

Article

Upscaling Groundnut Seed Production and Delivery through Long-Term Public–Private and Development Organization Partnerships: Experiences from Tanzania

Asha Ally Hatibu ^{1,2,*}, Essegbemon Akpo ^{1,3}, Gerald Alex Lukurugu ² , Joseph Nzunda ², Patrick Okori ¹ and Chris O. Ojiewo ⁴

¹ International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502324, India

² Tanzania Agricultural Research Institute-Naliendele Centre, Mtwara P.O. Box 509, Tanzania

³ Ecole de Gestion et de Production Végétale et Semencière, Université Nationale d'Agriculture, Kétou BP 43, Benin

⁴ International Maize and Wheat Improvement Center, Nairobi P.O. Box 1041, Kenya

* Correspondence: ashaally86@gmail.com

Abstract: Making quality seed of improved legume varieties sustainably available and accessible to farmers in a timely manner and at affordable price is a major challenge in sub-Saharan Africa (SSA). Overcoming this challenge requires collective and long-term action through public–private and development organization partnerships (PPDOPs). The PPDOP model was tested by key seed system actors under the Tropical Legumes (TL) and Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA) projects from 2008 to 2021. The study used the case of groundnut in Tanzania to assess the role played by long-term PPDOPs in groundnut seed production and delivery systems. The effectiveness of seed production and delivery models of the various actors involved in the TL and AVISA projects was analyzed. The study used secondary data obtained from annual reports, unpublished and published literature, and institutional websites. The PPDOP model brought about significant changes to the seed systems. It was found that sustained seed production and delivery over a decade enhanced the performance of the groundnut value chain in Tanzania. Under the TL and AVISA projects, a total of 49,046 tons of groundnut from different seed classes were produced through PPDOPs, covering an estimated 613,078 hectares with improved groundnut varieties. The intervention reached 45,201 stakeholders through 3048 demonstration plots, 128 field days, 55 seed fairs, and 8147 tons of small seed packs of 1–5 kg. The study recommends the use of long-term PPDOPs in seed production and delivery systems for greater impacts on increased variety adoption and consistent seed supply and availability in SSA. Long-term PPDOPs ensure proper coordination, open communication, clear accountability, solid trust, and standardized practices among actors in seed production and delivery systems.



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Keywords: PPDOPs; sustainable legume seed supply; smallholder farmers; East Africa

1. Introduction

Promoting a self-sustaining seed sector in developing countries requires collaborative efforts between the public and private sectors through strategic partnerships. Global climatic change, losses due to pests and diseases, and limited access to seeds of improved varieties hinder the production and productivity of smallholder farmers. Public–private partnerships (PPPs) with the involvement of development organizations (PPDOP) in seed production can alleviate the challenges of groundnut crop production. The PPDOP model enhances the joint actions of innumerable actors by sharing resources and risks and creating innovations for the development of sustainable groundnut seed production [1]. Collaborating efforts through partnerships is a key mechanism for assuring the reliable delivery of improved groundnut technologies and fulfilling smallholder farmers' seed requirements;

it can efficiently overcome any challenge through partnering [2,3]. Various studies have illustrated the value of PPP models in agriculture [4,5] and infrastructure [6,7]. The authors in these fields of study discuss the inception, organization, adaptable regulations, and financial benefits for the actors involved. In addition, the literature suggests the wide use of PPPs in attracting finance from agribusinesses and agro-industrial developments and in joint agricultural research, innovation, and technology transfer, as well as in building and upgrading market infrastructure and the delivery of business development services to value chain actors [8,9]. Nevertheless, little information is available on long-term public–private partnerships in collaboration with other development organizations such as national and international Non-Governmental Organizations (NGOs) in seed production and delivery. This study fills in the existing knowledge gap by analyzing long-term public–private and development organizations partnerships (PPDOPs) in the groundnut seed production and delivery systems in Tanzania to determine the most efficient pathways to the adoption of improved varieties and access to quality seed. These strategic partnerships of the public and private sectors, farmers’ organizations, and NGOs are expected to improve seed production and seed supply to farmers at affordable prices and contribute to enhanced agricultural productivity and services to smallholder farmers.

