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REVIEW ARTICLE

# Forage seed system performance of Ethiopia: An overview based on key indicators

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## Abstract

An increase in improved forages to serve as high-quality animal feed around the year is a necessity in countries with large livestock populations. However, for increased production of improved forages, a viable and sustainable forage seed system needs to be functional. In Ethiopia, an inadequate supply of forage seed has been identified as one of the major constraints to increased forage production. To assess the current state of the forage seed system, as well as, to monitor its growth in the future, the present study provides a framework that captures important information related to the forage seed system performance in Ethiopia. Data on key indicators along the forage seed value chain (such as variety development and release, early generation seed availability, commercial seed production, forage seed promotion and marketing, and seed quality assurance) were collected using a structured survey instrument. Results indicate a considerable number of forage varieties are already registered in the country through the national agricultural research system. However, a limited quantity of early generation seed is being delivered to seed producers. On the other hand, the involvement of commercial seed producers in the forage sector is limited. There are weak forage seed promotion and quality assurance mechanisms because most of the attention in the extension and regulatory structures is provided to the food crops. The study provides a template to monitor forage seed system performance in a developing country and identifies opportunities and recommendations for development partners, practitioners, national stakeholders, and decision-makers active in the Ethiopian forage sector.

**Keywords:** early generation seed, performance indicators, forages

## Introduction

Currently, the share of livestock to agricultural gross domestic product (GDP) in Ethiopia is about 47% and it supports the livelihoods of about 80% rural population [1]. However, in response to an increasing population, urbanization, rising income, and an emerging middle class, the demand for livestock products such as milk, meat, and eggs are growing rapidly in developing countries [2] including, Ethiopia. This increasing demand for livestock products offers opportunities for farmers to use livestock as a pathway out of poverty and food insecurity [3]. The Ten-Year Development Plan (TYDP) of the government of Ethiopia targets increasing milk production from 4.37 billion liters in 2020 to 11.8 billion liters in 2030, and meat production from 295,000 tons to 1.7 million tons [4]. Increasing livestock productivity entails the use of technological inputs such as improved livestock genotypes, improved feed supply, and health care [5].

However, the shortage of high-quality affordable feed, especially in dry periods, is a major constraint in Ethiopia. Natural pasture and crop residues have been among the main feed resources, but it too is challenged by increasing competition for land and shrinking grazing lands; low productivity, poor quality and grazing management of natural pastures; and erratic rainfall [6]. Expansion of forage production was taken in the TYDP as among the priority areas to achieve an increase in the production of livestock outputs [4]. Cultivated forages provide the opportunity to enhance livestock productivity in terms of supplying better nutrition. With the diverse agroecologies and irrigation facilities in Ethiopia, investing in the development of cultivated forages is a promising intervention to increase livestock productivity in the country.

The need to improve the quantity and quality of livestock feed in Ethiopia year-round to avoid seasonal bumps, using cultivated forages to improve livestock productivity and minimizing greenhouse gas emissions is well recognized by Dey et al. [7] that shows the costs of nutrients from cultivated forages are up to 15-fold lower than those from the conventional feed resources. The challenge related to the production of improved forages is the availability of high-quality forage seeds. Even though efforts were made to improve the situation in Ethiopia through select

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development projects, policy instruments, and technical meetings, there are still significant gaps that need to be filled in Shapiro et al. [8]. A wide range of forage species has been introduced and evaluated by the International Livestock Research Institute (ILRI) and handed over to the National Agricultural Research System (NARS) for further development [9]. However, the lack of good-quality seeds is still commonly cited as a constraint to expanding the production of cultivated forages [8, 10, 11].

Thus, to improve livestock feed and the supply of cultivated forages as animal feed, we need a viable and sustainable forage seed system. The present study was initiated to understand the performance of the forage seed system of Ethiopia using key indicators. The authors provide the national stakeholders and policymakers with a set of performance indicators that could potentially be used to track forage seed sector progress over time. In this way, the study also contributes to the realization of the feed and forage development strategy in practice by the Ministry of Agriculture [6].

## Methodology

Several steps were taken to identify the details of the framework. First, a literature review of the forage seed system was undertaken to determine the key performance indicators for which data would need to be collected. Next, a review of existing seed indices was important to examine what exists in terms of indicators for the broader seed system performance. There are three main indices for the seed sector: EBA (Enabling the Business of Agriculture), TASAI (The African seed access index), and ASI (Access to seeds index). TASAI was the closest for our purposes and we adapted and augmented it to a framework that would be applicable to the forage seed system. Second, a structured survey was designed to gather data, and stakeholders were identified as potential respondents (See Supplementary Material 1). Finally, when the indicators were populated with their values, validation workshops were conducted with data providers and national stakeholders to triangulate and confirm the information set.

## Forage seed systems of Ethiopia

A sustainable forage seed system ensures the production of high-quality seeds of a diverse range of forage varieties that are timely available and accessible at affordable prices to farmers. However, in Ethiopia, farmers have not yet benefitted from the advantages of using quality forage seed due to a combination of factors, including inefficient seed production, distribution, and quality assurance systems, as well as inadequate technical capacities [7, 11].

In Ethiopia, both formal and informal forage seed systems operate. However, a very limited quantity of forage seed is produced within the formal seed system [10–14] and more than 90% of the forage seed supply is from the informal seed system. Despite the strong justification for increasing the availability and use of improved forage seeds, public seed enterprises have so far shown little interest, probably for technical/commercial reasons [11]. Informal production and supply dominate the forage seed systems in Ethiopia [10, 13, 15]. Seed used by Ethiopian smallholder farmers is saved on-farm and exchanged among farmers [16]. Therefore, in our framework, we have included indicators to capture this pluralistic seed sector in Ethiopia.

In recent years, besides the formal seed supply system, community-based seed producer groups that are considered as an intermediary between the formal and informal seed systems, have initiated seed multiplication. These groups include Local Seed Businesses (LSB) or Seed Producer Cooperatives (SPC) which produce quality declared seeds (QDS) of improved varieties. QDS is an alternative, simplified seed certification scheme in which seed-producing farmers are responsible for seed quality, with the government playing a monitoring role [17, 18]. The seed proclamation 782/2013 of Ethiopia defines QDS as “seed produced in conformity with the required quality standards by organized and registered smallholder farmers, or individually registered smallholder farmers” [19]. In QDS, about 90% of crop inspection is the responsibility of the producer while only 10% of field inspection is done by the Seed Regulatory Authority.

