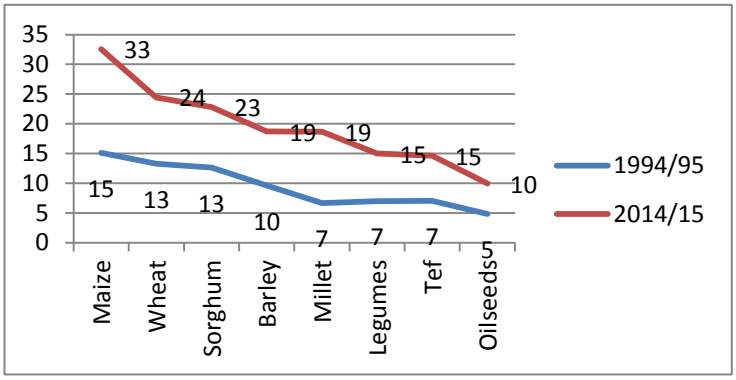


Figure 3. Trends in area, production and productivity of major crops in Ethiopia: 1994-2014 (a: area, b: grain production and c: productivity)

Table 5. Barley and faba bean yield gaps in Ethiopia

Category	Technologies	Average yield in t ha^{-1}			Source
		Food barley	Malt barley	Faba bean	
Research field	• Improved variety • Recommended practices • Researcher managed	3.8	3.3	3.8	MoA, 2011, 2012 and 2014
Farmers' fields	• Improved variety • Recommended practices • Farmer managed	2.7	2.8	3.6	
Farmers' fields	• Local variety • Recommended practices • Farmer managed	2.02		1.9	Kibebew Assefa et al. 2011; Berhanu et al. 2011
National yield level*	• National production of ten years	1.49	1.49	1.5	CSA, 2004-2014

Source: Alemu and Bishaw (forthcoming)

The Way Forward

The Ethiopian seed sector is highly characterized and subject to many studies and reviews during the last two decades. The challenges and opportunities for the seed sector have also been described and presented in the recently developed seed strategy document of ATA. Bishaw and Louwaars (2012) also presented key policy considerations in order to facilitate the progress of the seed sector development in Ethiopia. They advocated for enabling national policy and regulatory frameworks and institutional innovations to build a robust national seed system. They also raised critical issues to be addressed in promoting the private sector, diversifying the crops and seeds, seed marketing, seed quality control and certification and capacity development. Some of these and other options which are relevant today are presented and discussed in more depth below.

Demand Driven Agricultural Research

EIAR and recently the RARIs have played a major role in developing improved crop varieties and ICM technologies with significant contribution to the growth in production and productivity of agricultural sector. However, there is no room for complacency as we are confronted with more difficult challenges than before such as climate change and its aftermath like emerging threats of new pests, increasing temperature and frequent droughts with serious consequences on the agricultural sector. The continued population growth and natural resources degradation of unprecedented magnitude calls for more action. Climate smart and market preferred varieties/hybrids with high productivity and specialty traits in food quality and natural resources saving technologies are required more than ever for a wide range of environmental conditions and farming systems in the country.

Germplasm conservation and utilization

The Abyssinian region is an important primary and secondary center of domestication for some 38 crop species (Worede, 1992). The Ethiopian Biodiversity Institute (EBI) not only a repository of the largest collection of plant genetic resources in the country, but a focal

agency responsible facilitating its sustainable conservation, access and exchange for research purposes. EBI has a rich collection of thousands of accessions of several agricultural and horticultural crops (52 species and 70316 accessions at the end of GTP I), which can be of great value for crop improvement programs. The national germplasm collection needs to be evaluated systematically and made available to both public and private sector institutions with research capacity to ultimately bred superior varieties and hybrids for the benefit of smallholder farmers. The Ethiopian NARS and the EBI are expected to forge strong partnership and strengthen their capacity for exploiting this diversity in a much systematic manner to address the key agricultural development challenges of the country including emerging issues of climate change than veiled tussle between conservation and modernization.

However, Ethiopia as a signatory of CBD and IT-PGRFA is bound to the spirit of the international conventions in ensuring the sustainable conservation, utilization and exchange of these genetic resources. There is a need to develop national guidelines to facilitate the inflow and outflow of germplasm which is the basis of agricultural research and sustainable development in the country.