Enhancing the contribution of the agricultural sector and the adoption of improved varieties and quality seed by smallholder farmers is critical to the economy of SSA countries. It involves synergizing the formal and the informal seed systems [10]. In seed systems, PPDOPs are key because they ensure the collaboration of research institutes, private enterprises, NGOs, farmers’ organizations, women’s groups, and a range of other actors in agricultural seed value chains. The challenge of the unavailability of improved seed to farmers can be solved through partnerships of public, private, and development organizations because there are more than 100 registered private seed companies and more than 65 agricultural NGOs (local, international, and farmers’ umbrella NGOs) active in Tanzania [11,12]. Concerted and coordinated joint efforts of these strategic partners can substantially increase seed access in the country, making a significant contribution to food, nutrition, and income security. Strategic partnerships in groundnut seed production and delivery systems are essential because of increased demand for groundnut grain in the domestic and export markets [8,13]. For instance, groundnut production has increased by around 9.5 times, from 72,000 tons in 1995 to 690,000 tons in 2020, while the export has increased by 275 times, from 170 tons to 46,756 tons in the same period [14]. The increased grain demand by export markets with their specific market requirements fuels the supply of improved groundnut varieties with the desired traits to the market. Hence, the formation of PPDOPs in groundnut seed production and delivery systems in Tanzania has become essential for efficient, timely, affordable, and sustainable seed access and supply in the country. As a result, several initiatives such as the Tropical Legumes (TL) I–III and Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA) projects have been initiated in the country.

The TL and AVISA projects empowered national program partners, agricultural research institutions, private seed companies, and other development organizations to produce and commercialize quality seed of modern groundnut varieties through PPDOPs [15,16]. Increased seed supply at an affordable price will boost adoption rates of improved groundnut varieties, enhance grain quality, quantity, and productivity [6,16], and improve household income, food security, and nutrition. The outputs of these initiatives contribute to Sustainable Development Goals (SDGs) 1 and 2 to end poverty and hunger by achieving food security, improving nutrition, and promoting sustainable agriculture. Hence, this article provides insights into the potential of long-term PPDOPs to facilitate the supply of high-yielding groundnut varieties to smallholder farmers. Smallholder farmers have been supported in shifting from obsolete varieties to high-yielding stress-tolerant groundnut varieties in order to realize high productivity and profitability [17,18]. The specific objectives of this study were (a) to assess and/or characterize the institutional framework in which the long-term PPDOPs were embedded and (b) to examine the effec-

Table 1. Regions covered by the TL and AVISA projects (2008–2021), area allocated for groundnut production, and productivity per region.

Region	Area under Groundnut Production per Region (ha)	Production (t)	Productivity (t/ha)
Dodoma	132,427	176,287	1.4
Tabora	103,486	97,677	1.1
Geita	40,702	50,062	1.4
Shinyanga	45,746	41,031	1.1
Songwe	23,416	33,497	1.5
Mbeya	20,601	24,382	1.3
Katavi	17,373	22,996	1.4
Singida	22,533	21,769	1.1
Manyara	10,350	21,156	2
Kigoma	16,272	18,697	1.2
Mwanza	13,585	16,933	1.3
Mtwara	17,123	16,712	1
Simiyu	15,327	16,085	1.1
Ruvuma	5,789	7,154	1.3
Kilimanjaro	2,065	2,919	1.5
Lindi	2,870	2,713	1
Njombe	1,276	2,006	1.6
Iringa	943	1,924	2.1

Source: National Sample Census of Agriculture 2019/2020, National Report (2021).