## Indicators of forage seed systems performance

This section provides a discussion of the existing seed indices such as The African Seed Access Index (TASAI), Enabling the Business of Agriculture (EBA), Access to Seeds Index (ASI), and then a summary of proposed indicators to capture the performance of the forage seed system.

### CURRENT INDICATORS

Conventional indicators used by policymakers to assess seed industry performance in many developing countries include the quantity of seed produced, estimates of the quantity of seed demanded, and shortfalls or surpluses between estimated supply and demand, calculated from a comparison of these two indicators [20]. Aggregating the seed system performance indicators on seed demand and supply aspects may not show explicit performances in the forage seed system. Other conventional indicators like seed replacement rates are equally limited in analytical value because they are typically based on aggregated national and sub-national data from formal suppliers [20] and fail to indicate the specific nature of forage seed supply dominated by the informal system in Ethiopia.

The three main indices for the seed sector—EBA, TASAI, and ASIhave different goals and objectives, and none of them directly apply to forage seed system.

*Enabling the Business of Agriculture (EBA)*: EBA was developed by the World Bank Group, and one of the indicators is the seed supply indicator that measures laws and regulations that support the timely release of seed for use by domestic farmers. Besides, the indicator focuses on the formal seed sector it acknowledges that farmers use formal and informal systems to access different types of seeds at a given point in time [21].

*Access to seeds index (ASI):* It is designed to create a better understanding of how seed companies are improving access to quality seeds and, in turn, contributing to achieving sustainable development goals (SDGs). By creating a better understanding of the seed industry’s performance, the Index aims to contribute to the achievement of these goals [22].

*The African seed access index (TASAI):* It is a new tool developed to encourage African governments and development agencies to create and maintain enabling environments that will accelerate the development of local private sector-led seed systems serving smallholder farmers. TASAI provides an objective and easy-to-access tool that helps identify thresholds in the seed delivery systems and track their progress over time [23, 24]. However, the indicator is limited to only certain crops (maize, sorghum, teff, and wheat) and does not include forages. TASAI also largely caters to the formal seed system and does not include any information on alternative seed quality and certification schemes. For example, TASAI does not include any information on QDS protocols. Additional differences between TASAI and the present study are provided in Table 1.

### IMPLICATIONS OF CURRENT INDICATORS TO FORAGE SEED SYSTEMS

Despite the existing seed system performance indicators, none of them directly apply to the performance of the forage seed sub-sector. First, the demand for forage seed is influenced by

the crop's nature and demand for specific crop varieties. Many forage crops are perennial and once a farmer gets the seed of a forage variety the stands may persist for a long period of time (e.g., forage grasses 8 > 12 years, shrubs even longer) under good management practices [25]. Hence, the demand for forage seeds should be recalibrated based on such factors. Second, most farmers are getting forage seeds through support from non-government organizations (NGOs) and development projects in a limited area but are unlikely to purchase seeds on a regular basis, thus inhibiting the development of a real market. Third, there are significant differences between food and forage crops in the Ethiopian context. For example, it is important to recognize the differences between forage and food crops in terms of the variety development targets, seed multiplication requirements, seed quality assurance mechanisms in practice, and seed handling. Table 2 provides a summary of the key differences.

Given the differences in food crops versus forages, the pluralistic seed system in which Ethiopia functions, and the specificity required to understand and assess gaps in the forage sub-sector, we adapted and augmented the TASAI framework to render applicability for our study (see Section 5 for details).

## Forage seed system performance indicators for Ethiopia

The current study used the forage seed value chain to identify indicators ranging from variety development to seed quality assurance to measure the forage seed system performance of Ethiopia (see Fig. 1). Based on the forage seed value chain, and the pluralistic environment within which forage seed systems operate, this study establishes a set of performance indicators that are grouped into six key domains: (1) variety development and maintenance; (2) strength of forage breeding programs; (3) EGS availability; (4) involvement of seed producers; (5) forage seed promotion and marketing; and (6) seed quality assurance. For each of the domains, a set of indicators are prioritized. Table 3 shows definitions of indicators, their desired direction of change, units of measurement, and data sources.

### FORAGE VARIETY DEVELOPMENT AND MAINTENANCE

*Variety release*: A strong seed system relies on the availability of variety development, release, and registration program. A strong breeding program depends on the human as well as physical capacity. In Ethiopia, the forage breeding program is short of trained human capacity. Low performance in this indicator makes the forage seed system inadequate.

*Released forage varieties:* For every crop, the number of varieties sold in any given year is a good indicator of the breadth of farmers' choices [24]. Currently, 68 forage crops and fodder trees have varieties registered for production and use in Ethiopia [26]. In addition, a vibrant seed sector should retire old varieties as newer (better) ones become available and discontinue varieties that fail to meet farmers' needs. In Ethiopia, about 20 varieties were released and registered during the period between 2016 and 2020 (see Fig. 2, Table 4; Indicator No. 1). An increase in the number of high-yielding varieties with the desired nutritional quality is an indicator of the reasonable performance of forage seed systems.

*Germplasm availability:* The International Livestock Research Institute (ILRI) is the major source of germplasm for forage breeding in Ethiopia. ILRI's genebank holds a diverse collection of

**Table 1.** The comparison between The African Seed Access Index (TASAI) and framework of the present study—Ethiopia.

| The African seed access index | Current framework |
|---|---|
| Does not include all crops (only cereals are included). Does not include forages | Contains only forages |
| Does not include volume of price of early generation seed[1] | Includes volumes and prices of early generation seed |
| Does not include alternative seed quality mechanisms (such as quality declared seed) | Includes information on both certified and quality declared seed schemes |
| Focus is more on seed companies | Information and data on forages from coops and unions is included |

[1] Early generation seed includes breeder, pre-basic and basic seed classes in the generation system of seed production.