Application of biotechnology in agricultural research

There is a general decline or stagnation in rates of growth in crop productivity in recent years worldwide. Conventional crop improvement technology alone may not be sufficient to feed the ever increasing population without the use of modern tools such as biotechnology. An option is a balanced, safe and sustainable approach, using the best of conventional crop technology (well adapted germplasm) and the best of biotechnology (appropriate GM and/non-GM traits) to achieve sustainable intensification of crop productivity. The application of biotechnology to develop new improved varieties with special traits, particularly to provide effective and durable solutions against abiotic and biotic stresses deserves special attention. There is a need for effective implementation of EIAR biotechnology research strategy to make use of the benefits of new and modern breeding tools through sound investments in the R&D both by the public and private sector.

It will be appropriate to create awareness among farmers, civil society organization and the policy makers about the potential of plant biotechnology as well as its safe application. We must ensure that the regulatory process is also efficient and safe from point of view of environment and health.

Research in seed science and technology

The public sector institutions in the National Agricultural Research System, comprising federal and regional institutes, contributed significantly towards varietal development of agricultural and horticultural crops. There is limited research on technical aspects of seed science and technology for indigenous crops where there are knowledge gaps in seed production, seed storage, seed physiology, seed health and seed treatment as well as application of biochemical or molecular tools for quality assurance and enhancement. One of the important areas for research is a rigorous scientific approach and analysis of policy and regulatory framework and institutional innovations and its impact on seed sector development where NARS and universities can take the lead.

Expansion of small scale mechanization and conservation agriculture

EIAR's agricultural mechanization research is as old as crop improvement programs (established in 1976) and become a directorate in 2004, but focused on improving traditional farm implements and tools. Similarly, the three Regional Agricultural Research Institutes (Oromia, Amhara and Tigray) also established agricultural mechanization research programs under different names with additional responsibilities. Though limited in number, there are also private agricultural mechanization centers that contributed to the development of agricultural mechanization in Ethiopia among which Selam Vocational Training Center.

Provision of small-scale machines: Several small-scale technologies were developed and released for ploughing, planting, threshing, and shelling,. which are operated manually or semi manually. The use of agricultural implements is increasing especially in Arsi and Bale zones where the landholding is bigger than other areas. Currently, based on national data set of mechanization, around 12,000 medium to big (70-130 hp) tractors, 698 small tractors, 700 handheld motorized tillers and 5479 improved oxen driven ploughs are being used in the country. However, production marketing of these technologies and large-scale adoption is lagging behind due to several constraints. Currently, however, there are several alternative low cost and appropriate models for small-scale farmers which are labor intensive hand or motor operated small-scale planters, cultivators, harvesters, and threshers available from foreign sources for local adaptation, manufacturing and use.

Large-scale mechanization: Large-scale mechanization has been introduced with emergence of private estate farms and plantations and later expanded with public state farms under socialist government in different parts of the country. However, large-scale mechanization failed to take root in the peasant sector probably due to high cost, land fragmentation and the challenging topography. Lack of policy and strategy led to the slow expansion and development of agricultural mechanization in the country. In 2004, the Council of Ministers issued regulation No. 97/2004, for the establishment of Agricultural Mechanization Service Enterprise (AMSE). The ATA draft mechanization strategy is a comprehensive document that puts different agricultural mechanization options for different farm sizes. The draft document also frames agricultural mechanization strategy looking from value chain's perspective from designing machineries, importing machineries/spare parts, assembling, and distribution, ownership, and after-sale services.

GTPII has a strategy to ensure sufficient supply and access to agricultural mechanization by encouraging domestic manufacturing through joint ventures, creating enabling environment for establishment of spare parts and maintenance service centers by private investors and formulating agricultural mechanization services delivery system. The government aimed at providing various incentives such as access to foreign currency and credits for machinery manufacturers, importers or service providers. Much is expected from NARS to develop science based standards for a national testing and certification system envisaged to be established for both imported and locally manufactured agricultural mechanization technologies.