2.2. Conceptual Framework

The critical factors determining public–private partnerships (PPPs) include, but are not limited to, coordination and governance, innovation, and other support services to collaborating partners [19]. Coordination and governance in partnerships involve managing the synergy and regulation issues by trusted players among the partners who play the key roles [20,21]. Innovation involves knowledge and technology generation, exploitation processes, technical expertise, market orientation, and access. It creates novelties that become innovations when they successfully reach the market stage and create demand [22]. Facilitation of other services brings into perspective infrastructure, skill development, and closer service delivery to partners [21]. Seven dimensions in the spheres of knowledge and technology production and dissemination were considered in this paper (Figure 2):

1. Government/local government authorities as the public sector involves national agricultural research systems (NARS) through their research centers that are responsible for groundnut variety development, variety maintenance, and agronomic packages. The NARS are also responsible for breeder seed production, while local government authorities (LGAs) provide extension services and working space to all other actors in the system. Public seed enterprises such as the Agricultural Seed Agency (ASA) produce foundation seed of improved groundnut varieties for private seed companies and certified seed for groundnut farmers.
2. Private seed companies buy foundation seed of improved groundnut varieties from the ASA to produce certified seed, although some of these private seed companies with capacity can also produce foundation seed; such companies produce groundnut seed either on their own farms or by contract with trained farmers or groups.
3. Development organizations are mainly composed of NGOs that provide technical (advisory) and/or financial support services for improved groundnut seed delivery to smallholder farmers through other actors.
4. Small-scale farmers are the final users of improved groundnut seed and its complementary technologies that have benefited from public, private, and development organizations in the country.
5. Market development and delivery systems are facilitated by stakeholders from both the public and private sectors as well as from development organizations, for instance,

by having access to market information (groundnut trait preferences, groundnut quantity, and place required within and outside the country).

6. Advisory bodies include the National Seed Committee, which provides regulations for compulsory seed certification, laboratory seed testing, variety evaluation, and registration under the Tanzania Official Certification Institute (TOSCI). The TOSCI ensures that the improved groundnut seed produced adheres to the established certification and seed quality control procedures. Another advisory body is the National Variety Release Committee that determines whether to release or reject a new groundnut variety based on the data compiled in the release proposal.
7. Policymakers mainly include Parliament, which passes laws and examines all government policies nationally, and ward councils, which pass bylaws at the district level, as well as officials from the Ministry of Agriculture, which is the main watchdog of the agricultural sector in Tanzania. It provides policy guidance and services to modernize, commercialize, and make competitive and effective agricultural and cooperative systems in the country.

Partnerships among public, private, and development organizations represent a core aspect as they show the relationships between the government, private seed companies, development organizations, small-scale farmers, market and delivery systems, and regulators. The synergy between the different players and the long-term partnership achievements were analyzed to build on the existing knowledge around PPPs, with an emphasis on seed systems.

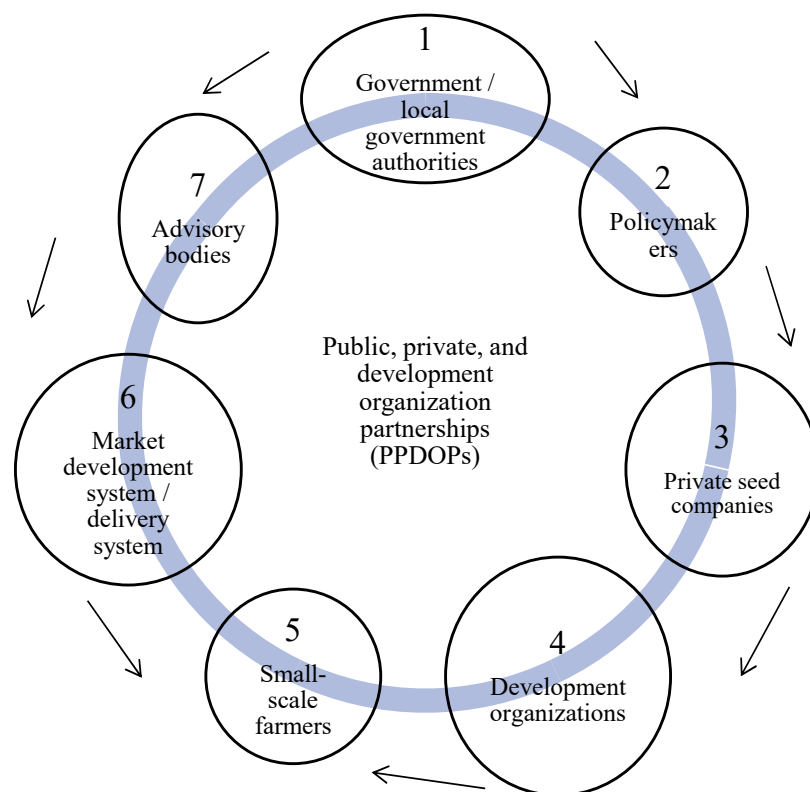


Figure 2. Conceptual framework.