**Table 2.** Status of seed system attributes for food and forage crops in Ethiopia.

| Seed system | Food crops seed | Forage crops seed |
|---|---|---|
| Variety development | Involve higher number of trained breeders, breeding target is human consumption | Lack trained breeders and variety development targets livestock and/or NRM (Natural Resource Management) |
| Seed multiplication | Demand is predictable to some extent | Seed demands are opportunistic |
| Seed supply system | Formal, informal, and intermediate with active participation of private entities | Mostly informal and intermediate |
| Seed production and post-harvest handling | Management and handling are relatively easier | Often less domesticated species which require specific skills and knowledge, which is often lacking |
| Quality assurance | Given better attention from formal regulatory | Mainly with quality declared seed system and informal |
| Seed productivity | Most of the food crop have comparatively better seed yield | Forage crops are bred for herbage yield and nutrition, thus limited seed yield |
| Marketing system | Better marketing structure | Opportunistic seed marketing |
| Price | Comparatively lower price | Mostly expensive |
| Promotion by extension | Better adoption rate by farmers | Limited adoption rate by farmers, limited extension efforts |

| Performance indicators | Regulatory/policy framework | System Actors | Impacts of positive change |
|---|---|---|---|
| Variety development and maintenance | Variety development and registration procedures, human capacity development strategy, a policy for strong and accessible forage germplasm stock collection | Ethiopian Agricultural Authority (EAA), Agricultural Research Institutes, Universities, International Agricultural Research Centers | High yielding, strongly completive forage varieties available for use by farmers |
| Strength of forage breeding programs | | | |
| Early generation seed (EGS) availability | Multi-actor EGS production through decentralization, market incentives for private sector involvement in forage seed production, forage seed extension strategy | Agricultural Research Institutes, Universities, International Agricultural Research Centers | Healthy functioning forage seed system in place; vibrant private sector providing farmers with multiple choice of seed sources realized. High livestock productivity achieved. |
| Involvement of commercial seed companies | | Bureaus of Agriculture, Public and private seed companies, community-based producers, farmers | |
| Forage seed promotion and marketing | | | |
| Seed quality assurance | Ethiopian Seed Standards, QDS standards, seed certification laboratories | Ethiopian Agricultural Authority (EAA), Regional Regulatory Agencies | Farmers access best quality forage seed. |

**Fig. 1.** Forage seed system map in Ethiopia (indicators, regulatory/policy frameworks, system actors, and the expected change).

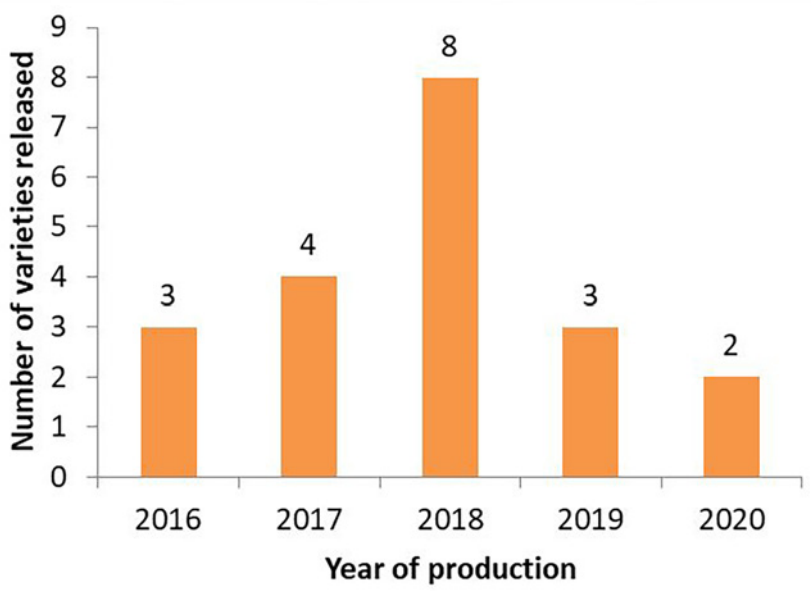


**Fig. 2.** Forage varieties released in Ethiopia during the last five years (2016–2020). *Source: Ministry of Agriculture (MoA), Crop Variety Register (2017–2021).*

forage accessions and related information. It makes this available as part of a global system of genetic resource conservation and sustainable use. The genebank in Addis Ababa, Ethiopia conserves approximately 19,000 accessions (Table 4, Indicator No. 2.1) of over 1000 species [27]. This is one of the most diverse collections of forage grasses, legumes, and fodder tree species held in any genebank in the world, it includes the world's major collection of African grasses and tropical highland forages. Table 5 shows

**Table 3.** Forage seed system performance indicators in Ethiopia.

| Indicator | Definition | Desired directional change[1] | Unit of measurement | Data Source |
|---|---|---|---|---|
| 1. Variety development and maintenance | Total number of varieties released by forage species in the last 5 years | (+) | Number | Secondary data collection from Crop Variety Register, Ministry of Agriculture |
| 2. Strength of forage breeding programs | 2.1. Available germplasm/accession collection (local, international stock) | (+) | Number of accessions | Secondary data collection from International Livestock Research Institute (ILRI), Ethiopia |
| | 2.2. Number of active breeders disaggregated by age and sex | (+) | Number | Secondary data collection from Research Institutes |
| 3. Early generation seed (EGS) availability | 3.1. Volume of EGS produced by forage species (average by species for the last 2 years) | (+) | Tons (MT) | Secondary data collection from Research Institutes |
| | 3.2. Share of EGS produced and sold | (+) | Number | Secondary data collection from Research Institutes |
| | 3.3. Price at which it is sold | (−) | USD/Kg | ILRI, Ethiopian Institute of Agricultural Research, Southern Nations, Nationalities and Peoples Region, Eden Fields |
| 4. Involvement of seed producers | 4.1. Total volume of certified forage seed produced in the last 2–3 years. | (+) | MT | Secondary data collection from Ministry of Agriculture |
| | 4.2. Number of entities producing forage seed | (+) | Number | |
| 5. Forage seed promotion and marketing | 5.1. Percentage share of forage seed produced that is sold | (+) | Tons | Secondary data collection from Seed enterprises and Research Institutes |
| | 5.2. Average forage seed price by species per kg | (−) | Birr (USD) per Kg | Primary data |
| | 5.3. Number of development agents trained in forages in general in the last two years. Should be gender and age disaggregated, if possible. | (+) | Number | Secondary data collection from Ministry of Agriculture |
| 6. Seed quality assurance | 6.1. Number of forage crops for which seed production standards available. | (+) | Number | Secondary data collection from Ethiopian Standards and regulatory agencies |
| | 6.2. Number forage crops with quality declared seed (QDS) standards | (+) | Number | Secondary data collection from Ministry of Agriculture |

[1] Desired direction of change: An increase (+) or decrease (−) in the measured value of an indicator contributes to a better performance of the forage seed system in Ethiopia.

the number of accessions available at the ILRI genebank for the most common forage crops tested and recommended for use in Ethiopia. The availability of a wide germplasm collection is one measure of the possibility of developing high-yielding forage varieties.