Conservation agriculture: Conservation agriculture has been widely adopted and its benefits have been manifold. Introduction of improved varieties and improved crop management as part of integrated soil, water and crop management packages should significantly increase resource use efficiency (water, nutrients), reduce costs of production and enable higher crop productivity. Conservation tillage experiments were conducted by SG-2000 in collaboration with EIAR on maize and tef. The results have shown higher yields and reduction in cost of production. The practice was beneficial to poor farmers particularly those who do not own a pair of oxen to till their land. However, the extension services did not promote the technology and farmers are not aware of the practice. The introduction of conservation agriculture has relevance to Ethiopia, but it should be better coupled with mechanization as provision of appropriate machinery is prerequisites for its adoption at national level.

Expanding irrigated agriculture

In Ethiopia, almost all crop production is traditionally concentrated in the highlands with few exceptions where the consequences of environmental degradation are huge leading to low productivity. Moreover, crop production is dependent on rainfed and subject to weather condition and exposed to the vagaries of plant diseases and pests like rust diseases of wheat in the highlands. Currently there is an estimated 3,798,782 ha of land suitable for irrigation in the seven river basins across the country including Afar, Benishangul, Gambella, Oromia and Tigray regions of Ethiopia. This is an alternative for rain-fed dependent agriculture and provides opportunities for expansion of irrigated agriculture in the lowlands which was predominantly inhabited by agro-pastoralists. Development of adapted germplasm for the lowlands with heat tolerance should be coupled with agronomic management technologies relevant to irrigated agriculture. Modern irrigation management technologies (irrigation scheduling, and drainage), water saving technologies (raised bed) need to be introduced, validated, promoted and disseminated.

Previous studies have demonstrated the potential of wheat production under irrigated conditions in the lowlands of Awash Valley of Afar region. Since 2006, there is growing interest for irrigated wheat production and in recent years, the WARC is introducing and testing germplasm from ICARDA and CIMMYT to identify high yielding and heat tolerant wheat, barley, chickpea and forage legume varieties for irrigated lowland areas. In recent years some new wheat varieties which are tolerant to heat, drought and salinity were released and recommended for irrigated lowland areas in Afar Regional State. Strong effort should be made to accelerate seed multiplication and dissemination of these new varieties in target districts and other potential regions.

Research partnership with private sector

Agricultural research and crop improvement is confined to the public sector domain and academic institutions. The Ethiopian seed sector is attracting multinational seed companies due to the potential of the agricultural sector, favorable investment environment, provision of land and cheap labor force. Few private seed companies including multinationals introduce the germplasm for local testing, registration and commercialization where there is limited technology transfer. Experiences elsewhere demonstrated that partnership with MNCs contributed significantly for the development of the seed sector. The partnership will provide access to germplasm, technology transfer

and varietal choice for farmers. Ethiopian NARS and public or private seed companies should forge such partnership and benefit from transfer of new technology and access to better germplasm to generate better crop technologies like GMOs.

Research on value addition

In Ethiopia, the transition from subsistence to commercial agriculture is a must if we need to transform the rural livelihoods. Experiences elsewhere show that agricultural transformation and rural industrialization can be achieved through agricultural clusters linking production with the agro industry. Ethiopia has embarked on the Agricultural Commercialization Clusters (ACC) project within the national agricultural transformation agenda aimed at providing a strategic platform to drive greater integration across priority value chains. Currently, progress been has made on commodity and geography prioritization, Identification of implementing organizations, basic and agro-processing Infrastructure improvements, mobilization of community leaders, creation of new institutions including technical Committees and research groups. Such farmer-industry linkage through ACC may pave the way for contract farming and will be an opportunity for future expansion and uptake of inputs such seeds, fertilizers and agro-chemicals by the farming community that can improve production and productivity of crops. NARS can play an important role in value addition technologies for the diversification of agricultural products and to increase farmers income and better livelihoods.

Developing the seed sub-sector

Two systemic bottlenecks in the seed sub-sector have been identified under GTPII where concrete steps need to be taken to: (a) Strengthen the enabling environment to attract investment and develop a vibrant and competitive seed sector; and (b) Strengthen federal/regional seed regulatory capacity, finalize structural reforms and legal frameworks to meet international standards. This objectives still shows the magnitude of the deficiency of the policy and regulatory framework of the national seed sector where detailed action plans are required for its improvement.

