Seeding Diversity:
Enhancing access to crop diversity through innovative seed system linkages in Tanzania

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List of acronyms

ABC	Alliance of Bioversity International and CIAT
ABS	Access and Benefit-Sharing
AGRA	Alliance for Green Revolution in Africa
ARIPO	African Regional Intellectual Property Organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BOLD	Biodiversity for Opportunities, Livelihoods and Development
BSF	Benefit-Sharing Fund
CGIAR	Consultative Group on International Agricultural Research Centers
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
COMESA	Common Market for Eastern and Southern Africa
CSB	Community Seed Bank
DUS	Distinctness, Uniformity, and Stability
EAC	East African Community
EGS	Early Generation Seed
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GCDT	Global Crop Diversity Trust
KII	Key Informant Interviews
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IITA	International Institute for Tropical Agriculture
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
NGOs	Non-Governmental Organizations
NMBU	Norwegian University of Life Sciences
NPT	National Performance Trial
NPGRC	National Plant Genetic Resources Center
PBR	Plant Breeders' Rights
PGRFA	Plant Genetic Resources for Food and Agriculture
PVP	Plant Variety Protection
QDS	Quality Declared Seed
SADC	Southern African Development Community
SUA	Sokoine University of Agriculture
TABIO	Tanzania Alliance for Biodiversity
TANSEED	Tanzania Seed International
TARI	Tanzania Agriculture Research Institute
TOSCI	Tanzania Official Seed Certification Institute
TPHPA	Tanzania Plant Health and Pesticides Authority
UN	United Nations
UPOV	International Union for the Protection of New Varieties of Plants

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Acknowledgments

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Elibariki Basso, a farmer from Slahamo village, displaying seeds from his community seed bank at the BOLD launch workshop in Dodoma. Photo: Teshome Hunduma Mulesa/NMBU

Executive summary

This report presents the results of the research phase of the Biodiversity for Opportunities, Livelihoods and Development (BOLD) project, a ten-year initiative (2021-2030) funded by the Government of Norway and coordinated by the Global Crop Diversity Trust. The project aims to strengthen food and nutrition security by preserving and utilizing crop diversity in genebanks. The study is a deliverable of the Genebanks and Seed Systems work package, led by the Norwegian University of Life Sciences (NMBU) in collaboration with the Alliance of Bioversity International and CIAT (ABC) in Uganda and the Tanzanian National Plant Genetic Resource Center (NPGRC). The research aimed to analyze the functioning of seed systems in Tanzania and identify strategies for improving smallholder farmers' access to and use of crop diversity.

The study offers a comprehensive overview of Tanzania's seed system by analyzing its primary components: variety development and management, seed production, seed dissemination, and seed governance. It examines the formal, national-level processes in place for the development, release, production and quality assurance of new varieties, as well as seed distribution. Additionally, the study investigates farmer-level dynamics by assessing the diversity of crop varieties present in fields and evaluating the seed security functions related to availability, access, quality, and varietal suitability. Finally, the analysis also considers the governance, legal, and regulatory frameworks that shape and guide seed systems in Tanzania.

Key informant interviews at the national level and focus group discussions in the districts of Liwale, Dodoma and Meru highlight several critical aspects of the country's seed sector. Notably, Tanzania possesses extensive genetic diversity utilized by farmers. The seed system is predominantly informal, with recent surveys indicating that 76% of farmland is planted with farm-saved seed.

NPGRC serves as Tanzania's primary public institution for conserving genetic resources, maintaining over 9,800 accessions of various plant genetic materials essential for food and agriculture. It also manages in situ conservation efforts and collaborates with 29 community seed banks (CSBs) that collectively preserve more than 163 different plant species. International organizations, such as the World Vegetable Centre, CGIAR genebanks, and the SADC Plant Genetic Resource Centre also maintain collections of various crops. These diverse genetic resources are crucial for developing new plant varieties.

CGIAR genebanks such as ICRISAT, CIMMYT, IITA, and Alliance of Bioversity International and CIAT (ABC), as well as national breeding institutions such as TARI and SUA. NPGRC and the regional and international genebanks collect, preserve ex situ, evaluate, and distribute germplasm of various crop species to researchers, breeders, farmers, and other users. For their part, TARI and SUA maintain germplasm, breeder seeds, and breeding lines in micro conservation facilities for their research and breeding work.

Despite the availability of these resources, there appears to be limited collaboration between NPGRC, other genebanks and the Tanzania Agricultural Research Institute (TARI). Many breeders tend to source genetic diversity through their own networks rather than utilizing the gene bank's collections. While TARI has the most important breeding programs in the country, private seed companies are increasingly playing a significant role in supplying commercial varieties in Tanzania, but this is mainly by importing varieties developed abroad.

Funding constraints significantly impact public breeding programs and the management of improved plant varieties. Although the Agricultural Seed Agency (ASA) and TARI are responsible for producing early generation seed (EGS), limited financial resources hinder the availability of EGS. Consequently, the private

sector often undertakes the production of EGS and foundation seed independently. The Tanzania Official Seed Certification Institute (TOSCI) is responsible for variety release and seed quality assurance in the country. To enhance efficiency and accessibility, TOSCI has implemented a decentralized system by training existing extension staff as Authorized Seed Inspectors specifically for quality assurance of quality declared seed (QDS). These operate similarly to extension officers, conducting basic certification assessments on behalf of TOSCI. This approach has improved the efficiency of inspections and reduced delays in seed certification.

In Tanzania, certified seed production is primarily undertaken by TARI, ASA and private sector companies. These entities often collaborate with farmer groups or individual farmers to multiply seeds for distribution. Despite these efforts, certified seed remains inaccessible to many farmers, accounting for only about 10-30% of the seed used, depending on the crop. Consequently, the country introduced the QDS class, which allows farmer groups, seed cooperatives, and community-based seed producers to multiply and sell seeds of registered varieties, thereby improving access to improved seeds. However, the QDS system primarily focuses on improved seeds of major crops such as maize, rice, wheat, and select legumes, limiting the diversity available to farmers. As a result, many farmers continue to rely on diverse local varieties, which are typically accessible only as farm-saved seed. Stakeholders have expressed the need to allow the registration of farmer varieties to enable their production through existing seed networks and subsequent commercialization. More recently, there is a gradual shift towards a flexible system that allows highly performing farmer varieties to be registered for commercialization. To this end, the government recently registered and gazetted 12 farmer varieties of maize and papaya through a ministerial order. This approach could significantly enhance access to diverse seeds while simultaneously improving livelihoods and food security. In summary, while initiatives like the QDS system have improved access to certain improved seed varieties, expanding the registration and support for farmer varieties could further enhance seed diversity and availability, contributing to greater agricultural resilience and food security.

An in-depth examination of local seed systems in Tanzania reveals that, despite the considerable crop diversity present in farmers' fields, there is an ongoing loss of genetic diversity. This decline is driven by factors such as climate change, market pressures, and changes in land use. Consequently, many traditional crop varieties are either threatened or have disappeared, leading farmers to depend on a limited number of varieties for household food security and income. This reliance on fewer varieties can increase vulnerability to pests, diseases, and environmental changes, thereby impacting agricultural resilience. Our study also finds that farmers predominantly rely on their own saved seed and social networks to meet their seed requirements, primarily due to factors such as proximity, availability, and affordability. These informal seed systems are crucial for smallholder farmers, especially in regions where access to formal seed markets is limited. However, the quality of farm-saved seed can be inconsistent, potentially affecting crop yields and overall food security. While Tanzania's local seed systems exhibit significant crop diversity, the loss of genetic diversity due to various factors poses a threat to agricultural sustainability. Strengthening informal seed systems and supporting initiatives that promote quality seed production are essential steps toward enhancing food security and farmer resilience in the face of these challenges.

The study recommends three main interventions to strengthen and improve seed systems. First, a ***Decentralized Integrated Seed System*** is essential. Engaging both farmers and breeders in participatory varietal selection fosters the exchange of knowledge and genetic resources. Decentralizing seed quality assurance processes is also critical for improving access to high-quality seeds. By involving local seed businesses, seed cooperatives, and community-based seed producers in QDS production, the availability and accessibility of quality seeds to farmers can be significantly enhanced. NGOs and other local community organizations can also be involved in seed dissemination and linked with TARI and private sector companies to improve access by many farmers.

To enhance Tanzania's seed systems, the study emphasizes the necessity of ***capacity development*** at both national and local levels. Locally, it is crucial

to provide community-based seed producers, seed cooperatives, and CSBs with the training and equipment needed for effective seed production and QDS initiatives.

At the national level, institutions such ASA and TARI require enhanced capacity to boost the production of EGS. This includes securing financial resources for variety maintenance and expanding seed multiplication efforts to satisfy national demand. Additionally, TOSCI should focus on training more Authorized Seed Inspectors specifically for QDS. This expansion is vital to effectively serve the country's diverse agroecological zones and to reduce transaction costs associated with seed inspection and certification. ***Multi-stakeholder platforms for innovative seed systems*** are proposed to help strengthen linkages between seed sector actors such as genebanks with research and with farmers and communities. By fostering collaboration, such platforms can improve seed delivery mechanisms and ensure broader reach, especially marginalized groups.

1 INTRODUCTION

1.1 Background

In Tanzania, agriculture employs about 65.5% of the workforce, contributes 28.7% to GDP (out of which crop sub-sector contributed 16.58%), 25% to export earnings, supplies 65% of industrial raw materials, and fulfills close to 100 % of the country's food needs[1]. Studies show that about 80% of Tanzania's farmers cultivate small, fragmented plots averaging 2.2 hectares, typically ranging from 0.9 to 4.1 hectares, with less than 4% of these farms irrigated, primarily for household food production (1, 2). Despite their key role in food production, smallholder farmers in Tanzania still face significant challenges to meet their food security needs, including severe climatic extremes such as drought, heavy rainfall and floods, unpredictable rain onsets, shortened seasons, temperature variations, strong winds, soil degradation, and increasing pests and diseases, all of which damage crops, reduce yields, and diminish food availability (3-6, 7-12). The effectiveness of seed systems utilized by Tanzanian farmers directly influences the range of crop species and suitable varieties accessible to them (13, 14), which is crucial for adapting to evolving climatic, socioeconomic, and environmental factors (9), including soil infertility, stabilizing crop yields, and enhancing productivity (15).

Tanzania's seed system is structured around a formal framework that integrates public institutions, private companies, and local seed initiatives to support seed production, certification, and distribution. The system is governed primarily by the Seed Acts of 1973 and 2003, which established the Tanzania Seed Company Limited (TANSEED) for seed production and marketing, and the Tanzania Official Seed Certification Institute (TOSCI) for quality control and certification (16, 17). Research and variety development are led by the Tanzania Agricultural Research Institute (TARI) and supported by academic institutions such as the Sokoine University of Agriculture (SUA). Policy and regulatory reforms—such as the Plant Breeders' Rights Act (2012), the TARI Act (2016), and alignment with SADC Harmonized Seed Regulations (18-20)—have encouraged private sector participation and regional integration. Private companies like Fica Seed, Tanseed International, and multinational firms (e.g., Monsanto, Pannar, Pioneer) complement public institutions in seed multiplication and marketing. However, recognizing the limitations of the formal system in reaching smallholders and ensuring crop diversity, Tanzania introduced the Quality Declared Seed (QDS) system to empower farmer groups and local seed enterprises at ward and district levels. This pluralistic approach strengthens local access to improved and locally adapted seed varieties while maintaining national oversight through quality assurance and regulatory bodies.

Despite significant investments in the formal seed system and pragmatic policy support for farmer-based QDS production and distribution of public crop varieties, the delivery of high-quality planting materials for both food security and cash crops remains constrained by limited access to foundation seed, challenges in seed inspection and testing services within the formal seed system (21). Additionally, despite their predominant role in supplying seeds to smallholder farmers, the lack of formal government policy and program support for farmers' seed systems underscores the need to explore technical and institutional innovations to strengthen an integrated seed system for increased seed security.

1 Based on estimates of various actors involved in Tanzanian agricultural development, such as the Food and Agriculture Organization of the United Nations (FAO), the Alliance for a Green Revolution in Africa (AGRA), and the World Bank Group.

1.2 Study objectives

The primary aim of this study was to propose strategies to strengthen connections between diversity holders—such as genebanks, agricultural research centers, farmer groups, and other seed system actors—to ensure sustainable access to various crop species and varieties for Tanzanian farmers. Based on the experiences and insights of diverse seed system actors at different levels, the study identified ways to improve key functions of the seed system—variety development, seed production, and seed distribution.

The first objective was to map and assess the roles, activities, and performance of seed system actors in Tanzania, identifying the strengths and weaknesses within the existing framework and detailing the current dynamics of seed governance. Second, the study examined farmers' seed systems in three selected sites, mapping crop diversity and seed sources and identifying farmers' seed security challenges. It considered cultural, political, climatic, market, and other factors influencing farmers' preferences and needs for crop varieties and seed types. Building on these findings, the third objective was to develop strategies to strengthen connections between seed system functions at both national and local levels.

Chapter 2 outlines the approach and methodology, including the conceptual framework, methods, and case study sites. Chapter 3 details the study's findings, including stakeholders' assessments of national seed system functions and local seed security outcomes. Chapter 4 discusses three proposals to enhance seed system linkages, focusing on long-term strategies for connecting diversity holders with downstream actors. Chapter 5 summarizes the main findings, offers key insights on improving coordination among seed system actors in Tanzania, and recommendations for short-term interventions.

Andrea Margwe (left) and Prisca Lulu (right) from the Rhotia CSB with maize seed ready to be distributed. The CSB markets their seeds through churches, village meetings, radio, and demonstration plots. Seeds are provided on a loan basis to local community members or sold to people in surrounding areas. Photo: Sarah Paule Dalle/NMBU

2 APPROACH AND METHODOLOGY

2.1 Conceptual framework

The study adopted a framework that conceptualizes the seed system as a structured, multilayered construct comprising interconnected components. It acknowledges the complexity and dynamism of the environment in which the seed system operates, involving multiple actors performing diverse functions within an integrated network (120). The way the actors interact and perform their functions may affect the functioning of the seed system and determine seed security outcomes, which ultimately also affect productivity and food security.

We recognize that in many developing countries, seed systems comprise both formal and informal components, each serving distinct yet complementary roles in meeting the diverse needs of farmers. The informal seed system includes activities related to the conservation, selection, management, exchange, and use of seeds by farmers themselves. This system remains the dominant source of seed in most developing countries—providing between 70% and 90% of the seed planted, including in Tanzania. Within the informal system, there are further distinctions such as farmer-managed seed systems and community-based seed production systems, both of which maintain a wide diversity of crops and varieties. These systems are largely governed by social norms, customary rules, and indigenous knowledge, reflecting deep cultural connections between farmers and their seed heritage. In contrast, the formal seed system is a structured and regulated framework in which varieties are scientifically bred, tested, and released following official protocols. It operates under specific legal and institutional regulations governing variety release, seed certification, and marketing. The formal system typically focuses on a limited range of major food and cash crops—such as maize, wheat, coffee, and tea—and involves a smaller number of actors, including public breeders, regulatory authorities, and private seed companies engaged in certified seed production and distribution. Together, these two systems form the backbone of seed supply in developing countries, highlighting the need for complementarity and coordination to ensure seed security, diversity, and resilience.

Our conceptual framework, adopted from Westengen et al. (22), acknowledges the different functions within any seed system (Figure 1) consisting of variety development and management, seed production, seed dissemination, and that these functions are influenced by seed governance and food system drivers. We consider that actors from both the formal and informal systems contribute to these functions, and that together, their performance affects farmers' seed security, which we view as the "outcome" of the seed system.

The first function, ***variety development and management***, includes conserving and utilizing plant genetic resources to ensure genetic diversity and adaptability in response to changing agricultural and environmental conditions, as well as the selection and development of new varieties. Farmers play a central role in variety development and management, serving as both custodians and innovators of agricultural biodiversity. Through traditional seed selection, exchange, and cultivation practices, they conserve and enhance genetic diversity on-farm (in situ). In the formal system, crop diversity is conserved ex situ in genebanks and botanical gardens, as sources to store genetic material for future use. Formal breeding programs develop new varieties through a range of scientific methods, which are subjected to procedures for variety release and registration before they can enter the market. Farmers, breeders, genebanks and other actors (NGOs, extension) sometimes also collaborate in "intermediate" or "integrated" approaches to variety development and management, such as community seed banking and participatory plant breeding.

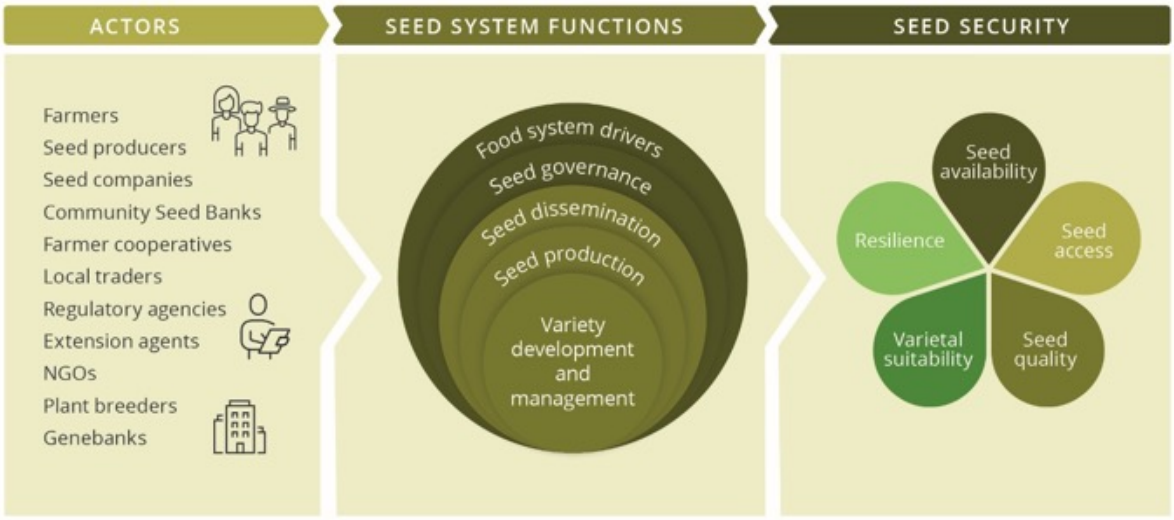

Figure 1. The conceptual framework for analyzing seed system actors' contributions to seed system functions and their seed security outcomes for farmers.

