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Review Paper

Building Better Seeds for Tanzania: A Comprehensive Review of the National Seed Systems

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***Abstract*— The Tanzanian seed industry is a critical pillar for achieving national food security and driving agricultural transformations. The industry is primarily dominated by the informal sector which accounts for over 80%. The formal seed system, though in the growing phase, accounts for only a short of 20% of the total national's seed demand. Despite notable progress in policy reforms and private sector growth, the industry is constrained by inadequate early-generation seed(EGS) supply, weak distribution networks, high seed costs, and the persistent presence of counterfeit seeds. This review synthesizes the current structure of the seed system, analyses key policies and regulatory frameworks, and evaluates the principal challenges and opportunities for escalating improved seed availability, accessibility and utilization. Future growth hinges on effective implementation of the new seed sector strategy, targeted investments in public-private partnerships (PPPs) for breeding and production, and the full operationalization of harmonized regional seed trade protocols.**

Keywords*— Counterfeit seeds, EGS, formal seed system, informal sector, PPPs

I. INTRODUCTION

Agricultural sector remains the pivot of the Tanzanian economy; the sector employs a vast of majorities in different nodes of its value chain, thereby contributing vitally (~24.8%) to the overall Gross Domestic Product (GDP) [1]. The production node as one among key stairs in the sector, roots the foundation of all subsequent nodes, it provides about (65%) of all the raw materials used in manufacturing industries, offering food and feed for the mankind and survivorship as well as economic welfare and prosperity [2;3; 4]. As noted by ref [5], production node itself accommodates up to 65% of youths, thus acting as the valuable source of employment. This make agriculture, to be among the most hiring sub-sector in Tanzania.

Notwithstanding the robust contribution of this portion of the sector, the average crops produce for major crops and cash crops like rice, maize, cotton, sunflower and common bean is yet slanted far below the global potentials [5;6;7]. For instance, the average yield potential for common bean crop reaches up to 3 t/ha, while the approximated yield in many parts of Tanzania lies between 0.6 t/ha and 0.8 t/ha[8;9].

This production short-count is primarily escalated by a myriad of hindrances accounted in are the issues of soil fertility and soil health deterioration, enormously rise in heat and temperature attributable to global warming, drought incidences, the rising impacts of pests and diseases and the insignificant adoption of improved varieties[10]

Adoption of clean seeds of improved varieties, is the major determining factor for crop yield in farmers' fields [11]. The scanty varietal turnover (~20%) for most of the major crops in Tanzania greatly explain why farmers get low yield seasonally[12;13]. Ref [14] highlights a trivial adoption of improved rice varieties averaging 1% of smallholder farmers being adopters. Another report by ref [15] stipulates the approximate adoption of improved seeds of legume crops from different countries, suggesting the estimated percentage of adopters in Tanzania being 13.1% for common bean and 32% groundnuts. This state of adoption is quite lower when compared with that of neighbour countries like Uganda with 29.2% common bean and 59.5 groundnuts.

Strategic intervention in seed system is thus of paramount eminence for the intent of upgrading production potential, market value of on-farm produces and the ultimate social livelihoods [8;10].

The aim of this review is to locate the current structure of the Tanzanian seed industry, identifying major opportunities for investment, and challenges inflicting the adoption of improved seed varieties. The review will also provide critical insights, fundamental for notifying policy, investment decisions, and the advance of the nascent Tanzania Seed Sector Development Strategy (TSSDS).

II. THE INDUSTRY: STRUCTURE AND KEY PLAYERS

Seed is an essential component for successful crop production. Unfortunately, this component cannot be accessed equally by all farmers. Underscoring this constraint, the Tanzanian seed systems is structured in a multidimensional stream to accommodate the diverse need of farmers. The system comprises of the informal, semi-formal and formal seed systems, operating complementarily to ensure farmers' access adequately and quality planting materials [16].

A. The Informal Seed System

This system plays a critical function in guaranteeing accessibility of planting materials to smallholder farmers, explicitly in the rustic areas. The system is adopted by more than 80% of the Tanzanian farmers, making it a principal source of seed for the majority of smallholder farmers[17]. Contrary to the formal seed system which involves certified seeds produced and distributed by registered companies under government regulations, this system relies on farmers' saved seeds. Farmers may also exchange seeds with neighbours, relatives, or members of their community, nurturing a strong culture of sharing and trust[18;19]. Local markets are another vital source of seed, where farmers purchase and sell seed that is not formally certified but is performing well under local environmental conditions [20].

Despite its potentiality for genetic diversity conservation, ease accessibility and cost-effectiveness, the system is often chased by a myriad of restraints explicitly in these eras of enormous climate change, the attributing factors include, frequent susceptibility to pests/diseases, low yields due to genetic contamination, and lack of varietal improvement [20;21;22].