National seed policy and regulatory framework

Seed policy: The National Seed Policy and Strategy (1992) explicitly advocated the role of both the public and the private seed sector in Ethiopia. However, the country stands out for its ambivalent attitude towards economic liberalization and the private seed sector (Alemu, 2011). The national seed policy so far fails to bring about the desired level of pluralism and diversity attracting a critical mass of private sector investment in crop improvement and seed delivery. It would be interesting to undertake a case study to assess the impact of national seed policy on the development of the private sector in the country and what policy incentives should be put in place to ensure its progressive development.

Seed regulations: The revised seed proclamation provides strategic direction of the seed regulatory framework in the country. Moreover, the Bio-safety law is now approved whereas that of PBRs is also under review. There are many gaps in terms of institutional capacity to undertake the huge task of variety registration, plant variety protection and

seed certification to the level of regional or international norms where investment is required in infrastructure and human resources.

National coordination: The national seed sector is much complex and not only about policies and regulations on varieties and seeds and confined to the agricultural sector. It is also about private investments (domestic or foreign), access to finance (capital or operational) and seed trade (domestic, international) where jurisdictions are not only with MoANR but with different ministries. Implementation of the national seed policy and its various laws and regulations as well as institutional arrangements in agricultural research and seed delivery at federal and regional levels require strong and effective coordination, monitoring and evaluation.

Subsequent to national seed policy, the National Seed Industry Council was established in 1993 to provide oversight and guidance to the national seed system. It was disbanded with the dissolution of NSIA (later NAIA). We once again advocate reconstituting the National Seed Council which could provide policy advocacy and formulation as well as the coordination, monitoring and evaluation of the seed sector. The Council could be constituted similar to that of NARC from relevant ministries and stakeholders from federal and regional states and the public and private sectors.

Currently information on seed sector is scattered and reliable and consolidated data remain with institutions and not publicly available. Apart from policy advocacy and coordination, the NSC could also serve as a national reference point on all issues related to the seed sector information system.

Functional plant variety release and protection systems

Bishaw and Louwaars (2012) advocated for the establishment of an independent variety release and quality assurance systems. To date the Plant Variety Release, Protection and Quality Control is established as an independent directorate within MoANR to coordinate centralized variety registration and plant variety protection at federal level while seed certification is decentralized to regional offices under Bureaus of Agriculture of regional states. The policy and institutional framework exists both for variety release, plant variety protection and seed quality assurance, but they still remain weak due to lack of capacity and competence as activities are scattered among different actors (Bishaw and Louwaars, 2012).

Mainstreaming variety release: Under the Ethiopian seed law, both DUS and VCU testing are required for release. PVP also impacts on variety release because granting a Plant Breeders Right requires an accurate morphological description of the variety, based on a DUS examination. It is important to move away from present ad hoc arrangements and establish a clearly defined operational mechanism to mainstream and implement these activities at national level taking into account different possible arrangements. It is either for PVRPQCD, to capacitate itself to conduct DUS and VCU tests on its own right or play a coordinating role through third party contract agreement with universities to undertake DUS testing and with NARS for VCU testing to ensure the independence of the system. The former may require substantial investments for physical, financial and human resources while the latter may make use of existing facilities and networks with some financial support. Given the proliferation of new varieties and the private sector interest

for protection it is now time to introduce the DUS testing as part of the release program in the country.

Another important element in variety registration and release is the issue of vegetable crops where DUS testing is neither desired nor feasible. Experiences from elsewhere shows that imported vegetable varieties are tested for adaptation probably for a year or two to enter commercialization in the domestic market. This may also extended to registration of mother plants for fruit tree crops.

In whatever form it is important to establish an effective, efficient and transparent variety release system that would promote not stifle the growth of the seed industry.