The second function, ***seed production***, supplies seeds produced through both formal and informal systems. In many countries, seed production is primarily carried out by farmers, who rely on indigenous knowledge and traditional practices for the selection, maintenance, and conservation of diverse crop varieties on their farms. The formal system focuses on production of certified seed of registered varieties, a process regulated by seed laws and regulations, resulting in seeds of high genetic purity that are then multiplied by private seed companies for distribution. Seed production can also be done through semi-informal arrangements, also known as integrated or intermediate seed systems, where community-based seed producers, local seed businesses, and community seed banks produce seed with groups of specialized farmers.

The third function, ***seed dissemination***, focuses on delivering quality seeds to farmers in an accessible and equitable manner. This process is facilitated through formal channels, such as participatory trials, certified seed distribution networks, private companies, and agro-dealers, as well as informal channels, such as community seed banks and farmer-to-farmer exchanges. Effective dissemination is supported by targeted extension services, awareness campaigns, and markets that provide farmers access to diverse varieties suited to their specific agroecological and socio-economic contexts.

Seed governance provides the regulatory and institutional framework that underpins the seed system. This includes policies and legislation for variety registration, seed certification, intellectual property rights, and quality standards, as well as mechanisms for monitoring and compliance. Seed governance also involves fostering collaboration among stakeholders, such as governments, research institutions, private companies, and farmer organizations, to ensure coordinated action. Policies that promote the participation of marginalized groups, including women and smallholder farmers, are essential for creating equitable and inclusive seed systems. Seed system governance in traditional local seed systems is largely rooted in community-based norms, social networks, and indigenous knowledge systems rather than formal legal or regulatory frameworks. Governance operates through customary rules and mutual trust, where farmers collectively manage the selection, exchange, and distribution of seeds. In these systems, informal institutions—such as farmer groups, kinship networks, and local markets—play a critical role in regulating seed flow and maintaining genetic diversity. Quality assurance is ensured not through certification but through farmers' experiential knowledge, reputation,

and continuous observation of seed performance across seasons. Women, in particular, often hold central roles as custodians of seeds and transmitters of related knowledge within families and communities.

Finally, our conceptual framework also considers the role of ***food system drivers*** that may affect seed system outcomes. These include broader social, economic, and environmental factors such as climate change, market demand, trade policies, population growth, and consumer preferences. For example, shifting climate patterns may drive demand for drought-tolerant and heat-resistant varieties, which in turn influences crops and varieties prioritized by breeding programs. Likewise, changing dietary trends may influence the types of crops grown by farmers and their adoption of improved varieties.

We use the FAO's (23) framework to assess farmers' ***seed security***, focusing on four parameters: 1) varietal suitability refers to the extent to which available crop varieties are preferred and adapted to farmer conditions; 2) seed availability examines if the quantity of seed available (from all sources) is sufficient to meet farmers' needs; 3) seed access considers whether farmers have the means to obtain seeds through cash, loan, barter, or gift, as well as access to information about the seed and where to obtain it; and 4) seed quality considers whether quality attributes such as germination, physical purity, moisture content, seed health, or genetic/varietal purity are acceptable to farmers.

The various seed system functions collectively determine farmers' seed security, which can be viewed as an outcome of the seed system. For example, robust variety development and management ensures that farmers can access diverse, high-quality, and climate-resilient seeds suited to local conditions. Effective seed production systems guarantee the consistent availability of viable seeds, while efficient distribution and dissemination mechanisms enhance affordability, reach, and timely delivery. Strong and inclusive governance structures are central to enforcing quality standards, protecting farmers' rights, promoting participation, and ensuring equity in access. Moreover, broader food system drivers, such as market dynamics, environmental pressures, and climate change, directly influence seed demand and availability, and shaping seed security outcomes. In this study, an analysis of how seed systems function and are governed is essential to understanding how these dynamics shape farmers' seed security and to design effective, context-specific interventions.

2.2 Data collection and analysis

The study utilized primary and secondary data to provide a comprehensive analysis. Primary data was gathered through qualitative methods, including stakeholder workshops, key informant interviews (KIIs), focus group discussions (FGDs), and document review. Data collection tools used are presented in the Seed System Toolkit.

An inception workshop held in April 2023 brought together 33 stakeholders from the seed system sector. Participants included representatives from genebanks, breeding programs, seed certification services, private seed companies, community seed banks, farmers' organizations, as well as local NGOs and CGIAR centers. The workshop facilitated discussions on the relationships and linkages between different seed system actors. A cross-linkage exercise conducted during the event provided valuable insights into the nature and dynamics of these relationships, highlighting critical connections between institutions such as genebanks, breeding programs, and farmer organizations.

KIIs served to understand the roles of different actors in the seed system, and discuss their views on strengths, weaknesses and opportunities in the seed system. Interviews were conducted with 51 actors (Table 1). These included breeders and researchers from the Tanzania Agricultural Research Institute (TARI) and the Tanzania Official Seed Certification Institute (TOSCI); as well as representatives from the Tanzanian Plant Genetic Resources Centre, which hosts the national genebank; universities such as SUA and the University of Dar es Salaam; agricultural extension officers from selected districts; non-governmental organizations (NGOs); and farmer organizations. Gender-disaggregated FGDs were conducted with farmers in the districts of Liwale, Meru and Dodoma, to characterize local farming systems and assess farmers' seed security situation. Participants included 45 farmers of whom 24 were female and 21 males (Table

2). Secondary data was sourced from past studies and reports on seed systems, relevant policy documents, and statistical data from various institutions.

Data analysis followed a twofold approach. First, a review of secondary information and government documents provided insights into the institutional and governance structures of Tanzania's seed systems.

Table 1. Total number of key informant interviews.

	Arusha	Liwale	Dodoma	Dar Es	Total
Men	27	7	9	0	43
Women	3	2	1	2	8
Total	30	9	10	2	51

Table 2. Farmers interviewed through FGDs for local seed system characterization.

	Arusha	Liwale	Dodoma	Total
Men	7	7	7	21
Women	8	8	8	24
Total	15	15	15	45

This was enhanced by data from Key Informant Interviews (KIIs), which highlighted key issues and challenges in coordinating actors within the formal sector, from genebanks to breeding, variety release, and seed dissemination. Second, data from Focus Group Discussions (FGDs) were analyzed to examine seed security issues faced by smallholder farmers in selected sites, offering insights into the diversity present in farmers' fields, how farmers access this diversity, and the challenges they face in maintaining seed security.

In February 2025, a three-day roundtable meeting was held with 11 key stakeholders (including the research team, public institutions and non-profit organizations engaged in the seed system) to review the research findings and discuss proposals and recommendations to enhance collaboration within the seed system and seed system outcomes. This process served as a validation of the present study and helped improve the report.

2.3 Description of study sites

The research was conducted in three districts in Tanzania—Chamwino, Liwale, and Arumeru—in the Dodoma, Lindi, and Arusha regions, respectively, as depicted in Figure 2 and described in Table 3. The criteria for selection of the study sites included the fact that they are representative of different agroecological zones in different regions in Tanzania, Central part represented by Dodoma, Southeast represented by Liwale and North central represented by Arumeru. All the sites have different land representing smallholder farmers with different land holdings and different farming systems as summarized in table 3 below.

Chamwino district in Dodoma region is located in the central plateau of Tanzania. The district has a dry savannah climate characterized by a long dry season from late April to early December and a short single wet season from December to mid-April. Average annual rainfall measures about 500mm, with approximately 85% of this precipitation occurring between December and March. The district experiences relatively low and erratic rainfall in frequency, amount, and distribution, especially during January, corresponding to the usual sowing period for most crops. Chamwino has dry and flat lowlands and is subdivided into two agroecological zones based on soil and climatic conditions for production purposes. About 70% of the total arable land is suitable for crop production, but only 44% of the acreage is utilized. Hence, the district has the potential for agricultural expansion. The forest and woodland areas in the district have significantly been dilapidated due to deforestation stemming from shifting cultivation, uncontrolled bushfires, overgrazing, and energy use. The agriculture and livestock sector constitutes the mainstay of the economy of the district and its population, providing income and employment and ensuring adequate food supplies. Only a tiny population is engaged in the commercial and industrial sectors. The latter sector is still limited to small-scale enterprises, including maize and oil mills, carpentry, and tailoring, mainly found at Chamwino and Mvumi Mission and trading centers. The cattle population accounts for about 20% of the regional cattle herd.

There has been a significant increase in the number of livestock in the district, partly due to the immigration of nomadic pastoralists into the area (24).

Liwale district in Lindi region lies in the tropical zone. The land is primarily flat, with a few areas with folded mountains. About two-thirds of the district is covered by the Selous Game Reserve. It has two rainy periods – a short one from late November to January and a longer one from March to May. Liwale experiences a dry season between July and October. The district does not have large rivers; it has seasonal ones that dry up during the prolonged dry season and drought periods. During those times, villagers travel long distances to find water (25). Rainwater harvesting is feasible using various means for most communities in the district. Major crops grown in the district include cashew, sesame, cassava, maize, millet, pulses (pigeon peas, cowpeas), groundnuts, sweet potatoes, and rice in the wetlands of the Kitere, Kinyope, and Ruvuma river basins. Cattle rearing is limited due to the infestation of tsetse flies. The Mimbo woodlands in the district are characterized by high tree species diversity, with some high-value timber species. Liwale district has high poverty rates and is amongst the areas targeted for livelihood alleviation programs. Factors contributing to poor productivity include poor distribution and unreliability of rainfall, lack of technology for agriculture, lack of sufficient farm inputs, i.e., fertilizers and pesticides, and tsetse infestation of livestock (26). Government priority potential investment areas in the district include seeking cashew nut processing, processing plants for sesame and sunflower, and establishment of sawmills due to the availability of timber as a raw material (27).

Meru district in Arusha region is characterized by undulating slopes ranging from 8% to 30% and intersected by rivers and streams, most of which originate from the forested areas where humidity is highest. This region's soil is predominantly volcanic and fertile, exhibiting a high base saturation and cation exchange capacity. The district experiences a bimodal rainfall pattern, with prolonged rains occurring from March to May and shorter rains from October to December. Typically, a lengthy dry spell prevails towards the end of January or early February, with two peaks of rainfall observed in December and April. Key crops such as maize, beans, potatoes, and vegetables are commonly traded in local markets, while livestock is the main source of income, food, and employment in most parts of the district. Arusha town serves as the district nearest major market center. Many women supplement their earnings by vending fruits, nuts, firewood, and medicinal products from trees and shrubs. The district has three agroecological zones: high-potential, medium-potential, and low-potential areas. High-potential areas, reliant on bimodal rainfall and specific temperature ranges, support intensive agricultural production, particularly in fertile, high-altitude regions such as the Eastern slopes of Mount Meru. Medium-potential zones have physical constraints for small-scale farming but still cultivate crops like maize, beans, coffee, and bananas alongside semi-extensive livestock systems. These areas receive slightly lower precipitation than high-potential zones. Low-potential areas, comprising plains at lower altitudes, exhibit drier conditions with less rainfall and more developed volcanic ash soil, suitable for less intensive agriculture (26, 28, 29).

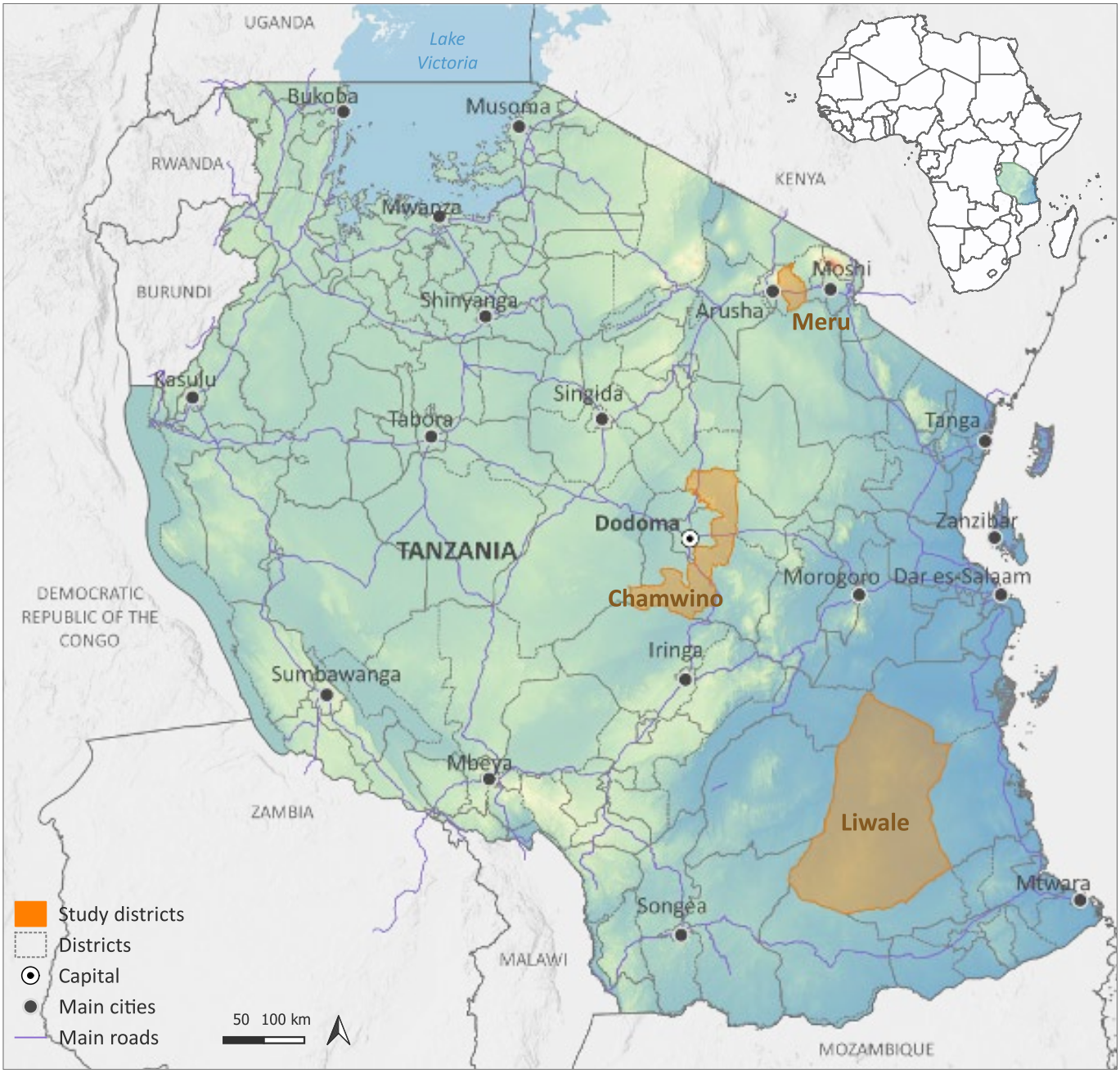

Figure 2. Map of study districts in Tanzania.

Table 3. Key characteristics of study districts.

Characteristics	Study districts		
	Chamwino	Liwale	Meru
2022 estimated total population	486,176	136,505	518,814
Ethnolinguistic group	Gogo	Mainly Ngindo. Other groups include Mwera, Yao, Ndonde, Mokonde, Ngoni	Waarusha, Wameru, Massai
Average landholdings (ha)	2.4 ha	1.6 ha (2007/8 agricultural census)	1 ha
Agroecology	Zone 1: Very dry, flat, undulating plain with a low population. It is almost entirely used for grazing except in the west where there is a tsetse fly. Rainfall could have been more reliable. Reddish-brown or dark loamy sands. Grey clay in depressions. Dark greyish brown loams in hills to the east. Zone 2: Flat, undulating hills in the south. Reddish-brown or dark loamy sands.	Predominant soil types are sands, loamy sands, and sandy loams; clay soils characterize valleys, while sandy-loamy soils are found in upland areas. Soils in the undulating plains have low fertility - top soils have low organic carbon.	Northern highlands. Three agroecological zones: high-, medium-, and low-potential areas. High-potential zones are mountainous and densely populated with fertile volcanic ash soils; medium-potential areas have browner, more fertile soils, while low-potential areas are relatively dry with more developed volcanic ash soils.
Farming systems	Agro-pastoral with livestock as a significant part of their livelihood systems.	Dominated by crop farming, limited mixed crop-livestock farming. Access to tree/forest resources, no pastoralists.	Crop/vegetable farming followed by livestock keeping/herding
Major crops	Sorghum, millet, maize, simsim, sunflower, groundnuts, tomatoes, onion, vines	Cashew, sesame, cassava, maize, millet, pigeon peas, cowpeas, groundnuts, sweet potatoes, rice	Maize, beans, potatoes, vegetables, bananas, pyrethrum, legumes, coffee, finger millet, sunflower, mango
Altitudinal ranges in meters above sea level (masl)	1000-1500	150–900	900-1500
Annual temperature ranges (^{0}C)	19-35	20-30	15-25
Annual rainfall ranges (mm)/Yr.	400-650	600-1000	500 -1200
Rainfall pattern	Unimodal	Bimodal	Bimodal
Access to irrigation	Yes (through dams, e.g., Buigiri Dam Irrigation Scheme and some cooperatives)	Yes, limited	Yes
Farmers' commercial orientation		High	High

Fresh okra, lemon, and peas displayed for sale by a vendor at the Central Market of Arusha, Tanzania. These crops represent key traditional vegetables available in urban markets, contributing to local dietary diversity and household income. Photo: Mubiru Daudi Mohamed/ABC

3 RESULTS

3.1 Functioning of the seed system: a bird's-eye perspective

3.1.1 Variety development and management

Variety development and management include conserving, breeding, cultivating, and maintaining diverse crop varieties in agricultural systems. In Tanzania, key actors in these processes comprise farmers, genebanks, plant breeding programs, community seed banks (CSBs), non-governmental organizations (NGOs), agricultural extension agents, and private seed companies, each playing specific (and sometimes overlapping) roles in this key seed system function (Annex 1).