1) Attributions pulling farmers toward the informal seed system

- Seed accessibility. In many rustic areas of Tanzania, certified seed is not easily available because formal seed outlets are few and far apart. During planting seasons, farmers can easily get seed from neighbours, local markets, or community seed banks, which makes the informal system more convenient[23;24].
- Seed affordability. Certified or hybrid seeds are usually expensive, and many smallholder farmers cannot afford to buy them every season. Instead, they prefer to save seed from their own harvest or exchange seed with other farmers, which helps them reduce production costs [25].
- In addition, limited awareness about the benefits of certified seed and weak agricultural extension services, contribute to farmers' reliance on informal sources. When farmers are not well-informed or supported by extension officers, they tend to continue using what they already know and trust [26]. Finally, social networks strengthen the informal system. Farmers commonly share, exchange or barter seed within their communities, especially through family, neighbours and local farmer groups. This system not only ensures easy access but also builds trust and cooperation among farmers [27]. Generally, the informal seed system attracts farmers because it is more affordable, accessible, socially accepted and suited to local conditions, even though it lacks the formal quality control that certified seed provides.

2) Stakeholders' intervention in the informal seed system

In recent years, many efforts have been put forth by NGOs, research institutions, and the government of Tanzania to fortify the informal seed system. Initiatives include training farmers in community seed banking, good agronomic practices for quality seed production, post harvesting handling practices and participatory breeding programs [26;27]. These programs aim to merge the strengths of all the seed systems, optimizing seed quality and accessibility while preserving indigenous varieties and farmer autonomy. Generally, the informal seed system is yet a keystone of the Tanzanian agricultural sector, supporting millions of smallholder farmers and nourishing agricultural diversity within the country.

B. The Formal Seed System

This embraces a range of breeding programs, variety registration and release, seed multiplication, quality declaration, and distribution and marketing of certified seeds. Key players are detailed in the table 1 below.

The formal seed system lays on the Seeds Act (No. 18, 2003), which proffers the legal foundation for variety development and release, certification of seed and seed quality regulation [28;29]. TOSCI was established under this Act to manage certification processes, field inspection, seed testing and variety release. TARI and other breeding institutions develop public demanded varieties of improved traits, and ASA was founded as semi-autonomous body to produce and distribute basic and certified seed. These institutions work in chain forming the mainstay of the formal seed system [32]

1) Seed production, importation and marketing in the formal seed system.

Seed production in Tanzania operates through a collaborative public–private model. Public institutions such as the Tanzania Agricultural Research Institute (TARI) and the Agricultural Seed Agency (ASA) handle breeding and multiplication of breeder, foundation, and certified seed for crops including maize, rice, legumes, vegetables, sunflower, and sorghum [31;32]. Private companies also produce certified seed, though many rely on foundation or breeder seed sourced from public research bodies and CGIAR partner programs [33;34 ;35]. To expand production efficiently while maintaining quality standards, both public and private entities often engage contract growers (farmers who are supplied with planting material, technical advice, and sometimes inputs to produce seed under supervision). The harvested seed is then bought back, processed, and certified by the contracting institution [36]. For example, ASA and several private firms use out-grower schemes for maize and rice [37]. International initiatives linked to CGIAR have also supported early-generation seed multiplication under similar models [38]. This system reduces capital investment for companies, provides farmers with assured markets and stable income, and ensures quality traceability required during field inspection and certification [17].

The production and importation trends for improved seed in Tanzania is dynamic with the potential increase in recent years. This increase is primarily influenced by policy reforms on seed sector, multi-stakeholder collaborative efforts and the noticeable raise in m the market demand for hybrid seed and improved varieties [39].The graph below posits a five year trends in seed production and importation in Tanzania.

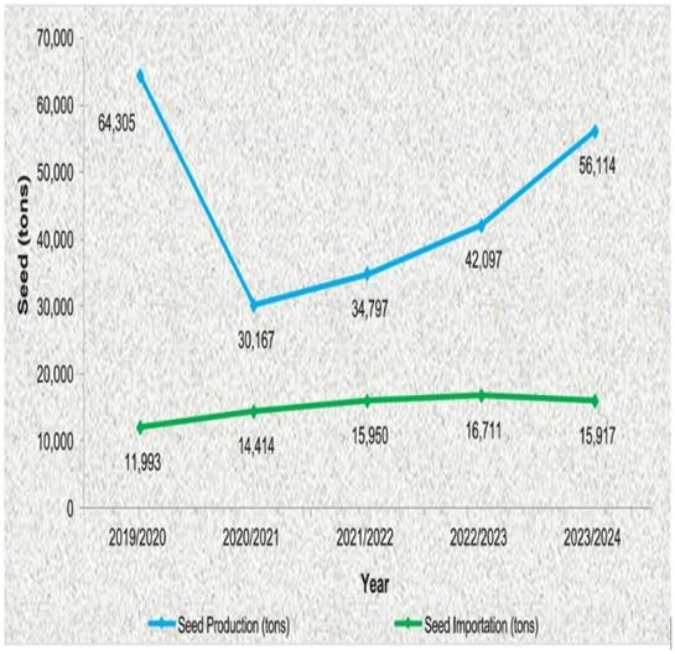

Fig. 1. Seed Production and importation trends from 2019/2020 - 2023/2024 cropping seasons (Values set in tons). Retrieved from ref [40]