*Human resource capacity:* A strong breeding program depends on human as well as physical capacity. Key informant discussions with researchers from the Ethiopian Institute of Agricultural Research (EIAR) indicated a very limited number (only 12) of researchers are forage breeders (Table 4, Indicator No. 2.2) by training and most of the researchers working on forage breeding are typically not trained in plant breeding. To achieve an adequate forage breeding program, it is essential to build human capacity with appropriate levels of training.

## EARLY GENERATION SEED (EGS) AVAILABILITY

The supply of EGS is the critical component of the formal seed systems. To sustainably increase forage productivity and ultimately livestock production, the forage seed system should be replenished with a regular supply of EGS. The level of involvement of the private sector is crucial for market-oriented forage seed production. The success of formal seed systems also depends on efficient seed promotion and marketing schemes.

*Early generation seed supply by EIAR:* The availability of basic and pre-basic forage seed to certified seed producers is a critical issue in the seed system's performance. The research centers in the national agricultural research system are the main source of basic and pre-basic forage seeds and there should be an adequate focus by the research system on the supply of EGS seed. EIAR yearly supplied about 20,727 kg of pre-basic and 26,033 kg of basic seed during the period between 2018 and 2020 (see Fig. 3). The largest EGS supply is in oats and alfalfa followed by Rhodes grass. Increased production of early generation seeds is a measure of increased access to forage seeds. The volume of pre-basic seed increased from 7370 kg in 2018 to 26,460 kg in 2020, and the increase in basic seed was from 22,970 kg in 2018 to 30,820 kg in 2020. In 2020, EIAR produced about 4200 kg of breeder seed for different forage crops.

**Table 4.** Details of indicators, their definitions, desired direction of change, units of measurement and types and sources of data.

| Indicator | Definition | Performance | Unit of measurement | Data Source |
|---|---|---|---|---|
| 1. Variety development and maintenance | Number of varieties released by year by forage species (last 5 years) | 20 | Number | Ministry of Agriculture |
| 2. Strength of forage breeding programs | 2.1. Available germplasm/accession collection (local, international stock) | 19,000 | Number of accessions | ILRI |
| | 2.2. Number of active breeders disaggregated by age by sex in the current year | 12 | Number | EIAR |
| 3. EGS availability | 3.1. Volume of early generation seed (EGS) produced by forage species (average by species for the last 2 years) | 47.9 | Tons (MT) | EIAR, ILRI |
| | 3.2. Share of EGS produced sold | GO (52.5%); NGO (45.0%); Farmers (1%) | Percentage | EIAR, ILRI |
| | 3.3. Price at which it is sold (USD) | 9.81–22.94 | Birr/Kg | EIAR, ILRI |
| 4. Involvement of seed producers | 4.1. Volume of certified forage seed produced in the last 2–3 years. | 324.3 | MT | Eden Fields, SNNPR BoA |
| | 4.2. Number of entities producing forage seed | 31 | Number | |
| 5. Forage seed promotion and marketing | 5.1. Percentage share of forage seed produced that is sold | NGO (98%); Farmers (2%) | Tons | Eden Fields, SNNPR BoA |
| | 5.2. Average forage seed price by species/kg | 0.58 – 35.92 | Birr (USD)/Kg | Survey or Assessment |
| | 5.3. Number of development agents trained in forages in general in the last two years. | 3263 | Number | MoA |
| 6. Seed quality assurance | 6.1. Number of forage crops for which seed production standards available /used. | 13 | Number | Ethiopian Standards Agency |
| | 6.2. Number forage crops with declared seed (QDS) standards | 5 | Number | Ethiopian Standards Agency |

Note: EIAR (Ethiopian Institute of Agricultural Research); ILRI (International Livestock Research Institute); GO (Government Organizations); NGO (Non-governmental Organizations); SNNPR (Southern Nations, Nationalities and Peoples Region of Ethiopia); BoA (Bureau of Agriculture); and MoA (Ministry of Agriculture).

**Table 5.** Number of germplasm available for commonly used forage species in Ethiopia.

| Forage crops | Number of germplasms |
|---|---|
| Oats (*Avena sativa*) | 122 |
| Phalaries ( *Phalaries aquatica*) | 11 |
| Elephant grass (*Pennisetum purpureum,* now *Cenchrus purpureus*) | 60 |
| Rhodes (*Chloris gayana*) | 69 |
| Panicum (*Panicum coloratum*) | 19 |
| *Panicum maximum,* now *Megathyrsus maximus* | 102 |
| Andropogon (*Andropogon gayanus*) | 48 |
| Vetch (*Vicia villosa* L.) | 12 |
| Vetch (*Vicia sativa* L.) | 198 |
| Alfalfa (*Medicago sativa* L.) | 54 |
| Dolichos lablab (*Lablab purpureus*) | 311 |
| Cowpea (*Vigna unguiculata*) | 692 |
| Trifolium (*Trifolium quartinianum*) | 41 |
| Pigeon pea (*Cajanus cajan* L.) | 137 |
| Sesbania (*Sesbania* spp) | 596 |
| Total | 2472 |

Source: International Livestock Research Institute Feed and Forage Development program, Addis Ababa, Ethiopia.

*Early generation seed supply by ILRI*: ILRI in Addis Ababa also provides tropical and sub-tropical forage seeds and planting material of selected best-bet species for use in establishing national forage seed production, with a herbaceous legume, grass, and fodder tree species [28]. ILRI supplied a total of 963 kg of forage early generation seed to government and non-government institutions during the period between 2018 and 2020 (see Fig. 4). In general, from the 68 registered varieties in the registry book, only 13 (19.11%) varieties are used for EGS production. This means, there is a need to create awareness and demand for the other varieties through activities such as field demonstrations so that newer improved varieties enter the seed production cycle and become available to farmers for adoption at the last mile.