Crop variety conservation

Tanzania is globally recognized for its remarkable biodiversity, with approximately 14,500 plant species and six designated biodiversity hotspots (30). This biodiversity extends to agriculture, where the country harbors a high level of agro-biodiversity that plays a crucial role in food security, ecological resilience, and rural livelihoods (31). However, in recent years, Tanzania has experienced a decline in agro-biodiversity due to the combined effects of climate change and shifts in land use (32, 33). These environmental and socio-economic changes threaten traditional seed systems and the availability of diverse crop varieties, which are essential for sustainable food production and adaptation to changing climatic conditions.

At the household level, farmers play a vital role in cultivating, selecting, and preserving diverse crop species and varieties, including neglected and underutilized species grown on farms (10, 34). Farmers' diverse economic, environmental, and socio-cultural conditions influence their prioritization of varieties based on preferred traits for cultivation and maintenance, contributing to the dynamic in situ/on-farm management of crop diversity (35, 36).

Along with farmers' on-farm management, several institutions in Tanzania maintain ex situ collections plant genetic resources for food and agriculture (PGRFA). A central actor in this regard is the National Plant Genetic Resources Centre (NPGRC) under the Tanzanian Plant Health and Pesticides Agency (TPHPA). NPGRC maintains an ex situ collection with 9,234 accessions in the national genebank, primarily landraces, and preserved 83 clones in 12 field genebanks and 20 in vitro cultures. It also supports in situ conservation efforts and serves as Tanzania's national focal point for the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Other institutions involved in ex situ conservation in Tanzania include regional and international genebanks such as the SADC Plant Genetic Resource Centre (SPGRC), the World Vegetable Centre in Arusha (World Veg), and CGIAR genebanks such as ICRISAT, CIMMYT, IITA, and Alliance of Bioversity International and CIAT (ABC), as well as national breeding institutions such as TARI and SUA. While NPGRC and the regional and international genebanks collect, preserve ex situ, evaluate, and distribute germplasm of various crop species to researchers, breeders, farmers, and other users, TARI and SUA maintain germplasm, breeder seed, and breeding lines in micro conservation facilities for their research and breeding work.

There are various collaborations between these genebanks. For example, SPGRC holds 40% of Tanzanian NPGRC accessions as safety duplicates, which they multiply (e.g., it multiplied 123 accessions in 2023) and characterize (e.g., 44 accessions in 2023). Additionally, SPGRC collaborates with NPGRC on joint germplasm collections and provides training and technical support for establishing field genebanks, characterization, and regeneration to Tanzanian staff (37). Similarly, CGIAR genebanks and World Veg conduct joint collecting missions with NPGRC

to conserve and ensure the safety duplication of NPGRC germplasm. For instance, between 2021 and 2022, World Veg together with NPGRC collected 1,200 accessions of vegetable landraces, conserving them in two copies in both genebanks (NPGRC and World Veg) while also providing continuous capacity building for NPGRC (38, 39).

At the community level, NPGRC, ABC and various national NGOs have collaborated since 2016 to support farmers in managing traditional varieties on-farm and linking them with ex situ conservation at the genebank. These organizations collaborate to train farmers to develop checklists documenting their crop varieties, traits, and utilization values for conservation, and raises awareness among farmers, communities, researchers, and other PGRFA users through seed fairs and training, promoting crop diversity appreciation and maintenance (40). More recently, there have been significant efforts to support farmers' groups across Tanzania to establish community seed banks (CSBs) to conserve, improve, and distribute diverse traditional crop varieties at the local level. Since 2019, 29 community seed banks (CSBs) have been established to promote underutilized crops such as bambara nut, finger millet, sorghum, sesame, pearl millet, pumpkin, eggplant, and amaranth. Five of these CSBs were founded by MviwaArusha[2]—a network of 446 farmer and pastoralist groups across six districts in Northern Tanzania—with support from the NGO Islands of Peace.

In cooperation with the NPGRC, CSB groups collect crop varieties from their localities and neighboring areas for conservation, multiplication, and distribution within their community. NPGRC also helps secure these collections by depositing safety duplicates of CSB holdings at the national genebank (41). According to our informants at NPGRC, 33 crop species, including six wild fruit tree species, have been preserved by the CSBs. However, the species diversity and the number of varieties they conserve vary from one CSB to another. For example, Rhotia, Kambi ya Simba, and Slahmo CSBs in the Arusha region conserve 91, 77, and 65 accessions of different crop species, respectively. Inspired by these successes, the government aims to establish 100 CSBs nationwide by 2030 under the National Ecological Organic Agriculture Strategy (2023–2030) to strengthen farmers' seed systems (42). Despite these efforts, NPGRC faces challenges related to limited human, infrastructure, logistical, and financial resources that hinder the effective exploration, collection, conservation, and use of PGRs. For example, a recent review of the national genebank (41) found that NPGRC has insufficient documentation of the extent of genetic erosion in the country (to guide its collections) and only 25% of its collections were characterized by 2023, and the NPGRC's collection covers just one-quarter of Tanzania's unique local PGRs. Furthermore, over the past five years, about 284 seed samples were distributed annually within the country and about 207 internationally, indicating that only 2% of the collection was distributed annually, reflecting minimal use of conserved materials. Our interviews suggest that breeders often obtain their breeding materials from breeder networks and CGIAR genebanks rather than relying on the national genebank. The 2015-2020 National Biodiversity Strategy and Action Plan has also highlighted the need for multiplication and increased direct germplasm sharing with farmers, but this has not been fully implemented. To increase use of the collections, the same review underscored the necessity for NPGRC to broaden its activities by expanding joint demonstrations, participatory evaluation, and testing of crop varieties in diverse agroecologies.

Plant breeding and variety development

Tanzania's crop improvement has traditionally followed a linear model within the formal seed system. Since the 1970s, the Tanzania Agricultural Research Organization (now TARI), and SUA focused their breeding efforts primarily on a few crops with extensive support from external development partners (43-45). This enabled TARI to develop and release 221 improved

2 Full name: Mtandao Wa Vikundi vya Wakulima na Wafugaji Mkoa wa Arusha

varieties of different crop species between 2001 and 2017 (44). SUA has also played a crucial role in training plant breeders, plant geneticists, agronomists, and conducting research.

Since 2016, Tanzania's research systems have been decentralized throughout the country. Through its nine main centers and eight subcenters, TARI's crop improvement programs now target a broader range of crop species adapted to different agroecological zones. Breeding objectives include development of pest-resistant, disease-resistant, and micronutrient-enriched crops (e.g., legumes with enhanced iron and zinc and maize with elevated Vitamin A), as well as varieties with shorter maturity periods for dry areas. International organizations such as World Veg, CIMMYT, ABC, ICRISAT, and Africa Rice Center also contribute significantly to this work by facilitating access to a wide range of crop germplasm and collaborating with TARI in plant breeding, and variety development (39, 45-50).

While varietal development is central to its role, TARI is also mandated to commercialize its varieties and ensure their rapid dissemination to farmers to boost agricultural productivity, food, and nutrition security, and export earnings (19, 51). In addition, it conducts final adaptation testing of finished or semi-finished varieties from other public research institutions, including several CGIAR centers, before releasing them.

Private seed companies are increasingly playing a significant role in supplying commercial varieties in Tanzania. However, few companies conduct plant breeding and develop their varieties within the country despite a favorable seed policy and regulatory framework. Instead, many companies breed and develop varieties abroad, then import them for adaptation trials and promotion before commercialization. The Tanzania Official Seed Certification Institute (TOSCI) has registered 1,054 improved public and private varieties across several crops released between the 1950s and 2024 (52).

TARI has developed some new approaches in its crop improvement work, such as the Farming System Approach and the Client-Oriented Research and Development Management Approach, both aimed at better meeting the needs of end-users (44). However, until recently, farmer participation in plant breeding in Tanzania has typically been limited to the use of participatory rural appraisal to understand farmers' preferences for breeding priorities (53-56) and on-farm trials of finished improved materials for assessing and selecting crop varieties with traits such as nutritional content, yield, and economic potential (57, 58). This contrasts with countries such as Uganda and Ethiopia, which have developed public, private, and community partnerships to improve minor crops through active farmer participation (59, 60).

Despite this, a few small projects recently supported by the UN-FAO have adopted more active participation in plant breeding (61, 62). Furthermore, organizations like ABC and World Veg, in partnership with TARI, have introduced the Tricot (triadic comparison of technology options) approach to conduct participatory on-farm crop variety trials with farmers in Tanzania (63-67). This initiative began in 2010 as part of the "Seeds 4 Needs" project, which provided farmers with diverse crop germplasm from genebanks for evaluating and selecting suitable varieties (65). Tanzania is now a leading country in implementing the Tricot approach at scale, with 1,804 trials conducted in 2023: 953 for sorghum, 599 for groundnut, and 252 for common bean. Two Tricot varieties from the groundnut program and one from the first sorghum program are expected to be released in 2024 (67). Formal policy support and a flexible seed regulatory regime in participatory variety development, such as the recent Tricot approach by CGIAR centers, could significantly impact this area.

Plant breeding programs in Tanzania face significant challenges, including limited access to irrigation facilities, limited budgets, inadequate advanced laboratory facilities for genomic research, and, according to key informants, the occasional appointment of breeding program leaders who lack expertise or relevant research backgrounds in the specific crops they oversee.

3.1.2 Seed Production

Here we discuss the strengths, challenges, and opportunities related to the production of different types of seed including farm-saved seed, certified seed, and QDS. While production of farm-saved seed

is not regulated, certified seed and QDS seed must meet the standards of Tanzanian seed legislation for their respective seed classes.

Farm-saved seed

Tanzanian farmers' seed systems, which rely on individual households and, to some extent, community-based producers like farmer groups and CSBs, generate most of the seed diversity and volume used in the country. Recent surveys indicate that 76% of farmland is planted with farm-saved seed (68), and over 80% of the total seed volume in Tanzania comes from these farmer-managed systems. However, this coverage varies from crop to crop (14, 21, 69, 70). Farmers rely on local knowledge and traditional practices for production, storage, and quality control. Production is generally focused on landraces, farmer-selected/enhanced varieties, and open-pollinated improved public varieties.

Farm-saved seed in Tanzania is often of poor quality though this varies by crop and among farmers. Vegetatively propagated root, tuber, and banana (RTB) crops tend to be particularly vulnerable to disease transmission (71). In Tanzania, farm-saved cassava tubers have been found to have 7 times higher disease incidence than in certified seed (72). However, in cereal crops, some studies of farm-saved seed in Tanzania found that farmers' seed met at least some national quality standards[3]. For example, farm-saved rice seed in Tanzania was found to be on par with seed from formal sources, meeting national standards for moisture content and germination, but not for genetic purity (73). In Tanzania's Lake zone, farm-saved maize seed also met moisture content standards but 85% of samples failed to meet those for germination and more than half were below standard for genetic purity (74). While CSBs have begun restoring and multiplying rare varieties with NPGRC and NGO support, their output remains limited due to inadequate skills, funding, and technical capacity. For example, as reported by a key informant, even two of the best-performing CSBs, Rhotia and Slahmo, have only managed to produce around 600 kgs of various crop species, including open-pollinated maize and beans. However, this appears to be increasing, as on a visit to Rhotia CSB in early 2025, members reported selling 1200 kg in 2024.

Early generation seed

Early-generation seed (EGS) comprises breeder, pre-basic, and basic classes, each being the progeny of the former. Basic seed is used as the foundation to produce both certified seed[4] and QDS.

Several actors are involved in the production of EGS. TARI maintains breeder seed of public varieties and also produces pre-basic seed on its farms and sometimes through trained farmers groups (75). The pre-basic seed is primarily sold to ASA, which multiplies them into basic seed. Some TARI centres also produce basic seed. These are then sold to seed companies, local seed businesses (LSBs) and cooperatives, for the production of certified seeds and QDS. Other public breeding institutions, such as World Veg and CGIAR centers, also produce and sell basic seeds.

Private seed companies produce all EGS of their own varieties. In addition, since 2011, private companies have been licensed to produce basic seeds of public varieties, promoting public–private collaboration (76, 77). For instance, Crop Bioscience Solutions Ltd produces basic seeds of bean for ASA and provides vegetative clones and tissue culture materials for crops like potatoes, cassava, and bananas.

Actors requiring EGS from TARI must submit their demand at least one growing season in advance, although this requirement is not consistently met. A 2021 study (14) found that TARI often fails to fulfill the demand of certified seed producers for many crop varieties, and that TARI's breeding programs face funding shortages and limited storage and irrigation infrastructure, constraining sustained breeder and

3 Although farm saved seed is not required to meet these standards, these are commonly used to assess seed quality. This said, farmers' own quality standards may differ.

4 There are two classes of certified seed; the first generation is called "certified 1", while the second is "certified 2". For hybrid maize only one generation (cross) is produced.

pre-basic seed production. The same study also highlighted that overlap and potential competition between TARI and ASA, may restrict ASA's access to pre-basic seed, limiting certified seed supply. Bottlenecks in EGS supply limit are reported to be especially important for vegetatively propagated crops like cassava, banana, and potatoes.

Certified seed

Since its establishment in 2006, ASA has been Tanzania's main public institution producing certified seeds across multiple agroecological zones. Operating five farms and collaborating with over 40 out-growers, ASA focuses on crops often overlooked by private firms, including cereals, oilseeds, legumes, and vegetatively propagated crops. It also imports certified seeds for local distribution. Occasionally, TARI also produces certified seeds of varieties that are not produced by seed companies. There is also an increasing number of private seed companies in Tanzania. According to TOSCI, Tanzania has 218 registered seed companies, 65 of which are currently active (68, 78). Since the mid-2000s, the private sector has supplied over 80% of certified seeds (77), with over 70% of these being imported (79).

Seed production occurs through company farms, out-grower contracts, and partnerships with local seed businesses and farmer organizations such as MVIWATA and Tanganyika Farmers Association. Larger companies possess advanced processing and storage facilities. All certified seed producers face major challenges, including limited land, irrigation, and demand forecasting for basic seeds (68, 77). The Tanzania Seed Trade Association (TASTA) advocates for stronger policies to expand domestic production and reduce import dependence.

Quality declared seed

In the early 2000s, Tanzania introduced flexible seed quality control measures to increase farmers' access to and use of good quality seed. The 2003 Tanzanian Seed Act defines QDS as seed produced by registered smallholder farmers that meets specific standards and undergoes prescribed quality control as defined under the 2020 QDS Regulations (80). Unlike in some countries where QDS bridges formal and informal systems, in Tanzania it is categorized as part of the formal seed system. The 2020 regulations authorize registered small-scale farmers or cooperatives—but not seed companies—to produce and sell QDS locally within their districts, under TOSCI supervision (81).

QDS production focuses on open-pollinated varieties (OPVs) such as beans, rice, sorghum, sesame, sunflower, and groundnut, but is limited to date for RTB crops. The number of growers, as well as the diversity and quantity of QDS, continues to rise in many districts, especially for rice, legumes, and African indigenous vegetables like amaranth (21, 82). Between 2015 and 2019, production rose from 188 to 343 metric tons, with rice comprising about 75% of the total QDS output (21, 82). For groundnut, QDS contributed more than 85% of all seed categories produced in 2018 (83).

QDS has improved access to quality seed, crop diversity, and smallholder income. However, challenges persist, including inadequate irrigation, pests, limited supply and long distances to access basic seeds, insufficient funding, poor storage, delayed certification. QDS producers still face difficulties meeting strict certification standards. Moreover, only officially registered improved varieties can be marketed, excluding farmer varieties. Despite these constraints, QDS remains crucial for strengthening community-based seed systems, supporting local seed supply, and enhancing food and nutrition security through increased availability of affordable, good-quality seeds.

3.1.3 Seed dissemination

Seed dissemination includes various ways of exchanging seeds and associated information and knowledge among households, communities, regions, and countries (22, 84). This exchange occurs through market and non-market mechanisms and involves both informal and formal channels. Formal channels operate within a structured system managed by TOSCI, which oversees the distribution of certified seed and QDS.

Informal seed dissemination involves both sale by grain traders and in local markets, as well as loans, gifts, bartering, or exchanges in-kind (seeds of another crop or variety) through social networks, mediated through kinship, ethnolinguistic ties, and other social

relations (13, 85-87). Between 70-90% of seeds used by Tanzanian farmers are disseminated through informal channels. Farm-saved seed is generally preferred by farmers due to their availability, affordability, trust in the source, familiarity with crop varieties, and local adaptation, although sometimes affected by poor quality.

CSBs are a new player providing access to diverse seeds to farmers within their localities. They use different methods, such as saving and exchanging seeds within the group, organizing seed fairs, providing seed loans, and selling to other farmers. CSBs sell their seeds as grains since it is prohibited to sell them as seeds by the country's seed law (121). Farmers from one CSB explained that they market their seeds through churches, village meetings, radio, and demonstration plots. They have also sent orders by bus and received payments with mobile transfers.

Dissemination of certified seed is dominated by private companies, accounting for about 80% of total distribution, with approximately 85% of seeds—mainly maize, vegetables, and sunflower—imported from Kenya, South Africa, Zambia, and Zimbabwe (88). Locally produced seeds come from both private and public institutions and are marketed directly, through agro-dealers, or via government input subsidy programs such as the National Agricultural Input Voucher Scheme (NAIVS) (88, 89). The number of registered agro-dealers has increased significantly—from about 2,000 in 2013 to over 7,000 by 2020, improving access but still leaving 30% of farmers over an hour from a seed supplier (68, 88). Private companies now tailor seed package sizes to suit different farming scales, ranging from smallholders with less than five hectares to large-scale commercial farmers. Humanitarian organizations also distribute subsidized seeds in remote areas.

TASTA plays a vital role in coordinating and professionalizing the sector. It trains agro-dealers, promotes collaboration between companies and government extension services, and advocates for input subsidies and policies that support domestic seed production. Despite progress, challenges persist, including limited agro-dealer coverage in remote areas, high seed prices, counterfeit seed circulation, delays in importation, and inadequate post-harvest storage (13, 14, 88, 90). Stakeholders emphasize the need for stronger regulation, broader agro-dealer networks, price stabilization, and improved farmer education on the benefits of certified seed.

QDS produced by registered smallholders and farmer groups, is sold directly by these producers within local districts, offering affordable alternatives to certified seed. This is especially important in in remote areas where seed companies and their agro-dealers have limited presence. Challenges related to QDS dissemination include unsustainable support for QDS producers from NGOs and donors, restricted marketing, as well as fluctuations in market demand for grain, such as export legumes, which affects the viability of farmers' seed businesses (14).