2) Market trends and demand dynamics

The Tanzanian seed industry is recently experiencing a potential raise in availability of improved seed. This showcases a promising shift from the ordinary seed recycling to an intuitive formal seed system. For instance, during the production season of 2023/24, the improved seed availability reached 72,031.9 tons, contrary to 58,807 tons of 2022/23. This was around 56% of the total seed demand of 127,650 tons year-1[40]. Moreover, the in-country seed production escalated to 56,114 tons compared to 42,096.7 tons of 2022/2023 [41]. Increased seed availability is primarily driven by higher potential market demand and the government intervention on strengthening production systems in the research institutions (TARI), ASA and private companies [42].

Market demand for improved seed is however unevenly across crops and regions. Crops with demonstrated high yield benefits such as hybrids of maize and horticultural crops tend to win the demand rivalry, often in regions where farmers have been exposed to demonstration plots, workshops and extension services [43;44]. The willingness to pay for certified seeds of hybrids and improved varieties is often attributed by price sensitivity, farmers are willingly to invest when the return is practical [6]. Other factors such as well-structured seed access with credit, input packages, or market guarantees also tend to optimize the adoption of improved seed [45;46;47]. The detailed summary of seed availability of some crops is as stipulated in the table 2 below.

TABLE I. KEY PLAYERS IN THE INFORMAL SEED SYSTEM

Operation nodes	Actors
Research and breeding programs	This node includes the Tanzania agricultural Research Institute (TARI), agrarian universities and the international centers (CGIAR) notably, the CIMMYT, IRRI, IITA, ICRISAT and CIAT, are major sources of Breeder Seed and new public varieties [30]
Production of Early Generation Seed (EGS)	The principal actor in this node in the Agricultural Seed Agency(ASA), the agency is engaged in the production of both foundation and certified seed of released and popular varieties. Private entities also intervene in EGS for their proprietary varieties [31].
Seed certification and quality assurance	Tanzania Official Seed Certification Institute (TOSCI), is the solely mandated body for carrying out activities related to seed inspection, seed testing, certification process, variety release and registration of seed dealers [56]
Seed multiplication and marketing practices	This cluster encompasses more than 60, national and foreign formal seed companies and numerous local seed enterprises, who multiply and distribute Certified Seed via a network of seed-dealers. The adoption of QDS seed is also strengthened to optimize local availability [69].

TABLE II. SEED AVAILABILITY FOR THE CROPPING SEASON 2023/2024

Crops	Import	Domestic Production	Total
Maize	13,729.40	29,539	43,268.40
Paddy	51.44	529	580.68
Sorghum	16.65	454	470.65
Sunflower	361.56	1,412	1,773.63
Vegetable Seeds	732.4	263	995.87
Pasture Seeds	3.76	0	3.76
Bean	30.19	43.27	73.39
Cotton	0	23,000	23,000.00
Green gram	0	0.75	0.75
Pigeon pea	0	2.2	2.2
Groundnut	0	9.4	9.4
Sesame	0	52.59	52.59
Wheat	315.85	522	838.18
Cowpea	0	0.25	0.25
Finger millet	0	1	0.5
Tobacco	0.29	0	0.55
Soybean	675.89	286	961.09
Total Availability	*15,917.43*	*56,114.46*	*72,031.89*

Data retrieved from ref [2]

3) Market forces influencing production and pricing

Numerous socio-economic and institutional aspects shape seed production and pricing in the country. Key issues include input costs such as high prices if fertilizers, credit access for seed enterprises, and the strength of agro-dealer distribution

channels. Market prices for crops produces (grain) likewise affect the selling potential of seed producers [48]. External actors, government programs, NGOs, and other stakeholders can momentarily scale up seed business via subsidies, vouchers, or demonstration campaigns, though these interventions may distort normal market functioning in a long-run [49]. Climate variability and uncertain rainfall patterns further influence farmer behaviour, prompting some to minimize risk by using retained seed or cheaper alternatives [50]. High transportation and storage costs, especially in low-density rustic areas, also increase seed prices and constrain competitiveness [25].

4) 4)Companies' perceptions toward hybrid seeds and OPV varieties

The strategic choices of seed companies often hinge on the potential return on investment and farmer preferences. Hybrid varieties are favoured by most private companies because they offer higher and more uniform crop produces, and have 100% seed replacement rate (SRR), hence creating recurring revenue [50;51]. In contrast, open-pollinated varieties (OPVs) are less costly, can be recycled and often with unpredictable demand, thus are more appealing to low-income or risk-averse farmers [52;53]. Public institutions such as ASA and TARI continue to support OPV production to enhance food security and affordability. few companies adopt a bi-strategy, promoting hybrids in commercial zones while offering OPVs or small packaging options for resource-constrained areas [55]. However, farmers often remain sceptical about switching from OPVs to hybrids unless tangible yield benefits are demonstrated through field evidence and trusted extension support.