Enforcement of PBRs**:** Breeding new plant varieties requires substantial long-term investment, be it by the public or the private sector. Any significant private investment in plant breeding particularly of non-hybrid crops depends on some form of legal protection to be innovative. The Ethiopian Plant Breeder's Right Proclamation (No 481/2006) accepted unequivocally the notion of intellectual property protection of plant varieties. In Ethiopian context, the purpose of PVP is manifold: (i) provide domestic plant breeders the legal rights to protect their varieties and ensure future investments in crop improvement; (ii) encourage foreign breeders and companies to introduce or develop new varieties for domestic seed market and commercialization; (iii) align and promote the development of the seed sector to international norms and standards; and (iv) fulfil the legal requirements for joining WTO and/or UPOV as deemed necessary.

The PVP law lay dormant for over a decade without implementation in either granting the protection or creating a mechanism for royalty collection, probably due to the indifference of the public nature of the national breeding program. The argument against extending PVP to public-bred varieties is neither valid nor accurate. Empirical evidence has shown that both public and private sector breeding benefit from PVP where it contributes to genetic improvement for example in wheat (Kolady and Lesser, 2008). Moreover, rapid yield improvements have been registered where private sector wheat breeding is a competitive business like the European Union (Curtis and Nilsson, 2012).

The PVP law does not guarantee return on investments unless backed by an effective royalty collection system. PVP can be enforced using a licensing mechanism and/or by designing an effective mechanism for royalty collection. It is time to take some initiatives and provide implementation guidelines to enforce PVP to build the trust and encourage investment by the private sector.

Managing variety list: It is stated elsewhere in this chapter that there is a very long list of improved varieties in the national crop variety register. Despite a long list of released crop varieties, just a few of them have entered large-scale commercial seed production and were made available to the farmers. The other tragedy, for some crops, most of the seed produced and distributed are old varieties with over 20 years. A review of existing list of released varieties does reveal that many old varieties are still in production with serious consequences. It is important to establish a review mechanism where 'obsolete' varieties with no demand are removed from the list and are no more recommended for

seed production. This could coincide with annual review meeting for registration and release of varieties and managed by NVRC.

Institutionalization of early generation seed production

The present ad hoc arrangement and campaign type source seed production has lots to be desired. Four principal issues are important for streamlining early generation seed multiplication from the federal and regional national agricultural research systems: adequate variety maintenance, breeder seed demand, decentralized multiplication and quality assurance.

First, early generation seed production can absorb a considerable amount of time and land and require significant physical, financial and human resources. The establishment of a separate 'Seed Unit' with a defined budget and resources provides a way to manage early generation seed production without competing with the main breeding program. Keeping the revenues from early generation seed sales as part of revolving fund can provide flexibility and eases the financial burden instead of sending it directly to the government treasury.

Second, NARS or breeding institutions are designated as responsible entities for maintenance of varieties they have released. Maintaining varietal identity and purity is a key in formal seed sector where appropriate procedures need to be followed to ensure quality and should be under the supervision of the breeders. However, neither the breeders nor the technology multiplication staff follows the right procedures; and as result there are complaints on the quality of early generation seed distributed by NARS.

Third, availability of and access to breeder seed is critical in the seed supply chain where adequate planning is necessary involving all seed sector stakeholders. India has one of the extensively organized breeder seed indent and supply system where each state in consultation with ICAR Institutes (national varieties), SAUs (state varieties) and seed producing agencies formulate seed plan (for Breeder, Foundation and Certified Seed) for the cropping seasons on the basis of an assessment of existing and new varieties in terms of actual or potential yield in each district/agro-climatic zone catering both for public and the private sector. In order to devise an efficient system, it would be beneficial to review these procedures and experiences and adapt to Ethiopian conditions.

Fourth, variety maintenance is handled by the NARS which releases the variety. In most cases lack of sufficient land and facilities does not permit the center to produce sufficient quantity of seed based on demand from other centers and seed producers. Decentralizing early generation seed production to regional centers where the variety is in demand may reduce the pressure from NARS that has released the variety and increase the availability of breeder seed.

Fifth, apart from breeder seed, all early generation seed (pre-basic and basic) is subject to certification where field inspection and seed testing are compulsory. The quality assurance either has to be conducted by the certification agency or enforced through accreditation based on internal quality control where expertise and facilities exist within NARS.