Access to information and agricultural extension

Access to information and knowledge about crop varieties and their traits and management, as well as where to access them (seed sources) are an important aspect of seed dissemination. While farmers exchange knowledge through social networks, a number of different actors are also involved in providing agricultural extension and other information.

Tanzania's agricultural extension system has evolved from a centralized, government-led model to a decentralized and pluralistic structure involving public institutions, private companies, NGOs, and community-based organizations (91, 92). Public extension officers, trained nationwide, educate farmers on agronomic practices and the use of improved varieties. The Ministry of Agriculture aims to deploy 12,319 officers—currently achieving 54% coverage—to strengthen farmer training and technology adoption. Private companies employ their own extension staff to assist certified seed producers and promote their products through demonstration plots, field days, seed fairs, as well as dissemination of promotional materials and media outreach to enhance awareness of new varieties (75). National events like the annual "Nane Nane" agricultural exhibitions attract hundreds of private and public seed actors. NGOs provide training on seed saving, exchange, and agroecological production, organize seed fairs, and support QDS producers together with TOSCI and ASA.

Collaboration among TARI, ASA, private seed companies, and NGOs provides farmers with information about quality seeds and technical support. However, conflicting messages from different actors sometimes confuse farmers instead of enabling informed seed choices (91, 92).

3.1.4 Seed governance

Here we analyze key governance issues related to the three key functions reviewed above. These include access and benefit sharing of plant genetic resources, variety release and registration, intellectual property rights, regulation of seed production and distribution, and the status of farmers' seed systems within the national policy. Key policies and regulations discussed here are summarized in Table 5.

Access and benefit-sharing of plant genetic resources

Access and benefit-sharing (ABS) refers to the way genetic resources—and the traditional knowledge associated with them—are accessed, and how the benefits arising from their use are shared fairly and equitably. It aims to ensure that countries and communities providing these resources receive appropriate compensation, support, or partnership (93).

At community level, local customs govern the free flow or saving, reusing, exchanging, giving, and selling seeds of landraces, farmer-improved varieties, and unprotected improved varieties. These practices shape local access and facilitate both market and non-market exchanges, including reciprocal payments in labor, money, or in-kind (seeds) among neighbors, friends, and family, enabling them to manage diversity and benefit each other collectively (94).

At national level, Tanzania has ratified the Convention on Biological Diversity, the Nagoya Protocol on Access and Benefit Sharing (ABS), and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which in principle govern access and benefit sharing to genetic resources in the country. However, Tanzania has not yet developed the national ABS policies and frameworks it targeted for completion by 2020 in the 2015 National Biodiversity Strategy and Action Plan and the National Ecological Organic Agriculture Strategy (2023). This absence of formalized frameworks hampers the operationalization of ABS under the ITPGRFA and the Nagoya Protocol. Indeed, there is currently no specific national law that protects farmers' rights or the access to and benefit-sharing from commercializing the plant genetic resources they conserve and share with commercial actors.

Although there is no designated authority or standardized process for distributing Annex I crops of the Multilateral System to international users, NPGRC facilitates germplasm distribution by utilizing the Standard Material Transfer Agreement outlined in the ITPGRFA. As reported by NPGRC, access to genebank collections is free upon written requests for national users, including farmers. Access to other genetic resources (non-PGRFA) requires a government permit based on Prior Informed Consent and negotiation for Mutually Agreed Terms with genetic resource holders (e.g., a community) in collaboration with the Tanzanian Ministry of Environment (95). These formal procedures are primarily intended for international users, though their implementation is uncertain (96). The Division of the Environment within the Ministry of Environment, headed by a director who also serves as the focal point for all Multilateral Environmental Agreements, coordinates biodiversity matters with sector ministries and plays a crucial decision-making role. A Nagoya Focal Point is appointed in the Vice President's Office (97).

As a member of the ITPGRFA, Tanzania has received support in two cycles of the ITPGRFA Benefit Sharing Fund. In the first cycle (2009-2011), NPGRC received funding to strengthen on-farm conservation and use of sorghum, finger millet, lablab beans, and yam diversity for improved food security and climate change adaptation. In the third cycle (2016-2020), Tanzania participated in a project led by ABC entitled "Promoting Open Source Seed Systems for beans, forage legumes, millet, and sorghum for climate change adaptation in Kenya, Tanzania, and Uganda" (61). The project facilitated the exchange of 400 accessions of beans, finger millet, and sorghum among the three national genebanks using SMTAs. Participatory variety selection was conducted in four locations with diverse climate profiles, and the resulting varieties were integrated into farmers' seed systems through CSB initiatives (62). In the same cycle, TARI's Mikocheni

Agricultural Research Institute also received support to characterize cassava germplasm for resistance and tolerance to various biotic and abiotic stresses in collaboration with sister institutes in Kenya and Spain. The institute applied marker-assisted selection to develop new cassava varieties adapted to these stresses. About 1,500 farmers received improved cassava materials, and both farmers and partners were provided with training, awareness, and capacity-building skills in marker-assisted selection and other molecular techniques (61).

Variety release and registration

The variety release and registration process in Tanzania is harmonized with international (98) and regional standards (99) through the 2003 Seed Act (80) and its 2014 amendments, associated regulations (100), and the Plant Breeders' Rights Act (18). The seed regulation requires that any new variety undergo Distinctness, Uniformity, and Stability (DUS) tests over two seasons to ensure it is distinct from existing registered varieties. Additionally, the Seed Act requires the variety to pass a National Performance Trial (NPT), also known as Value for Cultivation and Use, to assess its competitive advantage for the traits it was bred for. Together, these evaluations are used to assess the variety's suitability for release on the market. The DUS and NPT results are reviewed by several committees (NPT Technical Committee, National Variety Release Committee and the National Seed Committee), and if approved, the variety is registered and published online in the National Plant Variety Catalogue.

The Seed Act mandates TOSCI to conduct the DUS and NPT tests. According to the 2023 Amendments to the Seed Regulations (101), breeders must apply to TOSCI for DUS testing, paying a 1,200,000 TShs application fee one year before applying for the NPT. For the NPT test, they first need to document yield trials at three recognized testing sites (multilocation trials) for two seasons and at least one on-farm trial in relevant agroecological zones to gather data for informed decision-making. TOSCI conducts the initial DUS test and issues a certificate. Following this, breeders must apply for the NPT, providing the multilocation trial data and sufficient seed samples. The NPT is conducted over one season across three locations through TOSCI's branches in the recommended agroecological zones, with a 1,400,000 TShs fee required from the applicants. This process highlights the lengthy nature of the variety release procedure, particularly in areas with limited irrigation facilities, making it difficult to grow crops twice a year.

According to a 2016 study by the New Markets Lab (76), delays in the variety registration process are frequent since the NPT Technical Committee, National Variety Release Committee, and National Seed Committee are only mandated to meet once a year, sometimes less due to resource constraints. This study found that delays can be worsened due to mistakes caused by inadequately skilled staff, testing centers, and facilities, resulting in fewer variety releases. The authors report that breeders often struggle to trust the system, and have called for a more transparent tracking system and improved communication to build trust between applicants and TOSCI (76). During interviews conducted in 2023, a key informant from a seed company confirmed these ongoing issues.

The harmonization of regional seed regulations in Africa (102, 103), supported by major donors such as the World Bank, United States Agency for International Development, Bill and Melinda Gates Foundation, Syngenta Foundation, and AGRA, also impacts Tanzania's variety release and registration process. The objective is to reduce trade barriers, streamline procedures, lower costs, enhance sanitary and phytosanitary controls, standardize quality measures, and boost trade. Proponents argue that harmonization also encourages private investment in plant breeding and the development of new varieties, as well as the movement and availability of elite varieties to farmers (103-105).

Although Tanzania withdrew from the Common Market for Eastern and Southern Africa (COMESA) in 2000, it remains actively involved in two regional trade and agricultural agreements through the East African Community (EAC): the legally binding Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) agreement and the non-legally binding 2008 Southern African Development Community (SADC) harmonized seed regulatory system.

Each agreement has slightly different mechanisms to facilitate variety registration across member states. On the one hand, the SADC system allows a plant variety to be registered in the SADC Regional Variety Catalogue once it has been released by any two member states, enabling it to be marketed across all member states without further testing or restrictions (20). Individual member states may reject a variety if it is not suited to their specific agroecological conditions, and Tanzania is particularly concerned that some regional varieties may not perform well within its borders, according to a legal guide published by AGRA (76). On the other hand, the ASARECA agreement allows a variety registered in one member country's catalogue to be released and registered in another member country after just one season of domestic NPT testing, provided sufficient and appropriate test data is available (105).

Tanzania's 2003 Seed Act effectively implements the ASARECA agreement, enabling varieties released in harmonized member countries to enter the Tanzanian market following a single season of verification (103). However, reconciling ASARECA's variety release process, which requires only one season of NPT verification (and is non-binding), with the SADC system, which allows a variety to be included in the regional variety catalogue if it has been registered and released in two member countries (and is binding), presents a challenge for Tanzania. In addition, while the SADC system includes a regional variety catalogue, ASARECA's catalogue has yet to be realized (76).

To implement these regional regulations, Tanzania amended its 2007 Seed Regulation in 2023, adding a sub-regulation that states, "any variety released and registered in Tanzania pursuant to the [country's regulation] and any other variety registered under an agreement for harmonization of seed policy and legislation with Tanzania shall be eligible for certification," thereby paving the way for all registered varieties, including those on the regional catalogue, to be marketed in Tanzania. Despite this, implementation delays persist, as noted by key informants. Both regional seed regulation harmonization efforts require that member countries have plant breeders' rights legislation while considering farmers' rights (105). This has sparked significant resistance from civil society and farmers' organizations over the past few decades, as discussed below (106-109).

Intellectual property rights

In Tanzania, intellectual property rights for crop varieties are governed by the Plant Breeders' Rights (PBRs) Act of 2012 (18) and the PBRs Regulations of 2018 (110), both aligned with the UPOV[5] 1991 Convention, which Tanzania joined in 2015. These frameworks harmonize the country's legal system with regional initiatives such as the EAC-ASARECA and SADC harmonized seed regulatory systems. Together, they promote investment in plant breeding, seed production, and certified seed marketing, while also influencing farmers' access to improved seed varieties. The main goal of granting PBRs is to encourage breeders to develop and release better-adapted varieties for local and regional markets. However, in complying with UPOV 1991, the 2012 PBR Act excluded several provisions from the 2002 Act that it replaced, that helped balance farmers' and breeders' rights (107, 111).

The PBRs Office, under the Ministry of Agriculture, serves as the central regulatory body overseeing application, examination, and enforcement. Applicants, including private breeders, public research institutions, and farmers—must submit untreated seed samples, a unique variety denomination, proof of genebank deposit, and a fee of USD 200.

The Tanzania Official Seed Certification Institute (TOSCI) conducts DUS tests to confirm varietal uniqueness and stability. Through regional and international agreements such as UPOV and ARIPO[6], Tanzania accepts DUS data from accredited institutions abroad, enabling mutual recognition and reducing duplication of testing. After technical review, the PBRs Advisory Committee recommends approval or rejection. Approved varieties are registered, published in the national Gazette, and issued a certificate, granting

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exclusive commercial rights to the breeder. These rights cover multiplication, production, marketing, export, and import, and infringement can lead to legal action. Maintaining these rights requires an annual renewal fee of USD 200 and a certificate fee of USD 240, which can make protection costly, particularly for local breeders (76).

While the system supports innovation and private-sector participation, it has drawn criticism from civil society and farmer organizations (111, 112). Tanzania's PBR regime is viewed as conflicting with commitments under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and the UN Declaration on the Rights of Peasants (UNDROP), both of which safeguard farmers' rights to save, exchange, and sell seeds. Current PBR rules restrict these customary practices for protected varieties, creating tension between breeders' incentives and farmers' seed systems.

Despite these debates, Tanzania's PBR framework has contributed to a surge in new variety registrations, especially from private seed companies. An analysis of the National Plant Variety Catalogues shows that public institutions such as TARI continue to focus on staple crops—cereals, legumes, and oilseeds—while private companies dominate hybrid maize, fruit, and vegetable breeding (Table 4). Registrations by private companies appear to have spiked since 2018, coinciding with the implementation of the 2018 PBR regulations, as well as the 2017 amendment exempting vegetables from Value for Cultivation and Use testing (113, 114). While we lack data on how many varieties in the National Catalogue have plant variety protection, it seems likely that these reforms have stimulated greater private-sector engagement and diversified the national seed market. This diversification can be seen as a positive outcome which should be considered in discussions about farmers' rights and their seed systems.

Regulation of seed production and distribution

The production, import, export, and marketing of all certified and QDS seed classes in Tanzania are well-regulated. Informants from the formal seed sector expressed satisfaction with recent improvements in seed-related laws and regulations despite lacking a national seed policy. Strengthened seed and planting material regulations are seen as part of broader institutional innovations aimed at fulfilling the national development vision (115) .

The TARI Regulations 130, outline TARI's mandate to develop new crop varieties, multiply, distribute, and sell seed, and establish agreements with registered seed dealers to disseminate early-generation seed (EGS)—specifically pre-basic and basic seed—in exchange for royalties. These regulations strengthen the private sector's ability to access public varieties through licensing agreements, building on the 2011 MAFC circular that encouraged public–private partnerships in EGS production. The TARI Act, supported by the Local Government Act (116) and the Executive Agencies Act (117), enables district councils and agencies such as the ASA to establish seed farms, promote improved varieties, and produce affordable basic seed for certified and QDS producers.

In 2003, Tanzania's Seed Act (80) established TOSCI as the primary institution responsible for providing services to national and international actors in seed production and marketing in line with the 2007 Seed Regulations (100). TOSCI is mandated to register seed dealers, oversee field and seed inspections, conduct testing, and regulate certification in line with international standards. TOSCI is also responsible for overseeing QDS production, in accordance with the 2020 QDS Regulations (80) which specify registration procedures, production standards, inspection requirements, and service fees for QDS. TOSCI inspects at least 10% of QDS fields, while local agricultural officers monitor compliance. However, despite progress, TOSCI faces challenges related to limited personnel, facilities, and decentralization capacity.

Seed import and export operations are subject to phytosanitary certification, following OECD and International Seed Testing Association (ISTA) standards

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Table 4. Major improved crop varieties registered by private companies and public breeding programs, as of 2022. Color codes: green = higher number of private sector registration; orange = higher number of public sector registrations; grey=first registration after 2018. Source: https://www.tosci.go.tz/seed-varieties

Crop category	Crop	Number of varieties registered			First year of registration*
		Total	Private sector	Public sector	
Cereals	Maize	200	148	52	1968**
	Wheat	31	4	27	1973
	Rice	12	1	11	2001
	Sorghum	18	10	8	1978
	Barley	11	9***	2	1987
	Millet (finger & pearl)	5	0	5	1994
	Total Cereals	277	163	105	
Grain/ oilseed legumes	Bean	62	9	53	1977
	Soyabean	9	5	4	1990
	Cowpea	8	0	8	1978
	Pigeon pea	7	0	7	1999
	Chickpea	4	0	4	2011
	Groundnut	3	0	3	2015
	Total Grain /oilseed legumes	93	14	79	
Roots, tubers, bananas (RTBs)	Cassava	25	0	25	2003
	Sweet potato	23	0	23	2000
	Banana	4	4	0	2021
	Round potato	16	12	4	2012
	Total RTBs	68	16	52	
Fruits	Cashew	64	0	64	2006
	Watermelon	43	43	0	2021
	Grapevine	5	2	3	2023
	Papaya	3	3	0	2021
	Total Fruits	115	48	67	
Vegetables	Tomato	96	90	6	2021
	Pepper (hot, sweet & chilli)	55	55	0	2021
	Cabbages	45	45	0	2021
	Onion	18	18	0	2021
	Lettuce	16	16	0	2021
	Eggplant	15	14	1	2021
	Cucumber	13	13	0	2021
	Okra	12	12	0	2021
	Carrot	6	6	0	2021
	Broccoli	6	6	0	2021
	Squash	6	6	0	2021
	Cauliflower	6	6	0	2021
	Sweet corn	4	4	0	2021
	Total Vegetables	298	291	7	

*Exceptions include one variety of maize registered in the 1950s, one variety of rice registered in the 1950s, and one variety of sorghum registered in 1960, shortly before independence.

**106 (72%) of the maize varieties have been registered since 2013, out of which 47 varieties were registered on the national catalogue since 2018.

***All are malt barley varieties

to ensure pest-free, high-quality materials. The Plant Health Act of 2020 (118) restructured Tanzania's regulatory framework by establishing TPHPA, which manages pest control, pesticide regulation, and crop biodiversity conservation, including oversight of NPGRC. The 2023 Plant Health Regulations (119) further detailed TPHPA's role in import and export permits and introduced standardized service fees for certification, quarantine, and testing—addressing inefficiencies from previous unclear pricing structures.

The 2023 Amendments to the Seed Regulations (101) and the new Plant Health Regulations (119) introduced transparent and predictable fees for services that TOSCI and TPHPA provide, with the aim of resolving issues where unclear and unpredictable fees often led companies to cover extra, unlisted costs (76). Key informants reported that TOSCI's limited human resources and infrastructure capacity could hamper the full implementation of these regulations. To enhance efficiency and accessibility TOSCI has implemented a decentralized system by training existing extension staff as Authorized Seed Inspectors specifically for QDS. These operate similarly to extension officers conducting basic certification assessments on behalf of TOSCI. This approach has improved the efficiency of inspections and reduced delays in certification. The strengthening of regulatory and institutional frameworks through the 2023 Amendments, together with improved harmonization and decentralization efforts, marks significant progress toward a more inclusive, transparent, and regionally integrated seed governance system in Tanzania.

Status of farmer seed systems in national policy

In Tanzania, seed governance is shaped by a mix of formal laws, informal norms, and traditional practices that regulate the production and distribution of planting materials. However, the regulatory framework – including seed policy, seed law, and related regulations – has been consistently developed to enhance the formal seed system's performance, mainly promoting private sector-led variety development and marketing (120). Farm-saved seed—which represents over 80% of seed use (14, 94) and sustains crop diversity and resilience to climate stress—remains largely unregulated and is guided by customary systems of saving, selection, and exchange. Unlike countries such as Uganda and Ethiopia, which have adopted a pluralistic seed system (59, 60), Tanzania lacks a specific seed policy that recognizes the role of the farmers' seed systems (80).