5) Marketing Channels: Agro-dealers, Seed fairs and Bundled Packages

The marketing of certified seed primarily depends on networks of agro-dealer, which act as the main retail points linking seed companies and farmers. To complement this system, firms and development partners organize seed fairs, on-farm demonstrations, and cooperative purchasing initiatives, enabling farmers to visualize performance and compare varieties first-hand [56]. Increasingly, seed suppliers are adopting bundled marketing strategies, combining seed sales with fertilizer, training, or credit facilities to improve adoption [40] Mobile-based applications and e-voucher platforms are also emerging tools for seed information dissemination and targeted input distribution [7]. Though usage remains uneven due to varying literacy and infrastructure levels across regions.

6) Farmer engagement strategies in the value chain

Various strategies are used to fortify farmers' involvement in the formal seed system in Tanzania. These are tailored on un-blinding farmers to the potentials of improved seed, to foster adoption

a) Direct field demonstrations are key: seed companies often create on-farm demonstrations and field days so farmers can personally witness how new varieties perform under their local growing conditions, which is crucial for building trust and awareness [56].

b) Integrating farmers into production: Out-grower and contract farming systems leverage local farmers as partners in certified seed production, providing them with the necessary training, inputs, and a guaranteed market for their harvest [15;37].

c) Harnessing collective farmer power: By collaborating with farmer cooperatives (like MVIWATA), the demand for seeds can be pooled, facilitating bulk purchases for better prices, and strengthen their advocacy for supportive seed policies [57].

d) Strengthen the retail networks: building the capacity of agro-dealers (example, through programs like RUCODIA) by offering training and incentives, ensuring they can provide accurate advice and maintain proper seed handling for more efficient distribution [54].

C. Semi-Formal Seed System

Quality declared seed (QDS) is a system where a trained farmer is mandated to produce seed that meet s at least minimum quality standards without adhering to the formal seed inspection principles governed by TOSCI [58]. The system was founded by FAO in 1993 with the intent of assuring farmer access to quality seed and lessening the workload of the certification bodies[37]. In Tanzania the system was firstly adopted in the year 2000, and incorporate in the National Seed Act of 2003. Rules, regulations and operation procedures were incorporated in the seed regulation Act of 2007 [32]. The QDS system serves as an alternative approach to seed quality assurance, specifically designed for countries with limited resources [26]. It is less complex and more cost-effective than the formal seed certification system, while still ensuring an acceptable level of seed quality. However, not all countries have adopted the QDS system. In Eastern Africa, it is officially recognized in Tanzania, Uganda, and Ethiopia (for certain crops), and in Kenya, it is applied to vegetative propagated materials (VPG) [59].

The Tanzanian QDS system operate in a linear progression with ASA acting as the stock of planting materials. Trained farmers are supplied with foundation seed as the initial seed source, field management is done under the supervision of local extension officers trained by TOSCI. The inspection is done twice with the team consisting of trained staffs from the district office and a member from ASA. Yield sample is gathered and submitted to TOSCI for analysis of germination and purity percent. For instance, the accredited standards for OPV maize varieties are 80% germination, 98% purity and 13% moisture content. After the approval by TOSCI, QDS seed is sold within the district of its production [15;59].

III. Cascading Structures Of Seed Systems In Tanzania

Figures 2 and 3 illustrate the cascading nature of seed systems in Tanzania, demonstrating how seed flows through successive stages within the formal, semi-formal, and informal seed systems. The process typically begins at national and international agricultural research institutions, where breeding, variety development, and initial seed multiplication take place. From these institutions, early-generation seed such as breeder and foundation seed is transferred to certified seed producers, both public and private, who are responsible for large-scale multiplication under regulated conditions. The seed then moves through distribution channels that include agro-dealers, cooperatives, and development programs, ultimately reaching farmers, who serve as the final consumers within the seed

production and consumption webs. In many cases, farmers also act as secondary seed producers by saving, recycling, or exchanging seed, thereby reinforcing linkages between the formal and informal systems.

The formal seed system in Tanzania is characterized by structured regulation, quality control, and certification processes overseen by national bodies such as the Tanzania Official Seed Certification Institute (TOSCI). This system primarily supplies improved and hybrid varieties of major crops through registered seed companies and licensed agro-dealers. In contrast, the semi-formal seed system acts as an intermediary, involving community-based seed producers, farmer groups, NGOs, and local enterprises that multiply and distribute QDS seed. This system is particularly important in remote and underserved areas, where access to certified seed is limited, and it plays a critical role in enhancing seed availability while maintaining acceptable quality standards. The informal seed system remains the most dominant in Tanzania, accounting for the majority of seed accessed by smallholder farmers. It relies on farmer-saved seed, local markets, social networks, and traditional exchange mechanisms, and is especially vital for indigenous crops, landraces, and climate-resilient varieties.