Whilst the breeders has vested interested in commercializing the varieties released by making available breeder seed in a matured and competitive seed market, the lack of interest from public breeding programs remains a dilemma. There is an intense ongoing debate of early generation seed production where an independent study was commissioned by ATA and financed by AGRA. Whatever the outcome of the study, an action–oriented program should be developed and implemented. Any full cost recovery from the program may not be feasible where some government support is desirable.

Diversification of the seed sector

The Ethiopian seed sector changed little over the last four and half decades in terms of diversity of seed suppliers and certified seed of crops and varieties available to farmers. Public seed delivery and certified seed of wheat and maize continue to dominate the formal sector.

Participation of private seed sector

Deregulation, liberalization and restructuring of a publicly dominated seed industries were meant to create a competitive and pluralistic seed sector. However, the diverging policy implementation between countries has resulted in varying degrees of market concentration and the roles of public and private sector. From the outset, the Ethiopian national seed policy encourages that the private sector to play greater role in variety development and seed delivery. Despite policy pronouncements and incentives the private sector remains weak in a primarily public sector dominated seed industry. The Ethiopian seed sector is less diverse in many ways compared to countries even within East Africa.

Given government support for seed sector development and its critical role in agricultural development, we once again reiterate the need to create a funding mechanism to provide investment opportunities and incentives targeting the seed sector. Clear policy guidance is required on facilitating access to capital for investments including entry through joint ventures and direct foreign investments.

Moreover, efforts should be made to strengthen the yet infant Ethiopian Seed Growers and Processors Association to become better organized and become champions of the seed industry. It is expected to represent and protect the interest of its members particularly the emerging private sector both at national and international levels and become a strong partner in dialogue with a government at federal and regional state levels. The association should also be encouraged to develop its own code of conduct and linked to regional and international seed trade associations to promote the Ethiopian seed industry.

Promoting new technologies

Ethiopian farmers have demonstrated their strong demand for seed and their strong willingness to pay for hybrid technology. However, apart from the maize sector there is limited hybrid technology where such opportunities exist in crops like sorghum, millets, sunflower, cotton, etc. and recently for rice and pigeon pea. The introduction of hybrids through public breeding programs and/or joint ventures and production of seed needs to be promoted aggressively to improve productivity of these important crops.

Despite a controversy surrounding biotech crops, the last 19 years has shown a tremendous increase in terms of area covered and number of farmers adopted GMOs across developed and developing countries. From a modest beginning in 1996, about 18 million farmers planted more than 181 million ha in 28 countries during 2014. Both large and small scale farmers have benefited from adoption of biotech crops like cotton, maize, soya bean and canola, the major biotech crops. The approval of biosafety law is one step in the right direction and this should be pursued further to include as many crops as possible where the technology is available. Let the science lead the way not fear in shaping these decisions.

Root and tuber crops

In 2014, root and tuber crops covered about 216,971 ha and cultivated by 5.9 million small-scale farmers. Among this potato and sweet potato occupy, 67,362 ha and 59,398 ha, respectively and grown by 1.3 million and 1.7 million small scale farmers in the same order. Potato, become a food security crop because of its ability of high yield per unit of input compared to other crops and has a potential to grow on 10 million ha (Hirpa et al 2010). Moreover, it became an important rotation crop for weed control in predominantly cereal based mono-cropping in the highlands. Apparently, the formal sector appears to play insignificant role in potato seed supply where locally organized farmer groups and cooperatives play an important role. Options for true potato seed production should be sought to expand quality seed provision in the country.

Vegetables and fruit trees

Despite its great potential the horticultural sector has low priority in the country. Apart from limited research and private sector import and distribution of seed for some vegetable crops, neither research nor seed supply of many indigenous vegetables and fruit trees receive adequate attention. Ethiopia has great potential for expansion of fruit tree crops, local or introduced, for rehabilitation of degraded highlands. A systematic evaluation, release, multiplication and dissemination of fruit tree seedlings through the establishment of nurseries remain critical. Under GTPII it is envisaged to address the subsector through support to both the public and private sector.