Recent policy efforts, however, indicate a gradual shift. NPGRC and other stakeholders developed a National Biodiversity Strategy and Action Plan, emphasizing the conservation of agrobiodiversity and farmers' roles in managing it. In addition, the National Ecological Organic Agriculture Strategy (42), aims to strengthen farmers' seed systems through agroecological approaches, conservation of neglected and underutilized species, and the establishment of 100 community seed banks by 2030, promoting training, collaboration, and organic value chains. To address the tensions regarding intellectual property rights, Tanzania is reviewing its laws to include legislation on farmers' rights and access-and-benefit-sharing under the ITPGRFA to clarify and balance breeders' and farmers' rights.

While positive, most of these advances focus on the role of farmers' seed systems in conservation, with little attention to other functions within the seed system. For example, there are no frameworks that recognize farmers' roles in variety development or that encourage investment in participatory plant breeding that fully involves farmers. In addition, current laws prohibit non-registered individuals or groups from selling seeds. The introduction and implementation of QDS has helped create opportunities for smallholder farmers to establish local seed businesses. However, only varieties registered in the National Catalogue may be commercialized, limiting the dissemination and sale of farmer varieties, including those arising from participatory plant breeding and selection. This, for example, impeded the production and dissemination of QDS of the farmer-selected varieties developed in the "Promoting Open Source Seed Systems" Benefit Sharing Fund project (97). According to our interviews, some CSB groups see this as discouraging farmer innovation.

To address this issue, the registration of farmers' varieties is one option that is increasingly advocated so that their seed can be sold on formal markets (121). As discussed above, the existing variety release process in Tanzania, is both costly and technically complex, posing significant barriers for farmers to

comply with the standards in the formal seed system (76). Furthermore, the genetic heterogeneity of many farmers' varieties can make it difficult to meet the requirements of formal variety registration, while issues of rights and benefit-sharing also come into play (122). Some actors therefore argue that a more flexible system for registration of farmers' varieties is desirable. In June 2025, Tanzania took a step in this direction by formally recognizing indigenous farmer varieties through a ministerial order. This directive enabled the registration of these varieties even in the absence of explicit legal or regulatory provisions. Following the order, a government gazette notice was issued to officially announce their registration, through which TOSCI registered four maize varieties, four rice varieties, one bean variety, and three papaya varieties.

3.2 Coordination among seed system actors

Coordination among seed systems actors is important to the functioning of the seed system. To explore this, a participatory "cross-linkage exercise"[7] was conducted at the inception workshop of the BOLD project held in April 2023 in Dodoma. During the plenary session, a list of actors involved in Tanzania's formal and informal seed systems was first confirmed with the participants. Subsequently, participants were grouped to conduct a cross-linkage exercise aimed at assessing the extent of interaction among seed system actors. Each group analyzed the contributions of one actor (e.g., farmers) to each of the other actors in the seed system by examining their mandates, roles, and activities. Facilitators guided discussions to identify current contributions and interactions, then asked the group to rate these using a four-point scale: no contribution (0), minimal contribution (1), moderate contribution (2), and significant contribution (3). These ratings were assigned based on group discussions regarding how each actor contributed to the activities of other actors, considering their diverse perspectives and opinions. The results were organized in a matrix, enabling the computation of total contributions and dependencies for each actor (Figure 3), and were plotted on a quadrant chart (Figure 4).

Examination of Figure 4 reveals a group of actors in the top righthand quadrant that are highly integrated with other actors, e.g., with high contributions as well as dependence. Farmers stand out as the actor with the highest ratings on both counts, reflecting their central and multifaceted role in the seed systems, for example by conserving seeds providing access to genebanks, information /feedback and time to breeders, projects and seed inspectors, while also creating a market for seed companies and LSBs and receiving training, seeds and other supports from various others. Key actors in the formal seed system such as agricultural extension services, breeding programs, seed companies and TOSCI are also highly integrated with other actors, which may reflect the high level of specialization within the formal seed system, creating mutual interdependencies. For example, TOSCI provides key services to other actors in varietal registration, seed certification, and capacity building, while also depending on information exchange and from collaboration with other actors to carry out their role. Other actors such as NPGRC, ABC, and the Plant Variety Protection (PVP) office were less tightly integrated. NPGRC for example, had moderate to strong interactions with farmers, breeders, ABC, CSBs and NGOs, reflecting their work on both ex situ and in situ conservation, but few linkages with downstream actors like seed companies, agro-dealers, and LSBs that focus on commercialization of improved varieties. As a large international agricultural research centre, ABC has interactions with nearly all actors, through its genebanks, breeding activities, and agrobiodiversity management activities. However, their contributions are generally indirect, with ABC providing technical and financial support for seed system development including establishment of CSBs, seed policy development and research and dissemination on improved varieties of beans though TARI and ASA and in collaboration with some private seed companies.

7 This exercise was based on the "System Dynamics" method of Chevalier and Buckles 123. J. M. Chevalier, D. J. Buckles, Participatory Action Research:Theory and Methods for Engaged Inquiry (Routledge, London and New York, 2013), pp. 496.

Table 5. Seed classes and the key policies and regulations governing their production and dissemination in Tanzania.

Seed class	Protocol/guideline/provisions for production and dissemination	National and regional instrument
Farm-Saved Seed	• Neither the national development vision nor agricultural policy acknowledges and supports farmers' seed systems. • The agricultural policy attributes low agricultural productivity to the use of farm-saved seed and seeks to promote the use of high-quality, improved crop varieties • The agricultural policy and strategy acknowledge the loss of agrobiodiversity and the need for conservation, but it fails to mention farmers' on-farm management of crop diversity and government initiatives aimed at addressing the problems	2000 Tanzania Development Vision 2025 2013 National Agriculture Policy 2015-2025 Agricultural Sector Development Strategy
	• Acknowledge the decline in crop diversity and farmers' crucial role in conserving and sustainably using agrobiodiversity to support community livelihoods, but it is not harmonized in the mainstream agricultural development policy and strategy. • The TARI Act empowers the Institute to collect, conserve, and sustainably use plant genetic resources, but TARI regulations do not address the conservation and management of PGRFA. A draft NPGRC Act has been under discussion for many years but has yet to formalize NPGRC's mandate.	2015-2020 National Biodiversity Strategy and Action Plan 2016 TARI Act 2023 TARI regulation
	• This strategy emphasizes the importance of preserving seeds managed by farmers. It explicitly advocates conserving farmers' varieties and neglected crop species through agroecological approaches, utilizing both in situ and ex situ conservation approaches. The goal is to strengthen farmers' seed systems by establishing 100 CSBs by 2030 through collaborative efforts involving various actors — academia, government, NGOs, and the private sector.	2023-2030 National Ecological Organic Agriculture Strategy
EGS and Certified Seed	• The national development vision and agricultural policy aim to transform the economy from a low-productivity agricultural sector to a semi-industrialized and highly productive one driven by modern technologies —improved varieties and quality seed.	2000 Tanzania Development Vision 2025 2013 National Agriculture Policy
	• The Tanzania Agricultural Research Institute (TARI) Act established the Institute and provides a framework for improving crop varieties, seed multiplication, and deployment. • The act outlines the establishment of an Agricultural Research and Development Fund for technology development and dissemination, and regulation provides the mandate for multiplying, distributing, and selling all classes of seed/planting materials. • The regulation allows TARI to enter into agreements with seed dealers, granting them rights to use protected varieties in exchange for royalties to promote improved varieties and boost agricultural productivity.	2016 TARI Act 2023 TARI Regulation

EGS and Certified Seed	• The Executive Agencies Act empowers relevant ministries to establish and operate semi-autonomous executive agencies (e.g., the Agricultural Seed Agency) for effective public service delivery—production and delivery of quality seed at affordable prices for smallholder farmers. • The Local Government Act enables district councils and urban authorities to establish seed farms and provide seed production and extension services to farmers, thereby enhancing agricultural production and productivity.	1997 Executive Agencies Act and its amendment of 2013 1982 Local Government Act – District and Urban Authorities
	• The agricultural policy supports the review, harmonization, and development of laws and standards, such as plant breeders' rights and regional seed regulation harmonization, to encourage local and international participation, including the private sector, in plant breeding, seed production and marketing of pre-basic, basic, and certified seed. • The Seed Act established the Tanzania Official Seed Certification Institute (TOSCI), which provides services to national and international stakeholders based on established criteria in the seed regulations. For example, the institute registers seed dealers for seed production, selling, import, and export, as well as breeders and companies that introduce new varieties from countries with harmonized seed regulations. • The Seed Act and its regulations mandated TOSCI to oversee field and seed inspections, sampling, seed testing, and variety evaluation through National Performance Trials (NPT), Distinctness, Uniformity, and Stability (DUS) tests, control plot testing, variety registration or deregistration, and seed quality control and certification throughout production, processing, labeling, and marketing stages.	2013 National Agriculture Policy 2003 Seeds Act 2007 Seed Regulation and its 2023 Amendments
	• The Plant Health Act established the Tanzanian Plant Health and Pesticides Authority (TPHPA) by restructuring the Tropical Pesticides Research Institute (TPRI) and transferring responsibilities previously handled by the Director of Agricultural Development of the Ministry of Agriculture, Food Security, and Cooperatives. TPHPA now oversees all matters related to plant health and pesticides, including issuing seed import and export permits. • The plant health regulations govern the issuance of import/export and phytosanitary certificates, enabling seed dealers to participate in both domestic seed importation and international seed exportation.	2020 Plant Health Act 2023 Plant Health Regulations
Quality Declared Seed (QDS)	• The Seed Act introduced QDS as an alternative to farm-saved seed in 2003, aiming to improve access to quality seed in areas where certified seed is not readily available. • The SADC Harmonized Seed Regulatory System, of which Tanzania is a signatory, recognizes QDS as a seed class and mandates that QDS producers register with the national seed agency, i.e., TOSCI, which is also responsible for inspecting 10% of the seed crops. • The 2020 QDS regulations define QDS producers and dealers, land size requirements, inspection standards, associated inspection fees, germination tests, soil health testing, and training. • The regulations ensure that trained local agricultural officers conduct field inspections for QDS production of registered OPVs of cereals, pulses, oil crops, and RTB crops, and be marketed at the ward level by private individuals and at both ward and district levels by registered seed producer groups.	2003 Seeds Act 2008 SADC Harmonized Seed Regulations 2020 Seeds (control of Quality Declared Seeds) Regulations

	NPGRC	Breeding programs	CGIAR	Farmers	LSBs	CSBs	NGOs	Seed Companies	Agro-dealers	Agri. Ext	PVP office	TOSCI	Total Dependence
NPGRC		2	2	3	0	3	3	0	0	1	0	1	15
Breeding programs	2		3	3	0	3	2	2	0	3	3	3	24
CGIAR	2	2		3	0	3	2	2	0	3	1	1	19
Farmers	1	2	1		2	3	3	3	3	3	2	3	26
LSBs	0	2	0	1		2	2	2	1	3	2	3	18
CSBs	2	1	2	3	1		3	0	0	1	0	1	14
NGOs	2	2	2	3	0	2		1	1	2	2	2	19
Seed Companies	2	2	1	3	1	1	1		3	3	3	3	23
Agro-dealers	0	1	0	1	1	1	1	3		3	1	3	15
Ag. Ext	2	2	1	3	1	2	2	3	2		1	3	22
PVP office	0	2	2	1	1	1	2	2	0	1		3	15
TOSCI	1	3	2	3	2	1	2	3	3	2	3		22
Total contribution	14	21	16	27	9	22	23	21	13	25	18	26	235

Figure 3. Matrix summarizing the total contributions and dependencies for each seed system actor. Outcome of participatory exercise in the current study's launch workshop in Dodoma, April 13, 2023.

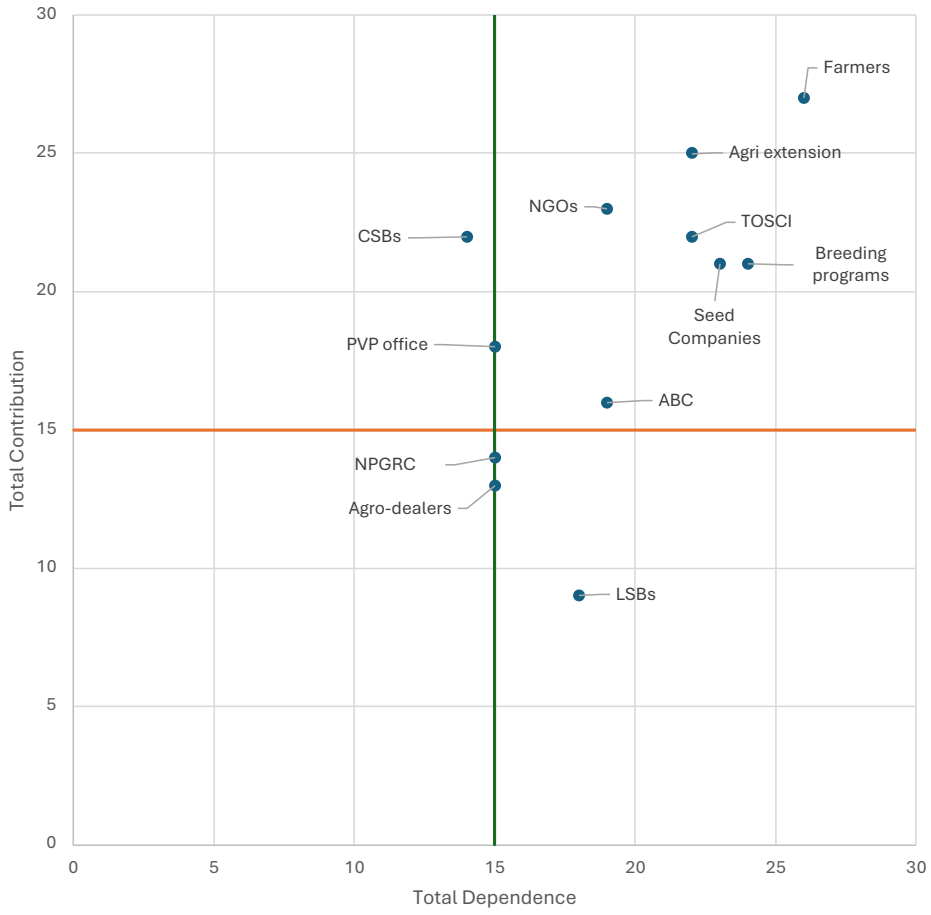

Figure 4. Quadrant chart showing total contributions (y-axis) vs. dependencies (x-axis) for key seed system actors. Actors in the upper-right quadrant are highly integrated with others in the seed system.

Interestingly, LSBs had relatively high dependence on a range of other actors, who develop improved varieties (breeders), produce foundation seeds (seed companies like ASA), and support their production and dissemination activities (TOSCI, NGOs and agricultural extension) but their contributions were considered to mainly benefit farmers (who buy seed) and TOSCI (to whom they providing information and advice). In contrast, CSBs were found to have a higher overall contribution, especially to NPGRC and other upstream actors, but still providing information and seed to a range of other actors. Yet CSBs were thought to receive relatively few supports, mainly from farmers and NPGRC, ABC and NGOs who support them, with otherwise weak interactions with formal seed system actors such as seed companies, agro-dealers, agricultural extension, and seed inspection services.

It is important to note that these findings are based on the perceptions of the workshop participants of the level of interaction among actors, and not the relative importance of the roles performed by any given actor. Our findings presented earlier demonstrate that the production and dissemination of QDS by LSBs has grown significantly in the last decade, contributing to making improved varieties more affordable and accessible in more remote areas. However, the cross-linkage findings do reveal that all actors analyzed depend on contributions from others, underlining the importance of coordination and governance within the seed system.

At the same time, the results also demonstrate relatively limited interaction between certain actors, particularly between those supporting in situ conservation (e.g. CSBs) and those engaged in the formal seed system, including LSBs. This is supported by our analysis of seed system functions above. On the one hand, in the informal system, collaboration occurs mainly among farmers, NGOs, and the NPGRC, particularly through CSBs that promote on-farm conservation and access to diverse crop varieties. NGOs such as Ile de Paix, SWISSAID, and Tanzania Alliance for Biodiversity (TABIO) assist farmers in establishing CSBs, training in seed production and conservation, and accessing markets. Informal seed exchange occurs through farmer-to-farmer sharing, community seed banks, and local markets, where seeds and grains are often traded interchangeably. On the other hand, TOSCI regulates seed certification and also produces EGS. While ASA is primarily involved in EGS production, TARI leads the varietal testing, release, and dissemination. NGOs also bridge gaps by supporting seed multiplication and farmer training. From this study, we found that interaction between these two groups of actors is limited, except through QDS production, which is supported by TOSCI and ASA, as well as NGOs.

3.3 Crop diversity dynamics and main agricultural problems

The functioning of the seed system, discussed above, directly influences farmers' seed security, which can be viewed as an outcome of the seed system. In this study, we assessed seed security across three study sites in Tanzania (Figure 2) and identified gaps and challenges based on information gathered from FGDs with women and men farmers.

In this chapter we first summarize the experiences shared by farmers related to their farming systems, including the diversity of crops they cultivate, drivers of change in crop diversity, and some of the main agricultural problems they face. In the next chapter we examine the seed security situation of key crops in the three districts. These data provide insights into the situation on the ground, from farmers' perspective.

3.3.1 Crop diversity

Crop diversity in rural communities in Tanzania plays a crucial role in ensuring food security and resilience against environmental challenges. To explore the crop diversity valued by farmers in the three study districts, FGD participants were asked to list the most vital crops for food and livelihood security in their community, and then to identify and rank the top ten most important crops. Each FGD then selected their top two key crops which were then further analyzed for seed security (see section 3.4).

In all FGDs, farmers identified a high diversity of crops they considered important for food and livelihood security, including cereals, legumes, roots, tubers, oilseeds and vegetables. In Chamwino, for instance, women listed a combined total of 25 crops, while men listed 23 crops. Similarly, in Liwale, women farmers'

groups compiled a total of 35 crops, whereas men listed 30 crops. Finally, in Arumeru, women documented a total of 48 crops, whereas men listed 33 crops.