Tables 3 and 4 further elaborate the roles of public and private actors across the Tanzanian seed value chain. Public actors including research institutes, regulatory authorities, and extension services provide foundational support through variety development, policy formulation, seed certification, and farmer capacity building. Private sector actors, such as seed companies, agro-dealers, agricultural cooperatives and input suppliers, drive commercialization, distribution efficiency, and market expansion. Non-governmental organizations and development partners often bridge gaps between these actors by supporting seed multiplication, strengthening farmer organizations, and promoting inclusive access to improved seed. Together, these interconnected actors form a cascading and interdependent seed system that balances regulation with flexibility, ensuring seed availability, diversity, and adaptability to Tanzania's diverse agro-ecological and socio-economic contexts.

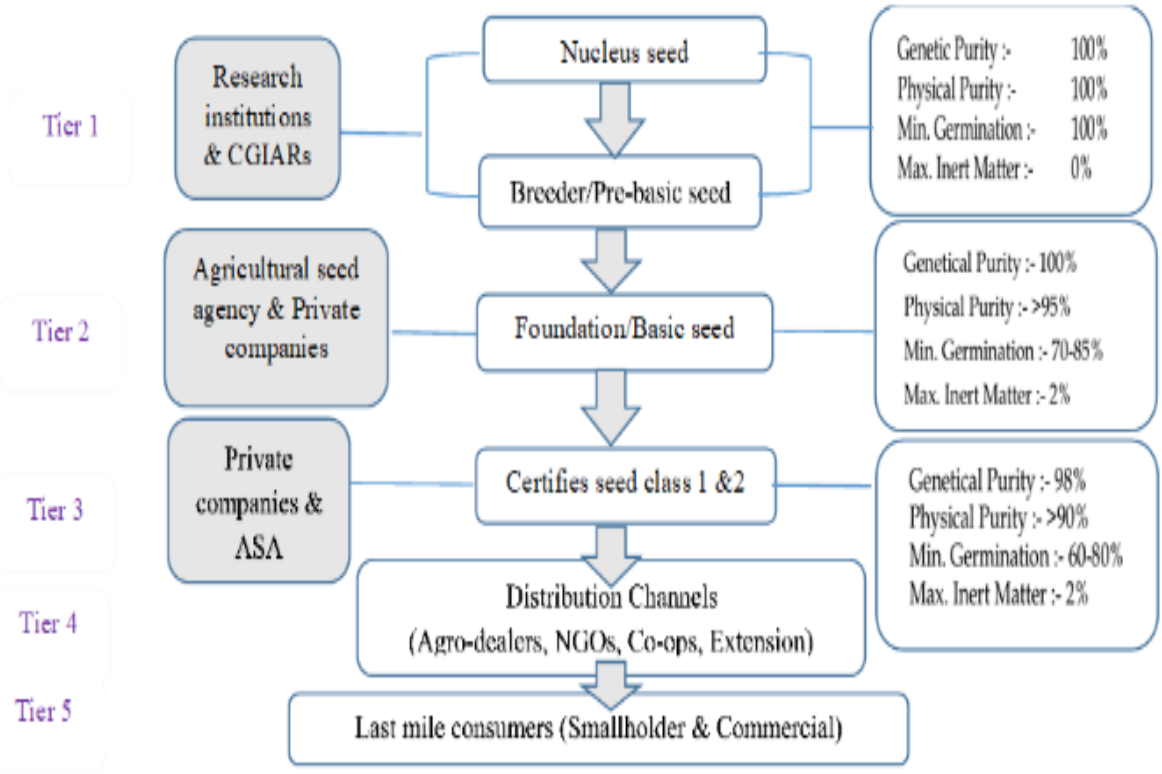

Fig. 2. The Tanzanian formal seed system scheme

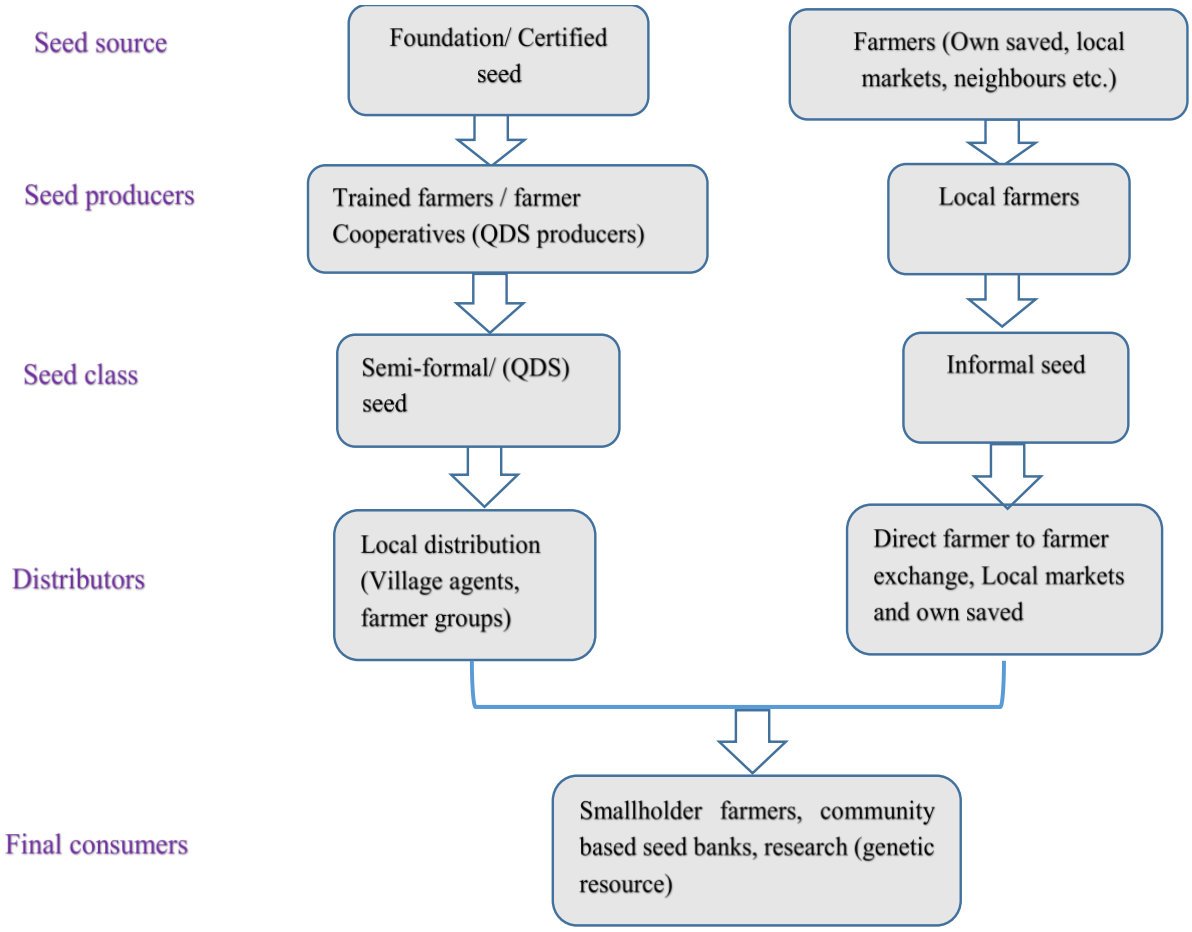

Fig. 3. The Tanzanian Semi-formal and informal seed systems

TABLE III. PUBLIC-BASED ACTORS SUPPORTING THE SEED SECTOR IN TANZANIA

Category	Actor/Stakeholder	Explanation
1. Research and Variety Development	TARI	TARI operates under the Ministry of Agriculture, the institute was established by the Parliamentary Act No. 10 of 2016. TARI coordinates national agricultural related researches and develops improved crop varieties. Its headquarters are in Dodoma, with 17 research centres (Makutupora, Tumbi, Dakawa, Kihinga, Uyole, Mikochemi, Ilonga, Maruku, Ifakara, Ukiriguru, Hombolo, Kifyulilo, Mlingano, Kibaha, Selian, Tengeru, Naliendele). Each centre has specific crop mandates.
2. Seed Production and Supply	ASA	ASA was established in June 2006 under the Executive Agencies Act [Cap. 245 R.E. 2002], ASA operates as a semi-autonomous agency of the Ministry of Agriculture. It produces, processes, and markets high-quality basic and certified seeds, and promotes private sector participation in the seed industry. ASA manages 13 seed farms (approximately12,000 ha) across the country producing maize, common bean, rice, sunflower, sesame, sorghum, groundnut, cowpea, green gram, wheat, chickpea, and horticultural crops. It also promotes certified seed demand through partnerships and farmer-preferred varieties.