2.3. Data Gathering

The study used secondary data from the annual reports of the TL and AVISA projects from 2008 up to 2021. Other secondary data regarding the roles and responsibilities of the actors and their relationships in seed production and marketing were obtained from published and unpublished literature and institutional websites. The data gathered

included the seed production models used, categories of actors, seed production data, promotion activities conducted, and estimations of the beneficiaries reached.

3. Major Findings and Discussion

3.1. PPDOs Shaping Groundnut Seed Production and Delivery Systems in Tanzania

3.1.1. Actors Involved from the Public Sector

Through the National Agricultural Research Systems (NARS), the public sector has the mandate to conduct crop research and provide agronomic packages to the public by developing different varieties that are suited to different agroecological zones [23]. The research institute produces breeder seed that responds to farmers' needs in different cropping zones in terms of drought resistance, pests and diseases, market demand, and early maturing. The Tanzania Agricultural Research Institute (TARI) Naliendele is a NARS center responsible for groundnut breeding and seed multiplication (Table 2). The breeder seed produced is sent to the Agricultural Seed Agency (ASA), which is a public seed enterprise, and to private seed companies that have regulatory authorization to produce foundation seed inspected by the Tanzania Official Seed Certification Institute (TOSCI) (Figure 3). These actors use their own farms and labor to produce seed or contract out-growers who are trained to produce quality certified seed. Breeders also share seed with farmer research groups who produce subsequent seed classes or quality declared seed (QDS) under their supervision [24]. The QDS is then produced by registered trained small-scale farmers or a group of small-scale farmers for their own use or sold to neighboring farmers within the ward where the QDS was produced. Agro-dealers supply certified seed and QDS produced by public and private seed companies and registered farmers to large commercial and smallholder farmers as the final users of the improved varieties [25].

Table 2. Public, private, and other development organization partner roles.

Partner	Roles	Possible Interventions for the Smooth Operation of the Value Chain
Research institute (TARI Naliendele)	<ul style="list-style-type: none"> - Coordinate sesame, groundnut, and cashew nut research programs at the national level - Collaborate with other institutes within and outside the country in verifying research outputs - Develop varieties/ technologies - Maintain seed purity, produce breeder/pre-basic seed - Transfer extension services and technology - Maintain good links with other stakeholders locally and internationally, enabling seepage/exchange of experience and technology - Cofacilitate the implementation of projects along with other research centers 	<ul style="list-style-type: none"> - Produce and sell enough breeder seed for other value chain actors at a lower cost - Develop good agricultural practices to enhance production and productivity of groundnut - Strengthen irrigation facilities to speed up breeding activities and increase seed production per season
Public seed agency (ASA)	<ul style="list-style-type: none"> - Expand seed production and distribution networks to facilitate seed availability to farmers - Promote increased private sector participation in the seed industry development through the establishment of public-private partnerships - Promote increased demand for certified seed by farmers - Strengthen research capacities for breeding and producing varieties that address farmers' specific demands - Strengthen collaboration with research institutes on matters related to the availability of new crop varieties - Produce foundation seed and supply to certified/QDS seed producers 	<ul style="list-style-type: none"> - Produce and market sufficient basic seed to private seed companies at an affordable price

Table 2. Cont.