Ranking of the top 10 crops by each of the 6 FGDs revealed a total of 25 crop species recognized as essential for food and livelihood security across the study sites (Table 6). The most frequently cited crops across the three sites were primary staples widely grown for household food consumption such as maize and sorghum, as well as crops grown for income generation and household uses, such as sunflower, cowpea, and tomato. Six crops were selected as "key crops": maize, sorghum, sunflower, cashew nut, Irish potatoes and common beans (Table 7).

This diversity not only provides nutritional benefits but also enhances the adaptability of communities to changing climatic conditions and market demands, which is evident by examining the crops selected by district.

In Chamwino District, farmers primarily cultivate grain, legume, and oil crops for food, income, and animal feed. Ten major crops were identified as most important: sorghum, sunflower, groundnuts, pearl millet, maize, cowpea, bambara nuts, tomato, pigeon pea, and sesame. Both male and female groups ranked sorghum as the most important crop, followed by sunflower (Table 7). Farmers explained that sorghum is vital for household food security because it is highly drought-tolerant and well adapted to Chamwino's harsh climatic conditions, making it a reliable staple in times of water scarcity. Sunflower, on the other hand, serves as a key cash crop, providing income and contributing to household livelihoods. Its ability to thrive in dry conditions further enhances its importance. Overall, the selection of these crops reflects farmers' adaptive strategies to balance food security and income generation under recurrent drought conditions.

In Liwale District, FGD participants identified cashew nut, maize, sunflower, rice, sorghum, pigeon pea, cowpea, sesame, cassava, and sweet potato as the ten most important crops. When asked to rank the top two, both men's and women's groups prioritized cashew nut as the leading crop, followed by maize (Table 7). Cashew nut has emerged as a key cash crop, widely cultivated for income generation and livelihood support across large areas of the district. In contrast, maize is primarily grown for household food security on smaller plots, reflecting its role as a staple food crop. The ranking highlights a clear distinction between livelihood-oriented cash cropping and subsistence production strategies among Liwale farmers.

Arumeru district predominantly focuses on horticultural crops. The 10 most important crops highlighted by the FGD participants included maize, irish potatoes, common beans, traditional leafy vegetables cabbage, onion, carrots, tomatoes, saro, capsicum, spinach and sukuma wiki. Asked to prioritize the top two most important crops, the men's FGD ranked maize first and common beans second while the women farmer group highlighted maize first and irish potatoes second (Table 7). Maize remains a vital crop for both male and female farmers, serving as a cornerstone for household food security and a key source of income. Much of the maize produced in this region is sold in local markets and exported to Kenya, contributing significantly to livelihoods. Common beans, primarily selected by male farmers, is equally important for both market sales and household consumption. Irish potatoes, mainly cultivated by women in Arumeru, is typically grown on small plots, often intercropped with other crops. Their short growth cycle makes them well suited for integration into diverse farming systems, providing households with both food and income.

3.3.2 Drivers of change in crop diversity

FGDs participants were asked to highlight the changes they have experienced in crop cultivation in the last 10 years and identify the drivers behind the changes. The discussion focused on crops that had increased or decreased in terms of area cultivated and number of farmers growing the crop, crop introductions and abandonments.

Across the three sites, several common trends in crop cultivation are evident, driven largely by market opportunities, climate pressures, and shifting production priorities. Market demand strongly shapes cropping decisions in all three sites, with farmers increasingly favoring crops that offer reliable or expanding commercial value. Sunflower, sesame,

tomatoes, and a range of horticultural crops are gaining prominence because they provide better income prospects and, in some cases, additional benefits such as by-products used for livestock feed. Conversely, crops with declining market demand, high production costs, or labor-intensive requirements are being reduced or abandoned. This includes several traditional staples that once formed the backbone of local food systems such as finger millet and pearl millet. Climate change intensifies these shifts. Prolonged droughts, erratic rainfall, pests, diseases, and significant post-harvest losses are undermining the productivity of small grains such as sorghum, pearl millet, and finger millet. Although these crops are inherently drought tolerant, certain varieties are

Table 6. Diversity of crops identified as the 10 most important crops across the study sites of Tanzania and relative rankings assigned by the FGDs. Crops are categorized by their use as follows: Blue = primary staples widely grown for household food consumption; Yellow = supplementary crops grown for specific use, e.g., stews, cultural uses; Green = crops grown for income and as supplementary crops.

Crop	Number of FGDs identifying the crop as among 10 most important	Number of FGDs designating the crop as their key crop*	Number of FGDs assigning importance rankings (1-10), where 1st is most important									
			1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Maize	6	4	2	2	1		1					
Sorghum	4	2	2		1		1					
Sunflower	4	2		2	1				1			
Cowpea	4							2	1		1	
Tomato	4								1	2	1	
Pigeon pea	3					1		1			1	
Sesame	3									2		1
Cassava	3						1			1	1	
Ground nuts	2				1	1						
Pearl Millet	2					1	1					
Cashew nut	2	2	2									
Bambara nuts	2							1	1			
Rice	2					1						1
Sweet potato	2										1	1
Irish potatoes	2	1		1		1						
Common beans	2	1		1	1							
Black night shade (Mnavu)	2					1	1					
Cabbage	2				1		1					
Onion	2							1				1
Carrots	2								2			
Amaranth	1											1
Saro	1										1	
Capsicum	1											1
Sukuma wiki	1							1				
Spinach	1									1		

**Each FGD selected the two most important crops as their key crop*

Table 7. The first and second crop preferences among FGD male and female participants in study sites. Blue and orange represent male and female FGD participants respectively, with numbers indicating first or second crop choices.

Crop	Chamwino		Liwale		Arumeru	
	Men	Women	Men	Women	Men	Women
Sorghum	1	1				
Sunflower	2	2				
Cashew nut			1	1		
Maize			2	2	1	1
Irish Potatoes						2
Common beans					2	

no longer viable due to low yields, poor taste or color, or susceptibility to storage pests.

Across the three sites, farmers are increasingly adopting new, early-maturing, high-yielding crop varieties that require fewer inputs and offer better returns under changing environmental conditions. This transition reflects an adaptation strategy aimed at managing production risks while maximizing income. Traditional crops and foods are steadily declining as farmers face limited consumer demand, reduced access to quality seeds, inadequate knowledge of appropriate agronomic practices, and competition from more profitable or resilient alternatives. These changes raise concerns about the future of indigenous food systems and agrobiodiversity.

Gender differences are particularly visible in Chamwino, where men and women identify different crops as increasing or declining based on their roles and responsibilities in farming. Nonetheless, both groups share similar perspectives on the influence of market forces, climate change, and resource constraints on crop choices.

3.3.3 Main agricultural problems perceived by farmers in production of key crops

Farmers across Chamwino, Liwale, and Arumeru identified a wide range of interconnected constraints affecting crop and seed production. Seed-related issues were among the most common, including limited access to seeds, inadequate availability of improved varieties, high seed prices, and the circulation of low-quality or counterfeit seeds. These challenges reduce productivity and limit the adoption of high-yielding or climate-resilient varieties across all sites. This is explored in more detail in the next chapter.

Production constraints were also widely reported. Farmers described high input and labor costs, frequent pest and disease outbreaks, and increasingly unpredictable weather patterns—particularly prolonged droughts—as major threats to crop performance. Limited financial resources and gaps in agricultural knowledge further restrict farmers' ability to manage crops effectively. Poor-quality agricultural inputs, shortages of basic farming tools, inadequate storage facilities, and low market prices were additional cross-cutting challenges. Farmers also highlighted inadequate extension support and poor infrastructure, such as insufficient irrigation facilities and weak road networks, which hinder timely access to inputs and markets.

Site-specific challenges further compound these general constraints. In Liwale, farmers uniquely reported severe crop destruction by wild animals—including elephants, wild pigs, monkeys, and birds—which threatens both food security and safety. In Chamwino, where sorghum and sunflower are key crops, both men and women cited limited knowledge on seed sorting, frequent sowing of poorly stored seeds, and high levels of storage pest infestation, particularly by weevils. Other storage-related issues included lack of knowledge on moisture determination, use of inappropriate storage materials such as plastic bags, and limited access to storage pesticides.

In Liwale and Arumeru, maize seed production faces persistent problems such as limited access to improved varieties at planting time, prevalence of counterfeit

seed, high prices of certified seed, and vulnerability to pests and diseases. Liwale farmers also pointed to the absence of local seed production companies, which further restricts timely seed access. In both districts, inadequate storage facilities and limited knowledge of seed storage practices contribute to seed quality loss.

Across all sites, farmers emphasized insufficient skills in post-harvest handling, poor storage infrastructure, and inadequate pest and disease management capacity. Limited extension services further exacerbate these challenges, underscoring the need for stronger technical support, improved seed system development, and targeted capacity-building to enhance both crop and seed production.

3.4 Seed security situation of key crops

Here we present results from the FGDs' assessment of the seed security situation of the six key crops identified in the three study districts (Table 7). The analysis includes the seed sources used; the availability, quality and ease of access to these sources in terms of cost and proximity; as well as the suitability of available varieties for the market, agronomic and culinary needs.

3.4.1 Seed sources used by farmers and their relative importance

FGD participants identified a range of formal and informal seed sources used to obtain seed of their key crops. Across the three sites, the most frequently used sources were own saved seed, social networks, government channels, local markets, and agro-dealers. Own saved seed, retained from previous harvests, emerged as the most frequently cited source of seed across sites, and was the most important seed source for sorghum and sunflower in Chamwino and cashew nut in Liwale (Table 8). Maize seed on the other hand was predominantly sourced by farmers in Liwale and Arumeru from agro-dealers, who typically stock seed purchased directly from seed companies.

Local markets were primary sources of seed for common beans and Irish potato in Arumeru.

For all crops, two or more sources were used by farmers in the study sites. Social networks—comprising neighbours, relatives, and friends—formed an important complementary seed source for sorghum, sunflower and beans. Farmers accessed seed through barter, gifts, or cash exchanges, emphasizing that trusted social relationships help reduce risks of counterfeit seed, varietal contamination, and pest or disease introduction. Government programs complemented these channels by providing seed through subsidy schemes or direct distribution via government shops in some districts, making improved varieties more affordable or accessible to poorer households.

Irish potato, analyzed in Arumeru, stood out as a special case due to its vegetative propagation. Farmers' main sources are local market and NGOs. The NGOs play a significant role by supplying planting materials either free of charge or on credit through farmer groups, while traders and local markets provided additional supply options, often involving cash transactions.

Overall, the diverse seed sourcing strategies used by farmers reflect a combination of practical constraints, economic considerations, and trust-based preferences, highlighting the importance of both formal and informal actors in ensuring seed availability and access.

3.4.1.1 Changes in seed sources

During the FGDs, both male and female farmers were asked to summarize the main changes that have occurred in seed sources and why they have occurred. Shifts in seed sources are influenced by various social, economic, agronomic, and environmental factors. Across the study sites, farmers expressed a tendency to switch to formal seed sources in pursuit of quality, early maturing varieties, high-yielding seeds, and those with superior germination rates.

Across the three sites, farmers obtain formal seeds from a mix of NGOs, seed companies, research institutions, and agro-dealers. These include organizations such as TARI Naliendele in Liwale, Seliani Research Station in Arumeru, and various private companies operating in Chamwino and Arumeru. Farmers generally recognize that these formal seed sources provide early-maturing, high-yielding varieties with improved drought tolerance and strong market appeal. Many also note that availability has improved over time, particularly

Table 8. Importance ranking of seed sources for key crops in the study sites. A rank of 1 indicates the most important source, 2 is the second most important, etc.

Seed source*	# of FGDs mentioning the source	Chamwino				Liwale				Arumeru			
		Sorghum		Sunflower		Cashew nut		Maize		Maize		Beans	Potato
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Own	11	1	1	1	1	1	1	2	4	2	3	2	
Agrodealer	8	3	3	3	2			1	1	1	1		
LM	7					2	2		2	3	4	1	1
SN	5	2	2	2				3				2	
GO	5	3			3	3	3		3				
NGO	2		4										2
Research	2						4				2		

*Seed sources include: own savings (Own), Agro dealer, Local Market (LM), Social Network (SN), Government (GO), NGO, and Research. Formal sources are highlighted in yellow and informal sources in blue.

for crops like sorghum in Chamwino, where consistent stocking has addressed earlier shortages.

Despite these advantages, farmers highlight several challenges associated with present-day seed sources. High seed costs are a common concern, especially for crops such as sunflower in Chamwino and cashew nut in Liwale. In some areas, improved varieties remain vulnerable to pests and diseases, as reported for Irish potatoes, maize, and common beans in Arumeru. Access inequalities also emerge, particularly in Liwale, where women report difficulty obtaining maize and cashew nut seeds that men farmers consider more easily accessible.

Some farmers express a preference for seed sources used in the past, citing several benefits. In Arumeru, women recall that older sources offered more affordable Irish potato seed and varieties of maize and common beans with better pest and disease tolerance. Farmers in Chamwino similarly remember earlier sorghum seed sources as being reliable, locally produced, and resilient to insect damage, which helped reduce production costs. Overall, while current seed systems deliver improved varieties and broader availability, concerns about affordability, pest resistance, and equitable access remain important considerations for farmers.

3.4.2 Seed security parameters by source

3.4.2.1 Seed availability

Seed availability refers to the presence of adequate quantities of seed of desired crop varieties within a farming system or community at the time farmers need them for planting (23). It emphasizes the physical presence of seed—whether produced locally, stored on-farm, supplied through markets, distributed by government or NGOs, or available through social networks. Seed availability is influenced by factors such as local production capacity, market supply chains, seasonal timing, storage conditions, and the functioning of both formal and informal seed systems. Ensuring seed availability is a core component of seed security and is essential for reliable crop production and resilience to shocks (124).

In this study, farmers indicated the availability of seeds for their key crops by categorizing them as 'always available in sufficient quantity', 'sometimes available in sufficient quantity' and 'rarely available in sufficient quantity'. Figure 5 illustrates the number of FGDs that rated the seed availability of their key crops using these categories across different seed sources.

Based on the analysis conducted, own seed, local markets, and agro-dealers emerged as the primary sources most often providing seeds in sufficient quantities. "Own seed" received the highest rating

as the top source for seed availability in 6 out of 8 cases, followed by agro-dealers with 5 FGDs and local markets with 2 FGDs. Farmers' own seed was noted for its reliability and availability, with grains being easy to store for extended periods, hence rarely unavailable.

In cases where farmers' own seed was sometimes insufficient, farmers accessed seed from agro-dealers and local markets. Government and NGOs received low ratings, as they are perceived to supply seeds only when deemed necessary, resulting in sporadic availability. Social networks were also reported to have variable availability, with excess seed used for transactions or barter trade and some sold to local traders.

3.4.2.2 Seed quality

In seed system literature, the notion of "quality seed" often differs between formal and informal seed system actors. Formal actors place emphasis on standards that prioritize genetic purity, vigor, high germination rates, absence of physical damage and impurities, and freedom from weed seeds, pests, and diseases; seed certification is obtained from regulatory agency that provide certification for quality assurance (125). In the informal seed system, farmers often judge seed quality based on visible characteristics such as color, size, viability, and the absence of physical damage. Additional attributes—including expected yield, local adaptation, and trust in the source—play a crucial role in farmers' decision-making. Seeds obtained from reliable and well-known sources are valued for their perceived credibility, while farmers' knowledge and familiarity with specific varieties further shape their assessment of seed quality (126). In this research, we asked FGD participants across all study sites to rate seed quality from various sources (Figure 6).

Seeds sourced from farmers' own savings were the only seed source represented across all four quality categories, with ratings of excellent (2), good (6), acceptable (1), and poor (1). Own saved seed was typically rated highly—often as good or excellent —largely because farmers are familiar with the characteristics and performance of these varieties. However, farmers also acknowledged that the vigor of saved seed declines over time, leading to reduced yields. As a result, they increasingly turn to alternative sources, such as agro-dealers, to replenish and improve seed quality.

Agro-dealers were identified as having the highest quality seeds, with 5 ratings of "excellent" and 1 "good", as they directly source their seeds from seed companies known for high yields and early maturation. Seeds obtained from the local market were deemed acceptable, albeit occasionally mixed, although farmers in Liwale reported good quality seeds for

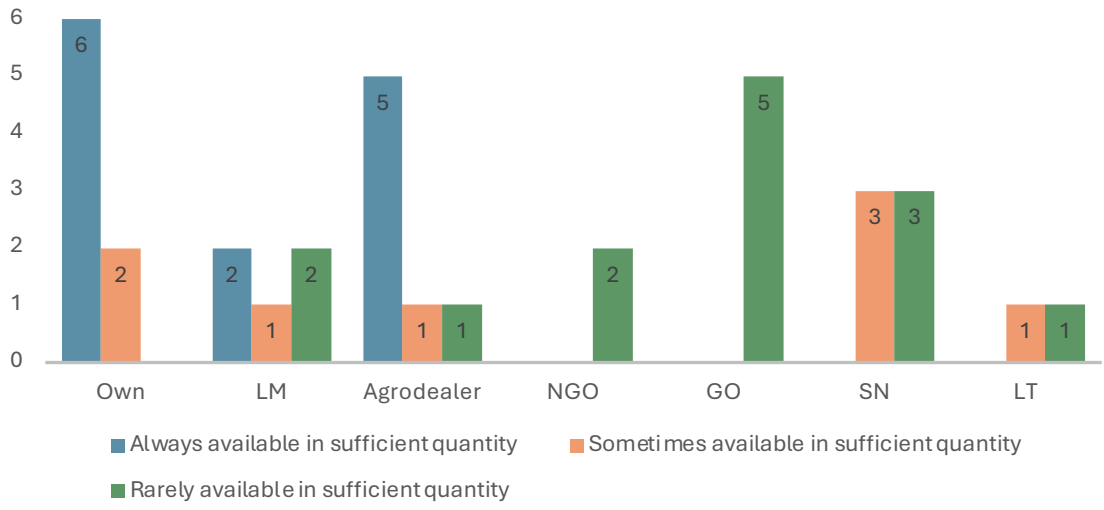

Figure 5. Number of FGDs rating seed availability of their key crops by source. The seed sources include own savings (Own), Local Market (LM), agro-dealer, NGO, Government (GO), Social Network (SN) and Local Traders (LT).

cashew nut from local markets, as they have a long shelf life and can take up to 5 years to expire. Social networks were found to offer seeds of acceptable quality based on the analysis.