3. Regulation and Quality Assurance	TOSCI	A government body under the Ministry of Agriculture, established by the Seed Act No. 18 of 2003 to oversee seed certification and regulation. TOSCI verifies and promotes high-quality seed both locally produced and imported to safeguard farmers from substandard or counterfeit products. Headquarters: Morogoro Municipality; Zonal Offices: Arusha (Northen zone), Njombe (Southern Highlands), Mwanza (Lake zone), and Mtwara (South),. The institute has enhanced certification through electronic labeling, laboratory upgrades, a genetic reference library, and decentralized online systems. TOSCI is a member of OECD and ISTA, operating an ISTA-accredited lab in Morogoro, Tanzania

TABLE III. PUBLIC-BASED ACTORS SUPPORTING THE SEED SECTOR IN TANZANIA (CONTINUE)

Category	Actor/Stakeholder	Explanation
4. Plant Health and Biosecurity	TPHPA	Established through Act No. 4 of 2020, TPHPA integrates the Plant Health Section of the Ministry of Agriculture and the Tropical Pesticides Research Institute (TPRI). The merger improved efficiency and coordination in plant health, pesticide management, and compliance with International Plant Protection Convention (IPPC) sanitary and phytosanitary standards.
5. Coordination and Policy Oversight	Seed Coordination Unit (SCU)	Operating under the Directorate of Crop Development – Crop Promotion, Agricultural Inputs, and Cooperatives (DCD-CPAIC) within the Ministry of Agriculture, the SCU coordinates and plans seed production, distribution, and access at the national level. It ensures effective collaboration among stakeholders to strengthen quality seed accessibility to farmers.
6. Education, Research, and Capacity Building	Sokoine University of Agriculture (SUA)	The university was established in 1984 by the parliamentary Act No 6 and re-chartered under the Universities Act 2005, SUA is Tanzania's leading agricultural university. It focuses on teaching, research, extension, and community service, emphasizing agricultural innovation, quality assurance, and human-capacity development. SUA also undertakes research on key crops, such as common beans for both academic purposes and seed production.