## COMMERCIAL SEED PRODUCTION

*The demand for forage seed:* Commercial production of forage seeds is weak because the demand pulls for forages is not well established due to the absence of strong market linkages, technical awareness of forage agronomics, and other factors. At present, the demand for forage seed is mostly linked with government and donor-supported projects or emergency responses. The majority of forage seed is exchanged by farmers through informal non-monetary transactions. An informal seed system includes seed that is saved by farmers, seed exchanges among farmers, non-certified seed purchased or borrowed from local grain markets or neighboring farmers, and emergency seed gifts through relief services. About 60%–70% of forage seed used by smallholder farmers is saved on-farm or exchanged among farmers, and only 20%–30% is borrowed or purchased locally [16]. Seed borrowed

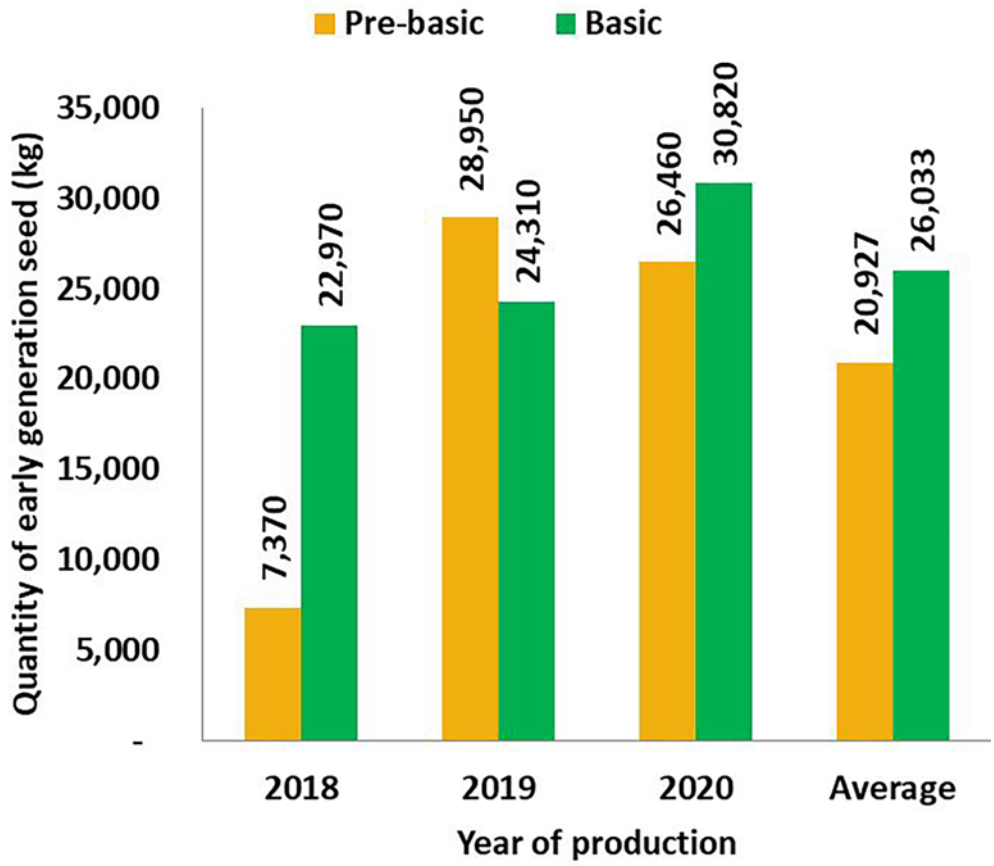


**Fig. 3.** Quantity of pre-basic and basic seed production (kg) by the Ethiopian Institute of Agricultural Research (EIAR), Ethiopia. Note: Early generation seed includes breeder, pre-basic and basic seed classes in the generation system of seed production. *Source: EIAR Early Generation Seed (EGS) database, 2021.*

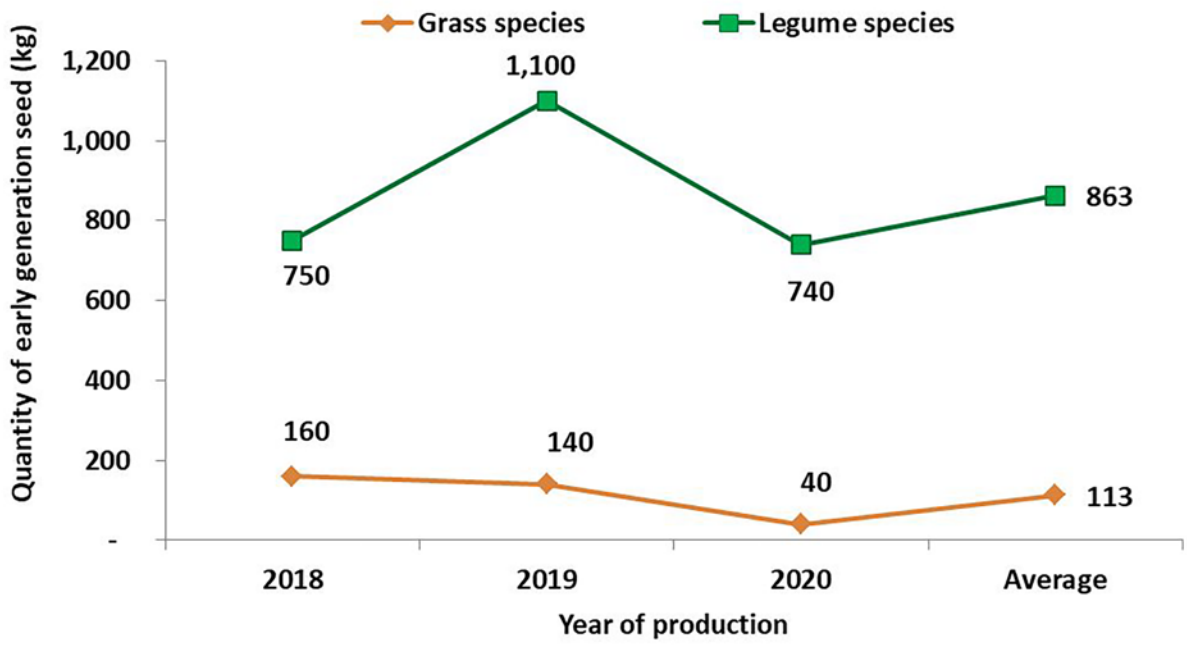


**Fig. 4.** Early generation seed production (kg) by the International Livestock Research Institute (ILRI) Ethiopia. Note: Early generation seed includes breeder, pre-basic and basic seed classes in the generation system of seed production. *Source: ILRI Feed and Forage Development*.

or purchased locally is not within the formal certification system, indicating that more than 90% of forage seed used by farmers is either own saved or obtained from local informal sources.