Challenges in seed production identified by the farmers include a lack of knowledge in seed production, poor soil nutrition, and infestations of pests and diseases such as fall armyworms, caterpillars, fungal diseases, and wilt, all contributing to poor seed quality and germination rates, ultimately leading to reduced yields. Storage challenges highlighted encompassed inadequate storage facilities, pest and disease infestations, and a lack of labor.

3.4.2.3 Seed access

Access to seeds refers to the ability of farmers to obtain suitable, affordable, and good-quality seed varieties in a timely manner and in adequate quantities to meet their production needs. It includes physical availability, economic affordability, and farmers' capacity to choose varieties that match their agroecological conditions, cultural preferences, and livelihood objectives (124). Farmers' ability to access seeds depends on factors such as purchasing power, position in social networks, proximity to suppliers and transportation infrastructure, and access to information on varieties and their traits, seed prices and availability from different sources. These factors determine how much of the seed farmers can access and whether they meet their actual needs (125, 127). In this study, we explored farmers' seed access methods across diverse sources and transaction practices. Male and female FGD participants shared insights into how they acquire seeds for their key crops from various sources, using different transaction types. The summary of their discussions is presented in Table 9 and Figure 7.

Across all sites, farmers rely on a range of seed sources, with different transaction types, levels of reliability, and degrees of accessibility. "Own saved seed" is the most accessible source, as it requires no transaction and is consistently available to farmers who retain seed from their previous harvests. This makes it highly dependable and rated as having high accessibility. "Social networks"—including neighbors, relatives, and friends—represent the next most common source. Seeds are exchanged through barter, gifts, or small cash payments. While these seeds are generally affordable and relatively easy to obtain, availability depends on whether others have surplus seed to share. Since farmers often store seed primarily for their own use, exchanges only occur when there is excess, resulting in a medium accessibility rating. Agro-dealers provide seed through cash transactions and are known for consistently stocking adequate quantities of seed throughout the planting season. Their seeds are viewed as good quality; however, the high cost makes them less accessible for many

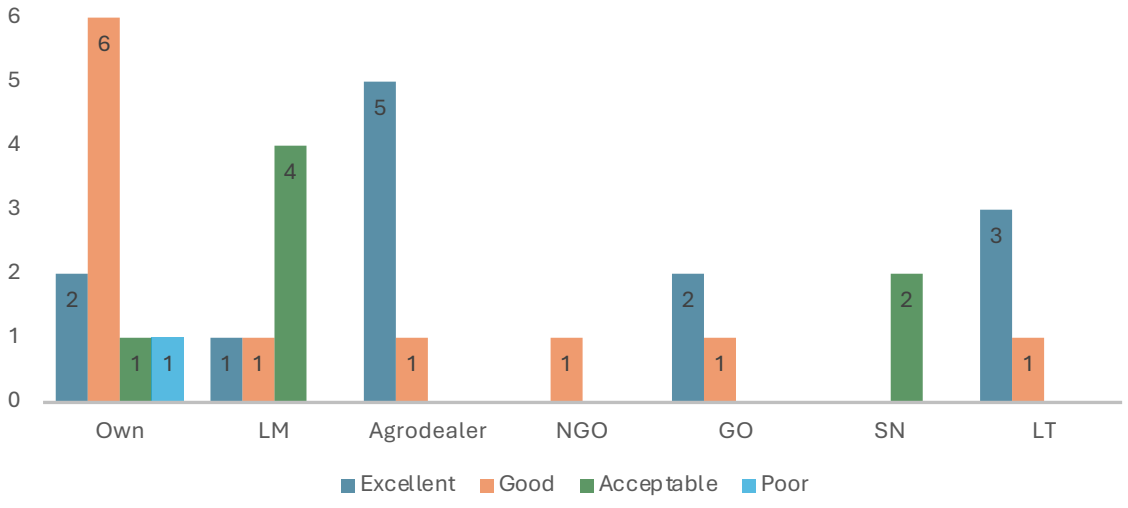

Figure 6. Number of FGDs rating seed quality of their key crops by source. The seeds sources included own savings (OWN), social network (SN), local markets (LM), local trader (LT), agro-dealers, government seed subsidy programs (GO)

farmers. Thus, despite high physical availability, their overall accessibility is rated low. The local market also operates on cash transactions but is considered an unreliable seed source. Seeds may be unavailable at critical times, and what is sold as seed is often indistinguishable from grain. Varieties are frequently mixed, and quality cannot be guaranteed. For these reasons, local markets are rated as having medium to low accessibility.

NGOs distribute seed either free of charge or on loan, but availability is inconsistent. Seed support is typically targeted to specific groups, crops, or crisis situations, meaning not all farmers benefit during planting time. Consequently, these sources receive a low to medium accessibility rating. Finally, government sources offer seed through subsidies or free distribution. However, like NGO sources, government programs often target specific farmer groups or regions, limiting universal access. Seeds are also not consistently available when needed, and stockouts are common. This results in a medium to low accessibility rating.

Overall, the table illustrates that while multiple seed sources exist, their reliability and accessibility vary widely, with cost, targeting, and seasonal availability shaping farmers' ability to secure the seeds they need. Furthermore, FGD participants explained that certain groups, such as women, youth, the elderly, and the disabled, face challenges in accessing seeds. These social groups often have less income, have challenges traveling and have limited access to knowledge. They employ various strategies, including relying on assistance from other (male) farmers, bartering, or receiving seeds as gifts from NGOs and government programs. Widows and orphans also utilize community support and assistance from NGOs and government programs to access seeds.

Table 9. Seed access rating from various seed sources based on transaction types.

Source of seed	Transaction types	Comment	Accessibility rating
Own seed	No transaction	Highly accessible	High
Social network	Barter trade, cash, gifts	Seed is relatively accessible and usually exchanged though gifts, barter or cash. If and when exchanged through cash, the cost is affordable.	Medium
Agro-dealers	Cash	Seeds are of good quality but very expensive	Low
Local market	Cash	This source was not considered reliable because seeds are not always accessible, and there is often a thin line between what is sold as grain and what is intended to be used as seed. May be sold at a cheaper price of grain.	Low to Medium
NGOs	Free, loan	Not always accessible to all during planting time and mostly distributed during crisis seasons to target farmers	Low to Medium
GO	Free, subsidy	Seeds are only sometimes accessible. Distribution often targets specific groups of farmers, particular crops, or defined geographical areas, which can marginalize other farmers. As a result, those outside the target groups may receive no seed at all.	Low to Medium

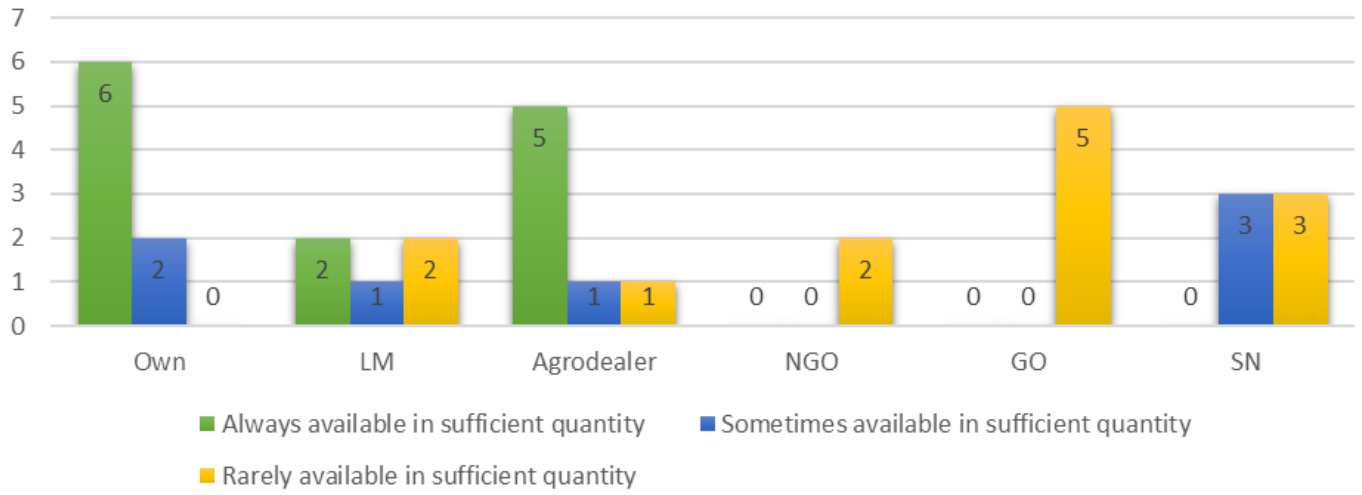

Figure 7. Number of FGDs rating seed access by source. The seed sources included own savings (OWN), social network (SN), local markets (LM), local trader (LT), agro-dealers, government seed subsidy programs (GO).

3.4.2.4 Summary of seed security by site

From the above discussion we find that seed availability, quality, and access combine to influence farmers' choice of seed source across the three sites.

In **Chamwino**, where sunflower and sorghum are key crops, seed access involves various transactions. Neighbours/social networks facilitate exchange through barter, gifts, and cash, while agro-dealers offer certified seed for cash directly from seed companies. NGOs provide seeds as loans through farmer groups, and the government sells seeds for cash within the community. Own saved seed is ranked as the most important source due to its low acquisition costs and adaptability to local climatic conditions. Neighbours and social networks are considered the second most important source for their known seed quality and cost-effectiveness. Agro-dealers are ranked third for assured seed quality labelled as adaptive to local climates, while NGOs and companies are ranked fourth for their reliable seeds with reduced acquisition costs and high germination rates and supplying early maturing crop varieties'.

In **Liwale**, transaction methods vary by source for cashew nut and maize which were identified as the top two key crops. Government distributes seeds as gifts or for cash, while the local market transactions are predominantly in cash. Agro-dealers are rated as the most important source for maize varieties, followed by the local market, government, and own saved seed sources.

In **Arumeru**, the key crops highlighted were Irish potatoes, maize and common beans. Transactions vary by source: government, agro-dealers, and local markets all require cash payments, while NGOs give seed as gifts or on credit paid at the end of the season. Agro-dealers are the most important seed source for maize, while the local market is rated as the most important seed source for potato and beans due to its widespread use and familiarity. Own saved seed is rated as second in importance. Social network is rated as third in importance because it is only used if there is no alternative source and seed quality is not assured.

Across all three sites, seed systems are predominantly informal for most crops, with the exception of maize in Arusha and Liwale, where some farmers source improved varieties from agro-dealers and . This reliance on informal systems leads to challenges with seed quality, which in turn undermines productivity. Access to seed is also a concern, particularly for materials coming from research institutions, government subsidy programs or NGO-supported distributions. These channels can unintentionally marginalize certain farmers, and their seed supply is often irregular and difficult to rely on from season to season.

3.4.3 Varietal suitability

To meet the varied needs and preferences of farmers in crop production, a diverse range of crop species and varieties is essential. No single species or variety has a whole range of adaptation to environmental factors such as climate (temperature, moisture, light) and soil conditions (moisture, texture, acidity, salinity), as well as producers', farmers', market, and consumer preferences (128). In this regard, we emphasize varietal suitability as a crucial element within this context of seed security. Varietal suitability covers agronomic, and quality traits tailored to meet farmers' specific requirements and preferences. These traits include yield, storability, and marketability, resilience to environmental stresses, pests, diseases, and alignment with culinary and cultural preferences (125).

The four-cell analysis

In our study, we employed a four-cell analysis method to assess the variety quantity and distribution of two key crops chosen by farmers at each study site, totaling six selected crops. This method entailed participatory discussions with male and female focus groups to classify varietal diversity for each key crop into four groupings: varieties grown in large areas by many households (LA-MHH), in large areas by few households (LA-FHH), in small areas by many households (SA-MHH), in small areas by few households (SA-FHH). In addition, any abandoned varieties were placed in a fifth group. The criteria used for classification were based on the average areas defined locally as small or large, and the number of households defined as few or many cultivating each crop variety. Although the average farm area and number of farmers they defined varied by crop and site, this allowed participants in the FGDs to share their perspectives on crop diversity, cultivation patterns, and community preferences within the areas under study (Figure 8).

Intraspecific diversity of key crops

Intraspecific diversity refers to the genetic variation found within a single species, encompassing differences among populations, varieties, and individual organisms of that species. This diversity is expressed through variations in morphological, physiological, biochemical, and adaptive traits—such as yield potential, disease resistance, drought tolerance, and maturity period (129). In agriculture, intraspecific diversity is especially important because it enhances a species' ability to adapt to changing environmental conditions, withstand pests and diseases, and meet diverse cultural and nutritional needs (130). It forms the foundation for crop improvement, natural evolution, and farmers' capacity to select varieties suited to local environments.

FGD participants identified a total of 50 varieties across the 6 key crops8. This includes 8 sorghum and 7 sunflower varieties in Chamwino, 5 cashew nut varieties in Liwale, 4 Irish potato and 8 common bean varieties in Arumeru, and 18 maize varieties in Arumeru and Liwale (Figure 8). Farmers' varieties were mentioned for all crops except for sunflower, representing 40% of all varieties identified. Improved varieties were mentioned for all crops, especially maize, while old (or obsolete) improved varieties were identified for sorghum, sunflower, cashew nut and common beans.

Variety abundance/richness and distribution/evenness of key crops

Variety abundance, also referred to as varietal richness, describes the total number of distinct crop varieties present within a farming system or study area. It is a key dimension of agrobiodiversity, indicating the breadth of genetic resources available to farmers (129). Distribution or evenness, on the other hand, reflects how uniformly these varieties are cultivated across farms or communities. High evenness means varieties are grown in relatively similar proportions, while low evenness indicates that only a few varieties dominate production, with others used sparingly (131). Together, varietal richness and evenness provide a comprehensive picture of intraspecific diversity, offering insight into farmers' crop choices, the resilience of production systems, and the adaptive capacity of agriculture under changing climatic and socioeconomic conditions (130).

The four-cell analysis was again used to assess the abundance and distribution of key crop diversity within farming. Through this analysis, abandoned varieties i.e. those that have either disappeared or are now rare or declining were identified. The aim was to understand the overall suitability of different varieties,

considering factors such as market dynamics, agronomic characteristics, and culinary preferences.

Our analysis categorized varieties based on farmers' explanations for their current cultivation extent or abandonment, as illustrated in Figure 10 and Annex 2. It was found that a significant portion of the varieties are managed by farmers in the informal seed system, including both farmers' varieties and old improved varieties (usually open pollinated), that are saved and exchanged by farmers through their social networks. For instance, primary sorghum varieties of importance in Chamwino included improved varieties locally known as lugugu and sandala, cultivated in large areas by a few households. A newly introduced variety, macia, sourced through the formal seed system, was cultivated in large areas by many households, while lugugu showed a declining trend alongside two other abandoned varieties, banyala and sanjaji. Sunflower varieties predominantly originated from the formal seed system and were cultivated by many households in large areas, serving as a crucial source of livelihood security for farmers. Notably, no sunflower varieties were abandoned. Varieties that are grown over large areas by many households consist of a significant number of improved varieties, serving a dual purpose of income generation and food security.

Figure 8. Illustrative diagram of the four-cell analysis used to assess the abundance (richness) and distribution (evenness) of crop diversity in a community.

8 The count represents unique variety names after eliminating duplicate names mentioned by the men and women FGDs across sites. The count represents unique variety names after eliminating duplicate names mentioned by the men and women FGDs across sites.

For instance, commercial and traditional improved maize and common bean varieties, known for their high yields and market acceptance, were prevalent. However, maize and beans exhibited a considerable number of abandoned varieties, totaling five and four varieties, respectively.

In Arumeru, four Irish potato varieties were identified: Obama, which is widely cultivated across large areas by many households, and Lushoto, grown on smaller plots yet still by numerous farmers. Each variety is valued for distinct agronomic traits that meet specific market demands. Conversely, two other varieties have been abandoned because they lacked desirable agronomic performance, culinary qualities, or market appeal.

In Liwale, five cashew nut varieties—both local and improved—form an important foundation for household incomes and livelihoods. The improved varieties are commonly distributed through government initiatives, supporting farmers' access to higher-yielding planting material.

The presence of multiple abandoned varieties – all farmers' varieties – underscores an urgent need for interventions aimed at varietal renewal. Strengthening participatory breeding programs and fostering collaboration among stakeholders in the seed system could support the reintroduction and enhancement of farmers' varieties. Such efforts would help enhance performance while reducing the erosion of valuable genetic resources.

Varietal traits affecting abundance and distribution

Varietal traits play a critical role in shaping the abundance and distribution of genetic resources within farming systems. Traits such as yield potential, drought tolerance, pest and disease resistance, maturity period, and culinary or market quality directly influence farmers' choices of which varieties to cultivate and at what scale (132). Varieties that perform well under local agroecological conditions or meet strong market demand tend to be grown more widely, increasing their abundance and dominance across communities. Conversely, varieties with poor agronomic performance, low market value, or undesirable taste and cooking qualities are often cultivated on smaller plots or gradually abandoned, reducing their distribution and contributing to genetic erosion(133). Farmers' preferences, informed by cultural uses, labor requirements, and risk-management strategies, further determine which varieties remain central to production and which become marginalized.