Retrieved from ref [65]

TABLE IV. PUBLIC-BASED ACTORS SUPPORTING THE SEED SECTOR IN TANZANIA

Category	Organization	Explanation
Seed Industry Coordination and Advocacy	Tanzania Seed Trade Association (TASTA)	TASTA is a non-governmental organization established in 2002 to create a platform for collaboration, dialogue, and information exchange among seed companies in Tanzania. It represents the collective interests of the seed industry at national, regional, and global levels, advocating for a conducive policy environment and sustainable sector growth. As a membership-based body, TASTA facilitates communication between members and government institutions, helping to address industry challenges. The association currently includes 40 seed companies and 5 affiliated non-seed entities.
Seed Production and Marketing Enterprises	Seed companies and firms	TOSCI has registered 218 seed related entities authorized for seed production and marketing across the country. Out of these, 51 companies are actively engaged in production and distribution. The active firms include 20 local companies, 13 regional companies, 14 multinational companies, and 4 public institutions.
Input Supply and Distribution	Agro-dealers	Tanzania has an estimated 7,189 agro-dealers distributed across different regions, though their presence is more concentrated in urban centers. Agro-dealers play a pivotal function in the seed value chain, connecting seed producers with farmers and facilitating access to essential agro-inputs like seeds, pesticides and fertilizers.
Farmer Networks and Advocacy Groups	Mtandao wa Vikundi vya Wakulima Tanzania(MVIWATA) (Tanzania agricultural cooperative networks)	Was established in 1993, MVIWATA is a country network that unites smallholder farmers across Tanzania to safeguard their economic, social, cultural, and political interests. The organization empowers farmers through training, advocacy, and capacity-building initiatives aimed at strengthening farmer organizations. It also promotes knowledge sharing, communication, and self-representation among smallholder farmers, ensuring their voices are heard in agricultural policy dialogues.

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Farmer Support and Market Development NGOs	Ruvuma Commercialization and Diversification of Agriculture (RUCODIA)	Registered as an NGO in 2005, RUCODIA focuses on empowering farmer organizations, improving agricultural inputs accessibility, enhancing market linkages, and supporting post-harvest and soil fertility management. It also facilitates agro-enterprise development and participates in agricultural policy dialogue. As part of the AGRA-supported PIATA-TIJA initiative in Western Tanzania, RUCODIA has transformed fragmented input distribution networks into efficient, commercially viable systems through partnerships with agro-dealers, seed companies, fertilizer firms, and research institutions. The organization promotes Quality Declared Seed (QDS) production to meet local seed demand. By 2022, RUCODIA had implemented over 50 projects, established 20 warehouses, and reached about 2 million farmers in 12 districts. In Kagera and Kigoma regions alone, it worked with 596 agro-dealers and 803 agro-growers, serving 257,921 and 172,661 farmers respectively.

Retrieved from ref [65]

IV. KEY POLICIES AND REGULATORY FRAMEWORKS

The Tanzanian seed system's operation is administered by a progressive, yet sometimes complex, regulatory environment that has seen recent reforms to encourage private sector participation. The primary legislation being the Seed Act and its attendant regulations, enforced by TOSCI. This act mirrors the recent and future projection of seed system's growth.

A. *Current reforms on the Tanzanian seed systems have focused on:*

- Regional Harmonization: Tanzania's adherence to the Southern African Development Community (SADC) and the East African Community (EAC)Seed harmonization protocols are essential for facilitating regional seed trade and variety registration [26] .
- Variety Release: Processes for releasing public varieties to private companies have been streamlined, notably through the launch of the Plant Breeders Rights Act (2012) and direct contracting between TARI and seed companies [61].
- Incentives: The government has waived taxes and levies on certain agricultural inputs, including seeds, and has achieved ISTA accreditation for its seed testing laboratory, boosting export potential [62].