Partner	Roles	Possible Interventions for the Smooth Operation of the Value Chain
Seed regulation agency (TOSCI)	<ul style="list-style-type: none"> - Certify and promote quality agricultural seed produced or imported into the country for sale - Issue guidelines and other requirements about the authorization of seed inspectors, samplers, laboratories, and analysts - Register newly released varieties in the national variety catalogue - License trade of seed of registered varieties, whether locally produced or imported 	<ul style="list-style-type: none"> - Lower certification and inspection fees for seed producers - Capacitate ward and district seed inspectors to decentralize quality and certification activities
Agricultural extension office	<ul style="list-style-type: none"> - Facilitate farmer group formation and give technical advice for making informed decisions to increase agricultural production - Transfer knowledge and information through farmer days, demonstrations, lectures, literature, and contact with farmers on their farms - Promote collaboration in the implementation of projects and programs - Ensure good relations/communication between research centers and farmers - Assist farmers in adopting improved varieties 	<ul style="list-style-type: none"> - Train farmers on good agricultural practices - Establish a sufficient amount of demonstrations at the ward and village levels to showcase performance of improved varieties
National Seed Committee	<ul style="list-style-type: none"> - Formulate and implement the seed industry policy and guidelines - Consult with the Directorate of Crop Development (DCD) to determine whether a variety should be registered - Coordinate and supervise the seed industry - Approve plant varieties and change variety names 	<ul style="list-style-type: none"> - Fast-track the process of releasing improved varieties
National variety release committee	<ul style="list-style-type: none"> - Make decisions to release or reject a new variety based on the national performance trial (NPT) and distinctiveness, uniformity, and stability (DUS) data compiled in the release proposal - Protect farmers from receiving bogus varieties without value for cultivation and use 	<ul style="list-style-type: none"> - Fast-track the process of releasing improved varieties if all the required information is available
Private seed companies	<ul style="list-style-type: none"> - Participate in the testing of new improved varieties and new technology in the field before commercialization - Produce certified seed either directly on their farms or through contracts with out-growers - Supply certified seed through their agro-dealer networks and farmers in the localities - Several active seed companies in the groundnut seed value chain are Temnar, MHEG, Iffa Seed, Alssem, Agriseed Technologies, Lima Africa, Meru Agro, SubaAgro, Rieta AgroSciences, Pavig Agro, and Zasse Agricultural Seed and Food Company Limited 	<ul style="list-style-type: none"> - Produce and market sufficient certified seed at an affordable price - Form links with off-takers to produce certified seed to their grain producers
Private seed company association (TASTA)	<ul style="list-style-type: none"> - Promote the private sector-led seed industry - Represent the interests of the Tanzanian seed industry by ensuring and enabling seed trade policies - Protect and promote the seed industry interests within Tanzania, Africa, and globally 	<ul style="list-style-type: none"> - Reduce the entrance fee for young and upcoming seed companies - Link seed companies with development partners for competitive grants - Deliver orders to basic seed producers early before the season starts

Table 2. Cont.

Partner	Roles	Possible Interventions for the Smooth Operation of the Value Chain
International agricultural research institutes (e.g., ICRISAT, CIMMYT)	<ul style="list-style-type: none"> - Advise the government on the best-fit groundnut varieties, genetic resources, and seed system development - Facilitate advanced technologies and resources related to crop breeding, digital agriculture, and genomics to NARS, private seed companies, and NGOs through projects, e.g., TL III, AVISA - Work closely with national research partners, farmers, public and private organizations, and nongovernmental organizations along the seed value chain to develop and produce seed, from breeder seed to quality declared seed - Facilitate and enable the network of public–private and development organization partnerships to implement activities along the seed systems’ value chains - Build capacity of scientists and non-scientists in the groundnut seed industry 	<ul style="list-style-type: none"> - Strengthen the NARS to breed their own varieties - Make joint proposals to attract funds from development partners - Strengthen collaboration between the CGIAR centers and the NARS that will fast-track the sharing of the germplasm
SMAEs	<ul style="list-style-type: none"> - Produce and market seed - Participate in field trials of new improved varieties - Help to scale up/out new technologies 	<ul style="list-style-type: none"> - Provide contracts to their seed producers based on market prices - Decentralize the seed business for enhanced outreach
NGOs	<ul style="list-style-type: none"> - Support and promote value chain development of crops, including groundnut, to improve rural livelihoods within communities - Facilitate seed access to last-mile users through their networks in difficult-to-reach areas - Several active NGOs in the groundnut seed value chain are World Vision, One Acre Fund, Care International, and RECODA 	<ul style="list-style-type: none"> - Expand their network to reach more farmers - Link their seed producers with grain off-takers and/or seed companies
Farmers and farmer organizations	<ul style="list-style-type: none"> - Act as contract out-growers for new improved seed varieties produced under buy-back agreements - Produce and distribute quality declared seed - Participate in field trials of new improved varieties - Adopt new technologies - Produce grain 	<ul style="list-style-type: none"> - Recruit more groups into seed production and marketing - Capacitate peers in the seed business orientation (business plans) - Form links with financial institutions
Grain traders/cereal stockists	<ul style="list-style-type: none"> - Aggregate and sell groundnut grain, sometimes accessed and used as planting material by farmers - Act as an initial source of information on new varieties to farmers 	<ul style="list-style-type: none"> - Establish contract farming with grain producers who use improved seed to enhance grain quality - Purchase certified seed or QDS from seed companies or farmer groups for their own grain producers on credit - Provide financial assistance to their grain producers