*Registered producers of forage seed:* There are several seed producers, who are registered for forage seed production in Ethiopia. In the Southern Nations Nationalities and Peoples (SNNP)

regional state a total of 23 producers are registered in forage seed production whereas, in the Amhara region, a total of 14 producers are registered for forage seed production (Table 6). Producers registered for forage seed production are mostly cooperatives in Amhara regional state while in SNNP they are mainly private seed companies. Even though there are multiple producers registered, these producers multiply the seeds of many other crops. Currently, there is no data that distinguishes or helps assert the correct number of only forage seed producers.

*Public seed enterprises:* Public seed enterprises are also registered for forage seed production and supply, but the Somali Seed and Forage Enterprise (SSFE) is the only enterprise that is highly engaged in forage seed production. The SSFE produced Sudan grass and Alfalfa and was annually harvested an average of 2000 tons and 1100 tons of forage seed, respectively [16].

*Private seed enterprises:* Private seed producers engaged in forage seed production are limited in number and supply. Eden Field Agri-Seed Enterprise is among the private seed companies with a notable contribution to the forage seed supply system of Ethiopia. The company produced 84 tons of forage seed (Table 7) during the period between 2018 and 2020 on 14 forage species that are recommended for production and use in Ethiopia. Ensuring a strong system requires diversified commercial entities with strong government regulation. The level of involvement of the private sector is crucial for scaling market-oriented forage seed production.

*Who buys forage seed:* The forage seed is sold to government and non-government organizations and private seed dealers but in varying proportions. For example, Eden Field Agri-Seed Enterprise reported that the lion's share of its seed (55%) was sold to government agencies in different regional states while about 43% was sold to different NGOs. Only 2% was sold to individual farmers. It is evident that the forage seed marketing structure is dominated by governmental and donor-supported projects than direct marketing demand from individual farmers.

## FORAGE SEED PROMOTION AND MARKETING

Farmers in mixed crop-livestock production systems give priority to crop production, and forage production is given lower importance. Farmers should be well educated on the commercial benefits of growing forage crops for milk and meat production. This implies forage seed producers need to be linked with forage growers who are then connected with livestock markets such as commercial dairy, feedlots, and quarantine stations.

*Adoption of improved forage varieties:* The consideration of farmers' preference for forage crops is crucial for the increased adoption of improved forage crops. Improved forage species have been progressively introduced to local farmers of Ethiopia since the 1970s to supplement the natural feed resources. However, there is limited adoption by farmers. Earlier reports indicated that adoption rates of forage species are affected by access to agricultural extension services, participation in forage training sessions, and higher cash income [29]; higher herbage yield, vegetative growth, tillering ability, and drought resistance [30]; labor available, size of livestock ownership, and farm size [31]; and household resource endowment, especially land and labor, and market integration and crop intensification [32].

*Limited culture of forage seed marketing:* Historically, improving forage seed production, distribution and promotion have received little attention in Ethiopia. Most smallholder farmers are not able to produce and sell improved forage crops because they use the little land they have for the production of food and cash crops. In addition, smallholder farmers and livestock owners have not yet developed the culture of purchasing seed as NGOs and regional agricultural bureaus often distribute the seed for free or at subsidized prices. Those smallholder farmers that produce forage seed, use it for their own livestock needs and maintain the seed for the next cropping season rather than selling it [16].

**Table 6.** Licensed seed producers involved in forage seeds by regional states in Ethiopia.

| Ownership | Amhara | Oromia | SNNP[1] | Tigray[2] |
|---|---|---|---|---|
| Community-based | 1 | 0 | 2 | 0 |
| Private | 0 | 2 | 21 | 3 |
| Public | 1 | 1 | 1 | 0 |
| Total | 2 | 3 | 23 | 3 |

Source: Ministry of Agriculture, Certification Database, 2021.
[1] Southern Nations Nationalities and Peoples (SNNP).
[2] Where there are no actors in a given ownership, the value was given '0'.

**Table 7.** Volume of certified forage seed produced (kg) by Eden Fields, Ethiopia.

| No | Forage crops | 2020 | 2019 | 2018 | Average (kg) |
|---|---|---|---|---|---|
| 1 | Oats *(Avena sativa)* | 2800 | 3200 | 1800 | 2600 |
| 2 | Rhodes (*Chloris gayana*) | 3200 | 2300 | 1600 | 2367 |
| 3 | Panicum (*Panicum antidotal*) | 2100 | 1800 | 1100 | 1667 |
| 4 | Vetch (*Vicia dasycarpa*) | 3800 | 2200 | 1700 | 2567 |
| 5 | Vetch (*Vicia villosa* L.) | 800 | 1200 | 800 | 933 |
| 6 | Dolichos lablab (*Lablab purpureus*) | 3500 | 3200 | 1600 | 2767 |
| 7 | Cowpea (*Cowpea unguiculata*) | 6700 | 4200 | 2400 | 4433 |
| 8 | Tree lucerne (*Chamaecytis* spp) | 900 | 1200 | 800 | 967 |
| 9 | Pigeon pea (*Cajanus cajan* L.) | 6000 | 4800 | 2700 | 4500 |
| 10 | Sesbania (*Sesbania* spp) | 800 | 1200 | 700 | 900 |
| 11 | Alfalfa (*Medicago sativa* L.) | 200 | 500 | 0 | 233 |
| 12 | Fodder beet (*Beta vulgaris subsp. vulgaris* L.) | 500 | 800 | 0 | 433 |
| 13 | Siratro (*Macroptilium atropurpureum*) | 700 | 1000 | 0 | 567 |
| 14 | Sudangrass | 6000 | 3200 | 0 | 3067 |
| Total | | 38,000 | 30,800 | 15,200 | 280,000 |

Note: Eden Fields is a private seed company involved in forage seed production in Ethiopia. *Source: Eden Fields (company database, 2021).*

*Forage seed extension:* The uptake of forage seed by farmers depends on their awareness of the endowed benefits in the improved forage varieties. The existing forage seed market is largely dispersed and fragmented with weak linkages between suppliers and buyers, and a general lack of market information [16]. Farmers need greater awareness on the differences between food crops and forages so adequate agronomic practices could be applied in the fields. Continuous training for both farmers and development agents is necessary to increase capacity on the ground. In the former state of SNNP, a total of 3263 development agents were trained on improved forages in the last two years (Table 8). This standalone information is not sufficient to gauge

whether there are enough agents trained in forages. Going forward, the Ethiopian government could collect detailed information on the number of agents specifically trained in forages versus other crop types. Furthermore, capacity building is a continuous process and must be sustained to ensure enhanced productivity in the fields.