B. *Emerging policy issues*

Despite efforts to reform the seed sector, significant policy barriers remain in Tanzania's seed system. Delays and uncertainty around VAT refunds for seed companies erode cash flow and discourage private investment [63]. The incomplete rollout of the Plant Breeders' Rights Act, 2012 (PBR) framework limits incentives for long-term breeding programmes [64]. Overlapping mandates among institutions such as, Tanzania Official Seed Certification Institute (TOSCI), research institutes and the Seed Unit, create bottlenecks in variety release and certification processes [65]. Early-generation seed (EGS) production remains unreliable, delaying availability of certified seed and raising costs [66]. Local government levies and inconsistent enforcement of seed standards further increase transaction costs and undermine formal seed firms [52]. Weak digital traceability and inspector accreditation reduce confidence in seed quality [67]. Financing constraints persist, especially among women-led seed enterprises, due to the lack of land titles and high collateral requirements [68]. Informal seed systems continue to dominate in many regions, creating parallel markets that undercut formal investments[18]. All these challenges combine to limit the adoption and dissemination of improved hybrid seed and commercial varieties, thus reducing the competitiveness of Tanzania's seed sector in the regional markets.

V. Key Challenges Facing the Tanzanian Seed Industry

The Tanzanian seed industry faces multiple constraints that impede the widespread adoption of quality seeds and hinder its potential growth. Some of these challenges are highlighted below.

- Inadequate early generation seed (EGS) supply: A persistent shortage of high-quality EGS (Breeder and Basic Seed) limits the volume of Certified Seed that can be produced by the private sector, particularly for public varieties. ASA often struggles to meet demand due to funding and infrastructure deficits (example, irrigation).
- Low adoption and accessibility: The adoption rate of improved seed remains insignificant. High seed purchasing cost is the frequently cited barrier for smallholder farmers, compounded by limited financial resources.
- Weak distribution and market fragmentation: Distribution networks are often insufficient, especially in remote rural areas, resulting in geographical disparities in access. This is exacerbated by poor infrastructure.
- Counterfeit and low-quality seed: The presence of fake or substandard seeds in the marketplace is a major issue, eroding farmer trust in the formal system and leading to significant crop losses and reduced income.
- Breeding and varietal portfolio: There's a gap between the varieties on the market and the specific varietal attributes (such as early maturity, pest and disease resistance and drought tolerance) which are preferred by farmers in diverse agro-ecological zones, particularly for orphan and indigenous crops.

VI. Opportunities For Growth

Significant opportunities exist to transform the Tanzanian seed industry into an efficient, private- sector-led engine for agricultural growth. Some of the potential opportunities in the Tanzanian seed systems are listed in the Table V.

TABLE V. POTENTIAL OPPORTUNITIES IN THE TANZANIA'S SEED SYSTEM

Opportunity	Description
Tanzania seed sector development strategy (TSSDS)	The planned TSSDS will provide an overarching, coordinated strategic direction for the sector, addressing the current fragmentation and weak coordination.
Public-Private Partnerships (PPPs)	Fortified collaboration is needed to scale up EGS production, leveraging TARI's and CGIAR's germplasms, to co-develop new varieties, explicitly through targeted licensing agreements.
Regional seed trade	Tanzania's strategic location and compliance with EAC/SADC protocols position it as a potential regional seed hub, capable of serving neighbouring deficit countries.
Decentralized seed systems	Expanding and formally supporting Local Seed Businesses (LSBs) and the QDS system can improve local availability and accessibility for diverse crops and remote areas.
Digital technologies and traceability	Utilizing digital solutions for seed certification, distribution monitoring, and farmer engagement (e.g., mobile-based traceability systems) can combat counterfeiting and improve supply chain efficiency.
Targeted subsidies and financial inclusion	Smarter, output-linked subsidy programs, coupled with greater financial inclusion (example, microcredit) can improve smallholder farmers' ability to purchase improved seed varieties and hybrids.

VII. Recommendations for Future Focus

The Tanzanian seed industry is undergoing a dynamic transition toward a more market-oriented and efficient system, supported by progressive policy reforms such as the Seed Act of 2003 (and its 2014 amendments) and the national seed policy of 2006. The formal system, led by public based institutions and private seed companies, continues expanding but remains constrained by inadequate production of EGS seed, weak distribution networks, and the persistence of counterfeit seeds. The semi-formal system, including Quality Declared Seed (QDS) producers, plays a vital role in bridging gaps between formal and informal sectors, especially in remote areas. Meanwhile, the informal system still dominates seed access for smallholder farmers, ensuring varietal diversity and local adaptation despite lacking quality assurance mechanisms. Strengthening coordination among these systems, enhancing enforcement of seed regulations, and investing in farmer awareness are essential for achieving a resilient, inclusive, and sustainable seed sector in Tanzania.

VIII. Conclusion

- Prioritize EGS investment: Dedicate significant public and private resources, including irrigation infrastructure, to ASA and TARI to strengthen production and supply systems for Early Generation Seeds.
- Strengthen enforcement and traceability: Aggressively implement measures against fake seeds, including mandatory digital traceability systems and stiff penalties for offenders, to rebuild farmer trust.
- Enhance regional integration: Fully adopt and utilize EAC/SADC seed harmonization mechanisms to foster regional trade and entice foreign direct investment in breeding.
- Farmer-centric variety development: Increase funding for demand-led breeding programs at TARI to develop and release high yielding, and climate-smart varieties with traits that align with specific farmer and market preferences across different AEZs.

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