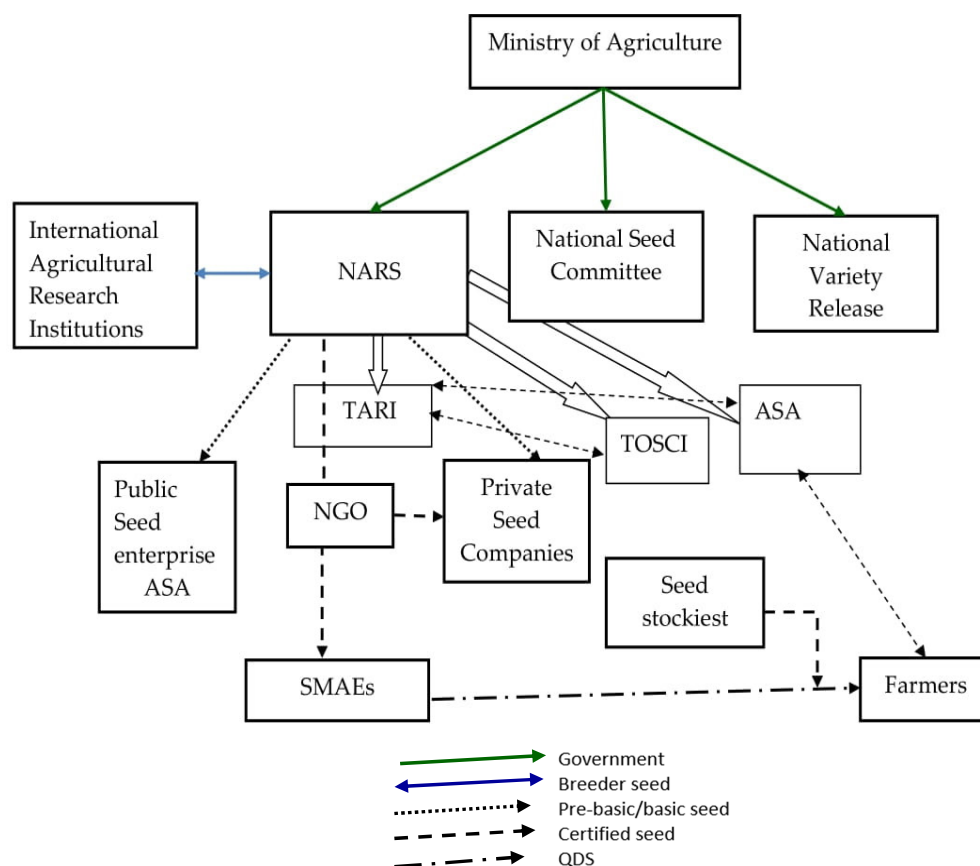


Figure 3. Main players and seed flow in the groundnut seed supply chain in Tanzania.