Understanding the seed market

In Ethiopia, seed marketing is highly centralized and regulated by the government through Inputs Marketing Directorate (IMD) of the MoANR at the federal level and the Input Marketing Processes of regional BoAs (Alemu and Bishaw, 2016). The key market actors are the public seed enterprises as suppliers and the cooperative unions and their respective primary cooperatives as distributors.

Demand assessment**:** At present the potential seed demand based on cultivable land and the central seed production planning practiced by the state may not reflect a truly effective seed market in the country (Bishaw and Louwaars, 2012). The national seed supply should be driven by economics with some policy oversight and direction. There is a general lack of reliable seed market data across the country – be it in terms of potential market demand (crop area and its agro-ecological characteristics like drought incidence), effective market demand (varietal use and seed renewal) and supply (seed volumes produced/traded). The study on wheat seed commercial orientation of farmers showed a mismatch between seed production and demand and also indicated that on average the

formal seed sector can target the wheat producers who are in the buying position and part of those who are in net selling and part of those who are in equally buying and selling position, targeting collectively 64% of wheat farmers in any given year (Alemu and Bishaw, 2015).

The seed demand collection and compilation process passes through different intermediary actors from farmers to district, zonal, regional and federal levels. First, there is a possibility to either over estimate or underestimate the demand questioning its reliability and transparency. Second there is no accountability attached to the volume of seed requested as either farmers or the institutions collating the demand information take any responsibility or enter any contractual agreement or make down payment for the seed demanded. In Syria, for example, submission of seed demand for winter (May of preceding year) and summer (August of preceding year) planting is fixed and farmers are required to make a firm commitment making some amount of down payment for certified seed.

Seed marketing: Certified seed is supplied at the federal level by ESE and at the regional level by the respective regional seed enterprises. Regional BoAs normally inform the federal IMD, the variety and quantity of certified seed demanded taking into account the quantity supplied by their respective regional seed enterprises. The IMD, based on the recommendations of the National Seed Production and Distribution Committee, makes an equitable appropriation to the respective regions. Regional BoAs then make allocation to the different cooperative unions targeting different zones where the respective union caters. Each union and primary cooperative is assigned to a respective zone and *woreda* with a mandate area of service provision. Therefore, the unions work closely with zonal BoA and the primary cooperatives with *woreda* BoA and *kebele* administration. For instance, whereas formal seed tends to be certified – the actual aggregate national volumes of certified seed per year are not systematically reported in the public domain or easily available elsewhere.

Direct seed marketing: The regional BoAs in the Amhara region in 2011 and in the Oromia and SNNP regions in 2012 has piloted direct seed marketing in five districts with technical and some financial support of the Integrated Seed Sector Development (ISSD) program in Ethiopia. In 2013, the program was expanded by the Bureaus of Agriculture into 33 districts of Amhara, Oromia, and SSNPR Regional states. The major objective was to create accountability of the seed quality to the suppliers and for timely seed delivery to farmers.

Under the direct seed marketing program, seed enterprises, both public and private, were authorized to sell seed, primarily hybrid maize seed, directly to farmers in the selected districts (Benson, 2014).Accordingly, DSM allowed the private sector to be competitive and remain in business. However, future direction should make use of the lessons learned and expand the operation to more districts and crops. MacRobert (2009) suggested formation of partnerships or dealerships with agencies like agro-dealers, wholesalers, farmer associations, NGOs, crop commodity dealers, and agro-processors as key for success. It is therefore important for liberalized system that would encourage competitive pricing and development of an effective dealership network to reach more farmers.

Seed pricing: The decision on certified seed prices for public sector is made by the joint meeting of federal and regional seed enterprises based on average production costs. The meeting is organized three times a year on a rotational basis. After the decision is made each enterprise will report the price to its respective board of directors for approval, without any changes. The set price is communicated to the key stakeholders and will be used accordingly. However, the private sector such as Pioneer can set their own certified seed price without any external interference based on market forces. The overall direction in price setting is to sell the certified seed at the same price throughout the country, while taking into account the differences due to overhead, transportation and handling costs.