*Forage seed price in Ethiopia:* The access to seeds of improved forage varieties might be dictated by the seed price. Compared to the price of food crop seed, prices paid for forage seeds are very high because there are not enough forage seed producers to supply quality seed relative to the quantity demanded. The average seed price at Eden Field Agri-Seed Enterprise ranged from 0.59 USD[1] per kg for oats (*A. sativa*) to 24.45 USD per kg for alfalfa (*M. sativa*) seed. The ILRI sales source seed at prices ranging from 2.93 to 9.78 USD per kg. The average certified forage seed price at regional states such as SNNPR is about 0.88 USD per kg for oats to 36.19 USD per kg for imported alfalfa seed. The seed price for oats is lower than that of other forages because the seed production is relatively easier, and the seed yield is better. High seed price in some forage seed species relative to food crops (e.g., certified seed of wheat is 0.94 USD per kg) is usually attributed to the high cost of production and low seed yield of forage species that are bred for their herbage yield. Rural households are willing to pay for improved forage technology if the technologies are available at their access and affordable prices [33].

*Forage seed price comparison with other African countries*: Seed prices of Rhodes grass, alfalfa, and cowpea were compared across Ethiopia, Kenya, and Zambia (see Fig. 5). The seed price in Ethiopia is comparably lower for cowpea and Rhodes grass. Minimal differences were observed in the seed price of alfalfa in Kenya and Ethiopia. Lower seed prices in Ethiopia for cowpea and Rhodes grass could be attributed to weak market linkages and demand creation efforts. Due to limited forage extension, the market for forage seeds is unpredictable and the demands are not reliable.

[1] One Ethiopian birr on 07 April 2022 was 0.020 USD.

**Table 8.** Number of farmers trained in forage development practices in the Southern Nations, Nationalities and Peoples (SNNP) Region, Ethiopia.

| Year | Male | Female | Total |
|---|---|---|---|
| 2018 | 521 | 245 | 766 |
| 2019 | 683 | 367 | 1050 |
| 2020 | 927 | 520 | 1447 |
| Total | 2131 | 1132 | 3263 |

Source: Southern Nations Nationalities and Peoples Regional Bureau of Agriculture, 2021.

## SEED QUALITY ASSURANCE

A strong quality assurance system is essential for a pluralistic seed sector. Given the important role the informal seed system plays, it is critical that there are policies and practices in place to bridge gaps between formal and informal seed systems [34]. Hence it is important to capture information on the seed and field standards available, the number of inspectors, and the level of knowledge they have in forage seed inspection. However, forage seed quality assurance did not receive adequate attention from the seed regulatory structure in Ethiopia. Key informant discussions in our study indicated that since the existing regulatory structure gives priority to the food crops, there is a need to separately organize a quality assurance structure for forage crops.

*Seed and field standards for forages:* A special feature of the national seed system of Ethiopia is that the quality standards are prepared and published by the Ethiopian Standards Agency (ESA) in consultation with the ministry of agriculture (MoA).

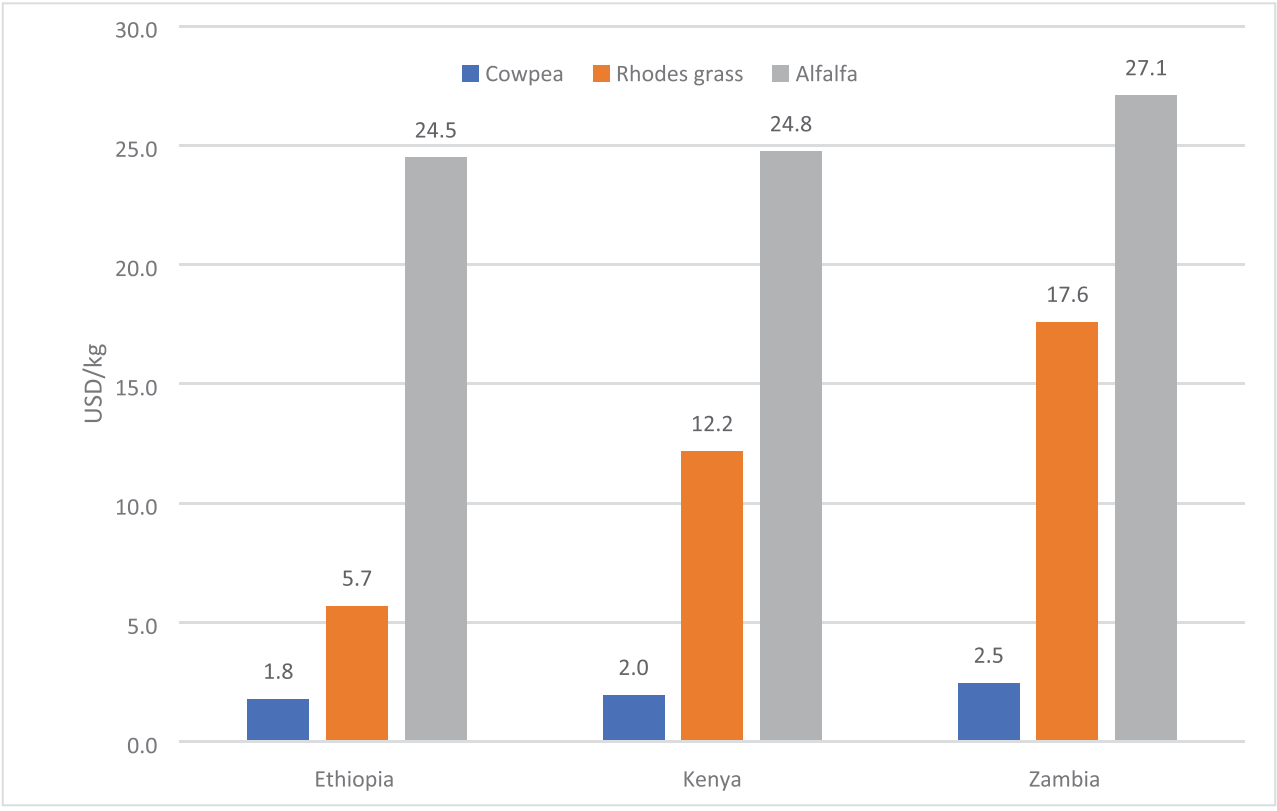


**Fig. 5.** Price (USD/kg) comparisons of selected forages (cowpea, rhodes grass, and alfalfa) in Zambia, Kenya, and Ethiopia. *Source: Authors' survey.*

A separate standard exists for almost every crop (including forages) and they are remarkably detailed based on information collected from relevant sources worldwide. Certified seed standards are available for 13 of the 68 registered forage species. There might be a need to increase the number of forage species with seed production standards so that seed quality assurance can be conducted with ease. However, some aspects of these standards would be difficult or impossible to implement or enforce with the facilities at the disposal of the regional authorities. Despite that there are standards for certain forage species; there is limited seed certification by the regulatory structure.