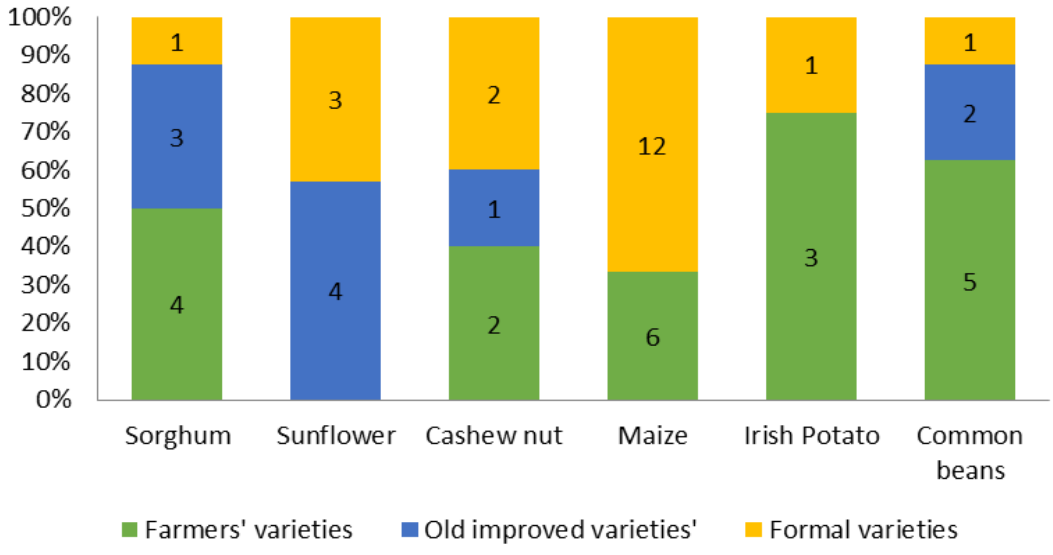

Figure 9. Proportion of variety types by key crops, including old improved and farmers' varieties managed in farmers' seed systems, alongside improved varieties sourced from the formal seed system, for each key crop across the study sites. The numbers in bar chart indicate the total number of varieties.

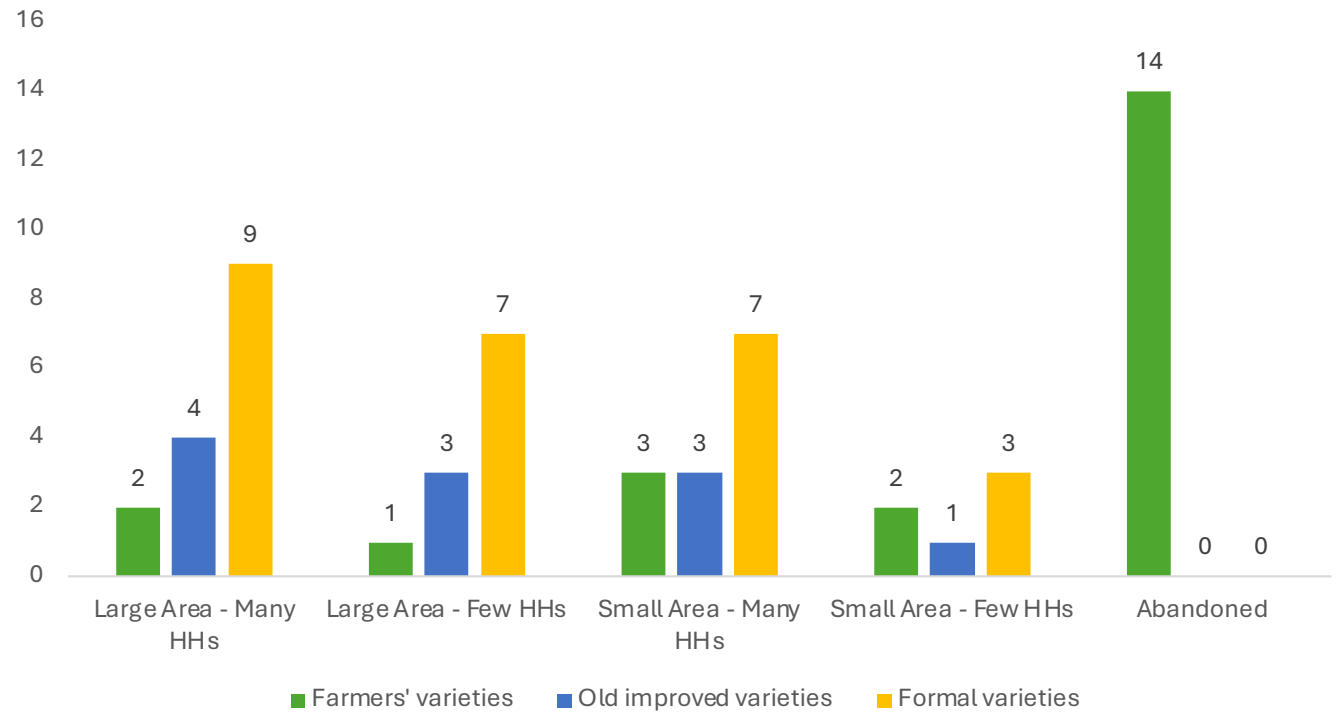

Figure 10. Four-cell categories of key crop varieties with number of varieties by variety type.

In this study, the abundance and distribution of key crop varieties in the study sites are influenced by various factors. These factors encompass varietal traits aligned with farmers' needs and preferences, such as yield, market value, disease and pest resistance, and early maturity. Additionally, farmers prioritize functional traits for culinary quality and cultural significance, as well as adaptability for multiple uses like soil fertilization and livestock fodder. To better understand the factors involved in categorizing different varieties (improved and farmers' varieties) into the four-cells or the abandoned category, we asked the participants of the FGD to provide further elaboration. They were asked to consider both positive and negative traits, and to consider market, agronomic, and culinary features for all the varieties.

Detailed summary of these traits is organized and presented in Annex 2. Here, we emphasize these factors, particularly highlighting the positive traits of popular varieties of few key legume, cereal and RTB crops cultivated by many households in large areas. Additionally, we emphasize on the negative traits contributing to the decline of varieties of these crops grown by few households in small areas, as well as abandoned varieties. We note that varieties grown by many households in small areas generally display a mix of positive and negative traits. This observation holds true for varieties cultivated by few households on large areas as well, with the distinction that these varieties are typically valued for their marketability.

Positive traits

In ***Chamwino district***, farmers described many ***sunflower*** varieties grown as high yielding, drought tolerant and having high oil content. For ***sorghum*** varieties, farmers emphasized characteristics such as high yields, early maturity, tolerance to pest and diseases, good taste and some varieties being less susceptible to bird damage. Farmers indicated early maturity and drought tolerance as desired traits. In ***Liwale cashew nut*** emerged as the key crop with farmers noting its positive traits as high yield, drought and disease tolerance, sweet taste, extended storage capability and low management costs.

Maize is the most grown crop across two of the three districts namely ***Liwale and Arumeru***. Positive traits for maize included high yield, drought and disease tolerance, low production costs, big cobs and good

milling quality. However, concerns were raised about susceptibility to storage pests and relatively smaller seed size. Farmers desire varieties that are more resistant to pests and diseases.

In ***Arumeru*** district, ***common beans*** received praise from men for being a nutritious food source without causing digestive discomfort, possessing good market demand, and high market prices. Despite these positive attributes, farmers' main concern across all varieties was the high cost of cultivation. They therefore expressed a clear preference for varieties that are less susceptible to pests and diseases and can be grown with low external inputs, in order to minimize overall production costs.

Negative traits

Many varieties of key crops seem to have been abandoned because a few households are cultivating them on small areas. The abandonment or decline of many varieties of key crops is attributed to various factors, including the introduction of new varieties that offer advantages such as early maturation, high yield, and resilience to climate change impacts such as drought and strong winds. Additionally, heavy losses during harvest, infestation by pests during storage, poor taste and color, limited market opportunities, and insufficient cultivation knowledge contribute to this trend.

In ***Chamwino*** district, farmers expressed concerns over the high cost of ***sunflower*** seed, particularly for varieties like Jupiter that yield less oil. Challenges related to ***cashew nut*** cultivation include processing difficulties, high production costs, and market-related issues. Similarly, farmers highlighted issues such as poor market demand, weather-dependent yields, and high production costs for certain varieties of cashew nuts.

In the Arumeru district, farmers voiced concerns about the high costs of ***Irish potato*** seed, leading some to rely on donations from NGOs or credit systems. For ***common beans***, the abandonment of four varieties was attributed to climate change impacts, low yields, and issues such as excessive gas production. These challenges underscore the need for interventions to address issues related to seed availability, production costs, market access, and climate resilience in order to sustain crop diversity and ensure food security.

The World Vegetable Centre vegetable seed kits with a variety of different seeds for farmers to try on farm. The packages include a flyer with information on the varieties and their production. Photo: Sarah Paule Dalle/NMBU

4 RECOMMENDATIONS FOR STRENGTHENING COLLABORATION AND SEED SYSTEM OUTCOMES

This final chapter provides a synopsis of the approaches proposed by stakeholders to strengthen seed system outcomes in Tanzania. Based on the insights gained from this study, recommendations from key informants, and discussions at the final roundtable meeting, three core areas of intervention have been identified as essential for strengthening the functioning of the seed system and improving farmers' seed security in the country.

First, given Tanzania's vast size, diverse administrative regions, and varied agro ecological zones, a *decentralized approach to seed system development* is necessary. This includes localized efforts in variety development through TARI, streamlined processes for variety release and testing, and the promotion of *community-based seed production* through QDS systems. Some of the groundwork for this is already laid and strengthening such decentralization would enhance farmers' access to improved seed varieties that are better suited to local environmental conditions and production needs.

Second, *capacity development* is crucial for strengthening seed systems, particularly for downstream actors such as local seed businesses and community-based seed producers. Strengthening technical knowledge in seed production, quality assurance, business models, among these stakeholders will enhance their ability to produce and distribute high-quality seeds, thereby improving overall seed availability and adoption at the community level.

Finally, *enhancing stakeholder engagement and collaboration* through *multi-stakeholder platforms* or other mechanisms is vital for improving efficiency and reducing transaction costs in the seed sector. These platforms should facilitate collaboration among genebanks, breeders, farmers, policymakers, private sector actors, and research institutions to drive innovation in crop and genetic improvement, seed security, and sustainable seed system development. By fostering dialogue, knowledge exchange, and coordinated action, such platforms can contribute to a more resilient and inclusive seed system in Tanzania. They can be especially impactful if they successfully bring together actors focused on in situ conservation and farmers' seed systems with those focused on the formal seed sector.

4.1 Decentralized approaches to seed system development

Tanzania is a vast country rich in diverse genetic resources, yet its seed system remains predominantly informal, with an estimated 70–90 percent of seed sourced through farmer-managed channels. In this context, farmers play a crucial role in maintaining and conserving these genetic resources. Many key informants therefore stressed the need to strengthen Tanzania's already interconnected seed system—one that builds on farmers' strengths in conservation and local adaptation, while also harnessing the formal sector's expertise in breeding, variety release and quality assurance. They highlighted the value of developing innovative mechanisms to disseminate both formally released and farmer-developed varieties. Such an approach would help close the gap between the two systems and improve the overall performance, resilience, and sustainability of the national seed sector.

To move towards this kind of integrated system, several approaches were proposed:

Registration and commercialization of farmers' varieties

Once farmers' varieties are officially registered in the national catalogues, they transition from being informal, locally circulated seed stocks to being part

of the formal seed system. This official recognition confers several advantages:

- Access to formal quality control: Registration would enable the varieties to undergo standardized testing for traits. These tests establish a verifiable quality assurance benchmark that helps ensure the seeds perform consistently under diverse conditions.
- Enhanced market credibility and commercialization: With formal quality certification, farmers' varieties would gain legal recognition that not only builds trust among buyers but also opens up access to national markets. Certified quality and standardized performance become selling points, helping seed companies, farmers' organizations, and public institutions to commercialize these varieties more effectively.
- Potential for higher market prices and strengthened support mechanisms: Official registration would enable farmers to command higher prices for their seeds, as the quality is validated through formal procedures. Moreover, registered varieties can be linked to public and private initiatives—such as QDS schemes—that further support the scaling up of seed production and distribution.

Utilizing existing QDS systems

Although QDS systems in Tanzania are currently applied to improved varieties, it is proposed that they could be expanded to include farmer varieties as well. Registered farmers' varieties could be commercialized through QDS production, which can be carried out by farmer groups, seed cooperatives, and community seed banks. This approach would help ensure that quality seed is available at affordable prices while also supporting local production networks.

Participatory plant breeding

Many stakeholders have also advocated for participatory plant breeding as an effective way to enhance and modernize popular farmer varieties. In this approach, farmers and formal breeders work hand in hand from the early stages of selection to the final improvement of the variety. The process ensures that key traits valued by local farmers—such as adaptation to specific agroecological conditions, taste, cooking qualities, and resilience to pests and diseases—are maintained or enhanced. Once improved, these varieties can be released and commercialized under the already existing QDS system, which offers a cost effective and less cumbersome alternative to full seed certification. This not only reduces the regulatory and financial burden for smallholder farmers but also facilitates faster uptake and wider dissemination of quality seed through existing informal seed networks.

Decentralization of TOSCI and increasing the number of certified seed inspectors

Decentralizing TOSCI and increasing the number of certified seed inspectors is essential for enhancing seed quality and market access. By establishing regional TOSCI offices, local communities receive faster, tailored support for seed certification. Expanding the inspector workforce ensures comprehensive field assessments, accurate testing, and timely approvals, which reduce logistical delays and strengthen accountability in the certification process. Ultimately, decentralization and a larger inspector network empower smallholder farmers, improve seed quality standards, and facilitate broader distribution of reliable, high-performing seeds throughout Tanzania's diverse agro-ecological zones. There are already steps in this direction (e.g., training of Authorized Seed Inspectors for QDS) and this should be strengthened.

Engaging farmers and community-based seed producers in dissemination of varieties

Engaging farmers and community-based seed producers in the dissemination of crop varieties is vital for sustainable agricultural development. By actively participating in seed multiplication, sharing, and marketing, farmers strengthen local seed systems and accelerate variety dissemination. Currently TARI or private companies produce and distribute seeds themselves—missing the opportunity to build on the strengths of community-based actors. If TARI could engage farmers and community-based seed producers in seed production and multiplication in collaboration with TOSCI for seed quality assurance, the seed value chain would be improved. This could include production of QDS but also of EGS—as one participant from TOSCI argued at the roundtable meeting, farmers

produce QDS as well as certified seed as outgrowers for private companies; they have capacity to also meet requirements for EGS if properly supported. The involvement of farmers also builds trust in the quality of seeds, while community networks facilitate timely distribution and adaptation. This collaborative, decentralized approach not only enhances biodiversity conservation and resilience to climate variability but also empowers smallholder farmers.

4.2 Capacity development

The study identified essential capacity needs at both local and national levels. At the local level, stakeholders emphasized the importance of engaging CSBs and community seed producers in seed production activities, ensuring alignment with TOSCI's quality assurance standards. Additionally, there is a critical need to systematically identify and register community-based seed producers and seed banks eligible to qualify as QDS producers. This initiative would strengthen local seed systems, facilitate access to high-quality seeds, and ultimately empower smallholder farmers by enhancing local seed production capabilities and improving overall seed quality and availability, thus ensuring food security.

Capacity development at the national level plays a crucial role in reinforcing Tanzania's seed systems. Focused efforts are needed to enhance genebanks' capacity to integrate in situ and ex situ conservation. Strengthening collaboration between CSBs and genebanks, along with creating formal protocols for their interactions, will improve the management and conservation of genetic resources. Furthermore, plant breeders and TARI should be supported in participatory plant breeding techniques, engaging farmers to develop genetically diverse varieties suited to specific agroecological regions and culturally acceptable needs. Capacity building for TOSCI and ASA is equally essential, ensuring effective early generation seed production and improved certification standards to boost seed availability.

Seed delivery is vital for agricultural sustainability, yet the study reveals critical bottlenecks. Challenges include low breeder capacity for variety maintenance, unrealistic EGS demand forecasting, limited variety information, minimal private sector involvement in EGS production, and insufficient infrastructure and funding. Extension services are poorly connected with farmers and key actors such as TARI and private sector partners, exacerbating the seed delivery gap. In Tanzania, NGOs including PELUM, Ile de Paix, SWISSAID, and TABIO, have played an essential role by linking farmers to markets and building capacity in seed production, conservation, quality assurance, and community-based seed enterprise development. TOSCI has supported this by providing training in QDS production.

4.3 Multi-stakeholder partnerships for innovative seed delivery

Multi-stakeholder partnerships are essential for innovative seed delivery, fostering collaboration among government agencies, research institutions, non-governmental organizations, private companies, and local communities.

The study shows that Tanzania's seed system is highly fragmented, with weak linkages between the national genebank, breeding programs and TARI. Conventional breeding within TARI tends to operate in isolation, with limited farmer participation and little coordination with the private sector for seed dissemination. Many breeders also depend on CGIAR collections or materials from their own breeder networks, rather than drawing on the national genebank. As a result, connections between the genebank and breeding programs remain poor and uncoordinated. Furthermore, there is a clear gap in EGS production. Overlapping roles between TARI and ASA, combined with resource constraints, prevent TARI from meeting demand—prompting some private-sector actors to step in and produce EGS. This disjointed structure hampers the rapid adoption of improved varieties and restricts scaling of innovations.

To address these challenges, there is an urgent need to establish innovation platforms that bring together all key stakeholders at both national and local levels. At the national level, such a platform would enable coordination among seed sector actors, while complementary district-level platforms would facilitate more localized collaboration, seed demand articulation, engagement with local actors and implementation at the local level.

As such, the national platform should link the national genebank—responsible for ex situ conservation—with farmers engaged in in situ conservation, and facilitate collaborative variety development and release between TARI, the national genebank, and farmers. TOSCI must play a central role in variety release, seed quality assurance, and building capacity for quality seed production. Additionally, NGOs and private sector actors are critical for enhancing seed delivery. Integrating formal and informal seed markets by including community-based seed producers, cooperatives, and CSBs will further strengthen the seed system, enabling more effective dissemination, improved adoption of superior varieties, and ultimately, enhanced agricultural productivity and food security in Tanzania. At the local level, platforms should connect TARI and ASA with key seed system actors such as local seed businesses, seed cooperatives and community seed banks. These spaces would help articulate farmers' seed demand and serve as channels for the dissemination of new varieties.

These alliances enable the pooling of expertise, resources, and market channels to address challenges in seed production, certification, and distribution. By integrating formal and informal seed systems, partners improve quality assurance, promote the development of locally adapted varieties, and enhance access to reliable, high-quality seeds. Innovative approaches build capacity, empower smallholder farmers, and stimulate rural enterprise development. Ultimately, multi-stakeholder partnerships transform seed delivery into a resilient, inclusive, and sustainable agricultural system, fostering long-term, equitable food security.

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