The current price setting mechanism has both advantages and disadvantages. The advantages are it: (i) limits the entrance of excess intermediaries in the market, which helps farmers to get seed at reasonably better prices, (ii) enables farmers with limited access to markets (those in distant areas with poor road) to purchase seed equitably, and (iii) promotes group marketing especially through membership in cooperatives. The disadvantages are it: (i) limits the competitions among the different seed producers, and (ii) creates disincentive for seed producers to work and invest in their own distribution systems. In recent years, however, direct marketing of seed is being piloted in some districts and appeared working well.

Strengthening institutions of the seed sector

Lack of institutional and individual capacity often undermines the long-term impact of otherwise technically sound programs. Availability of trained and skilled human resources and technical capacities are fundamental to ensure the future development of the seed sector. Strengthening the capacity of human resources and infrastructure for the seed sector should be one of the key policy directions. The emergence of the new PSEs and the private sector created stiff competition for the already limited experienced staff in the seed sector. A short and long-term strategy should be put in place to train a cadre of seed specialists who can lead and manage the seed sector with particular attention on seed business management.

From production of breeder seed to certified seed, adequate facilities would be required for field operations, seed processing and storage. NARS would require adequate facilities (access to land, irrigation, farm machinery, etc) to overcome the bottleneck in early generation seed (breeder and pre-basic seed) production. Although the formal seed sector has built up its seed processing capacity over the past two and a half decades, most of the facilities are owned by the ESE and are not located strategically for serving small farmers throughout the country. Newly established PSEs and the private sector (except PHI-bred) do lack adequate facilities for seed operations and BoA for adequate enforcement of the seed law. Support should be provided to upgrade the processing and storage facilities.

Collaboration and linkage with regional/global seed agencies

Ethiopia has a great potential in seed production both for domestic and export markets owing to diversity of its climate and strategic geographic location. It is believed that with liberalization the domestic markets will be linked to the global seed industry to ensure that farmers have better choices and access to modem technology. Collaboration with and linkages to international and regional seed related organizations would help to gradually

raise the standards and harmonize with international norms leading to eventual membership in these organizations as deemed necessary. This will improve the overall performance and profile of the seed sector and may attract the much need investments in the Ethiopian seed industry.

Conclusion

In Ethiopia, the evolution of organized seed sector is shaped by its socio-economic and political context. There is no 'one size fits all' recommendations, but there are ample experiences elsewhere to be shared and adapted to own unique situation. In countries with federal structure, for example in India, agricultural research is organized and coordinated at a national level (with state agricultural universities at state level), public seed production organized both at national and state levels and decentralized seed certification operating at state level. In Pakistan, there are both federal and provincial agricultural research establishments coordinated at a federal level, decentralized public seed production at a provincial level and centralized seed certification at a federal level with regional laboratories. In both countries, there a vibrant and dynamic private sector which plays an important role in agricultural research and/or seed delivery including a wide range of small to large domestic seed companies and multinationals owing to adequate policy and regulatory framework which advocates pluralism and diversity in the seed sector.

Several organizations have supported the development of the seed sector over the past several years through multilateral agricultural and financial institutions, overseas development agencies and NGOs. The Agricultural Transformation Agency established by the government has recently developed the strategy, interventions and road map believed to provide the guidance in transforming the seed industry. Translating the strategy into actions for implementation through provision of adequate resources is critical whose success is dependent on adequate ownership, coordination, and accountability of partners at all levels.

The national seed policy and regulatory frameworks as well as institutional and organizational arrangements are in place. It is important that the seed operations are implemented in a coherent manner both at federal and regional state levels where strong coordination and guidance is crucial both in agricultural research and seed delivery. Reconstitution of an apex advisory body such as a national seed council composed of relevant stakeholders would serve the purpose not only to guide the seed sector development but also as a repository of all seed related data and information in the country. Any reforms at national level should be harmonized with regional or international norms to enhance the competitiveness and facilitate linkages with the global seed industry.

The Ethiopian Government has identified improving the efficiency of the seed system as the most effective means of meeting the Sustainable Development Goals. In GTP II, it is also expected to strengthen the enabling policy environment to attract investment and develop a vibrant and competitive seed sector and reform or strengthen seed regulatory

frameworks to meet international standards. Concrete steps are required to translate the policy direction into practical action if we need to support the entry of the private sector.

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