*Forage crops with Quality Declared Seed (QDS) standards:* In Ethiopia, a total of five forage species namely *Dolichos lablab* (*Lablab purpureus*), Andropogon (*Andropogon gayanus*), Clover (*Trifolium quartinianum*), Elephant grass (*Pennisetum purpureum*), and Phalaries (*Phalaris aquatica*) are registered for QDS standards. Since forage seed production is not well commercialized, including more forage species that are demanded by farmers in the quality-declared seed schemes may increase community participation in local availability and access to improved forage varieties. Enhancing community participation in quality declared seed (QDS) production, in turn, may improve farmers' access to seed at local levels. However, the number of forage seed producer communities using QDS standards is limited or not largely available.

*Field inspectors*: Seed inspectors in Ethiopia work both on food and forage crops. There are no inspectors specified for forage seed field inspection. When training is delivered to seed inspectors, the aspects of forage seed quality are rarely/commonly included in the training programs. However, there is a pressing need to increase the number of seed inspectors aware of forage seed production standards.

## Summary

To study the performance of the forage seed system of Ethiopia, a total of six major indicators and twenty-six sub-indicators were identified (Table 3). The sub-indicators ranged from germplasm acquisition to certified seed marketing and seed quality assurance. Using data from various sources, these indicators were populated (Table 4). However, these figures for the forage sub-sector at the moment are only a static snapshot. Going forward, the values of these important metrics should be calibrated periodically to assess trends and movements in the sector and thus identify targeted interventions.

The average number of varieties registered during the five years was four per annum. It was learned that the forage variety development procedures were tailored to meet specific requirements in forage crops. Germplasm stock for recommended forage species ranges from 11 germplasm to 692 germplasm per species. ILRI serves as a major source of germplasm for forage variety development through the EIAR has access to germplasm from other CG centers. However, access to germplasm is not as high as desired. One of the challenges in the forage variety development process is that currently there is a limited number of trained forage breeders. Those involved in forage variety development are either trained in animal nutrition or crop agronomy.

The major share of EGS produced is sold to the government and NGOs. This implies the market for forages is largely driven by institutional buyers. There are a few entities registered for forage seed production, and that too is unclear whether all of them are indeed actively producing forages. The number of seed quality protocols for forages is also limited – 13 for certified seed production and 5 for QDS. Thus, the formal sector is unable to increase forage seed production due to limited regulatory standards. However, informal seed system players are exchanging forage seeds and playing a role in the supply of forages in local communities. Thus, there should be efforts in bridging the gaps between formal and informal systems and community forage seed production mechanisms fostered to meet the demand for forage seeds.

## Conclusion and recommendations

The forage seed system performance in Ethiopia is not well recognized and lacks specific measurements, unlike the food crops seed system. This study has tried to fill in that gap by proposing performance indicators bearing in mind the pluralistic seed sector in Ethiopia.

The forage seed industry performance in Ethiopia is weak in terms of various development and the strength of breeding programs, early generation seed availability, commercial seed production, seed promotion, and seed quality assurance. Forage breeding programs lack trained breeders, and variety development is usually carried out by individuals trained in animal nutrition or other related disciplines. Early generation seed multiplication schemes are available at research institutes, but those schemes are too weak and do not usually consider recently released varieties.

In terms of commercial seed production, several seed companies are registered for forage seed production, but not all are actively involved in the seed production of forages. Besides, commercial seed production is caught in the opportunistic forage seed market. There is weak forage seed promotion and marketing concerning creating awareness and linking the forage seed industry with livestock output markets. To assure the quality of seed produced and marketed, seed standards are available for certain forage species, but there is little attention from the seed regulatory system due to limited resource capacity (human and physical resources). The following recommendations are suggested to bolster the forage seed system in Ethiopia.

First, strengthen forage variety development and breeding programs through training breeders on forages and enhancing the availability and access of forage genetic resources. Second, early generation seed multiplication schemes at research institutes with a due focus on recently released forage varieties should be made a priority so that research material could move from research labs onto farmers' fields. Third, the involvement of the private sector forage seed production should be encouraged and supported through the establishment of forage-feed-livestock output marketing linkages. A holistic value chain approach to forage seed development strategy should be employed to foster demand-driven forage seed production and marketing. Promoting forage and fodder production and trade through creating new and strengthening existing livestock output market linkages is a must. Additional seed quality assurance certification standards for forage varieties that are preferred in the market need to be created. Similarly, local forage seed production by informal seed system players should be formalized and provided with adequate training to bridge gaps between formal and informal seed systems. Finally, training programs for development agents that are targeted for forage seed multiplication and forage crop growers should be enabled to build capacity at the last mile.

The current study helps establish a framework to assess forage development in the Ethiopian context recognizing the pluralistic nature of the seed systems. However, national stakeholders and decision-makers must continue to populate these metrics to assess dynamism in the sector and thus, design better-targeted interventions to improve forage productivity, and year-round supply of animal feed based on cultivated forages.

## Conflict of interest

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

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## Acronyms/abbreviations

| | |
|---|---|
| ASI | Access to Seeds Index |
| BoA | Bureau of Agriculture |
| EBA | Enabling the Business of Agriculture |
| EGS | Early Generation Seed |
| EIAR | Ethiopian Institute of Agricultural Research |
| FDRE | Federal Democratic Republic of Ethiopia |
| GDP | Gross Domestic Product |
| ILRI | International Livestock Research Institute |
| LSB | Local Seed Business |
| MoA | Ministry of Agriculture |
| NARS | National Agricultural Research System |
| NGOs | Non-governmental Organizations |
| NRM | Natural Resource Management |
| PDC | Plan and Development Commission |
| QDS | Quality Declared Seed |
| SDGs | Sustainable Development Goals |
| SNNP | Southern Nations, Nationalities and Peoples |
| SPC | Seed Producer Cooperatives |
| SSFE | Somali Seed and Forage Enterprise |
| TASAI | The African Seed Access Index |
| TYDP | Ten Years Development Plan |

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