3.1.2. Actors Involved from the Private Sector

In the private sector (Table 2), private seed companies produce and supply certified groundnut seed to farmers at a reduced cost in various small seed packs that every smallholder farmer can afford to buy. The seed companies include Temnar, Mbozi Highlands Economic Group Ltd. (MHEG), Iffa Seed, Rieta AgroSciences, Alssem, Agriseed Technologies, Lima Africa, PAVIG Agro, Meru Agro, and SubaAgro. In addition, many farmers are employed as out-growers by private seed companies through contract farming (Figure 3). Furthermore, small and medium-sized agro-enterprises (SMAEs) such as Malagarasi Agricultural Company Limited located in Kigoma region also produce and market certified groundnut seed. Private seed companies and SMAEs produce groundnut seed either on their own farms or by contracting other seed producers in different locations. This group of actors also includes individual seed entrepreneurs (ISEs) who produce and market QDS to their fellow farmers within the ward. In addition, ISEs sometimes act as contract out-growers for research stations, such as TARI Naliendele, and seed companies, such as MHEG, LIMA Africa, and DASPA. These groups participate in field trials of new improved varieties and field days and serve as channels for early dissemination of new variety technologies among farming communities.

3.1.3. Development Organization Actors Involved

Working jointly with other seed value chain actors, NGOs participate in multistakeholder innovation platforms established through PPDOPs to give more support to seed systems in the country (Figure 3). For instance, World Vision works with seed companies in collaboration with TARI Naliendele and other research centers through its different area projects to distribute new variety technologies to farmers, especially in such regions as Tabora, Simiyu, Shinyanga, Mwanza, Dodoma, and Singida, which are important producers of groundnut. So far, other NGOs that have been engaged in supporting groundnut seed

production and marketing are CARE International, One Acre Fund, RECODA, Aga Khan Foundation, Swiss Aid, and Farm Inputs Promotions Africa (FIPS-Africa). These NGOs play an important role in the seed supply system and in securing livelihoods [26,27] through a wide range of participatory methods such as multistakeholder approaches. NGOs support individual farmers, farmer groups, rural women, and youths by distributing improved groundnut seed in remote locations that are difficult for private seed companies to reach and in which to maintain extension services [28].

3.1.4. Farmers, Seed Producers, and Farmer Organizations

Smallholder farmers and farmer associations, schools, and village and church groups mainly produce QDS and are also beneficiaries of improved varieties of groundnut (Figure 3). They host demonstration plots for improved groundnut varieties and are involved in participatory variety selection (PVS) through on-farm and multilocation trials for groundnut varieties prior to release [29]. This work is carried out by 530 farmer research groups and 316 individual seed entrepreneurs throughout the country [28,30]. These groups receive technical and managerial training and support directly from extension officers and are assisted by the public and private seed companies working with them. Extension officers effectively transfer the knowledge obtained through the TL and AVISA projects to farmers [31]. For instance, farmers benefited from over 4500 promotional materials in a year, including about 1500 copies of leaflets capturing information on different groundnut technologies, e.g., guides to production and aflatoxin mitigation, distributed through the projects to farmers and other stakeholders during field days, seed fairs, visits to demonstration plots, and agricultural shows, e.g., *Nanenane*. *Nanenane* (“eight–eight” in Kiswahili) is a Farmer Day that is also a national agricultural show held every year in Tanzania beginning on the 8th day of August (the 8th month of the year) and lasting for eight consecutive days.

3.1.5. Legal and Regulatory Framework in Seed Systems in Tanzania

The seed policy normally serves as the overall framework for regulatory instruments such as the seed law and related legislation [32]. The first seed act of Tanzania was enacted in 1976, followed by the National Agricultural Policy in 1983 and the Agricultural and Livestock Policy in 1997. Both policies were mandated to encourage and facilitate national and local seed production and marketing [33]. The policy was modified as the National Agricultural Policy in 2013 after recognizing that only 10% of all the seed used was improved seed [34]. Farmers were therefore encouraged to use improved seed by providing different support systems, including allowing various stakeholders such as NGOs, private sector actors, and other partners to collaborate in facilitating the supply of quality seed to smallholder farmers. In the same vein, the production of quality declared seed (QDS) at the farm level was initiated, but adoption was slow due to the low number of seed entrepreneurs [33,35,36]. Furthermore, the Seeds Act No. 18 of 2003, which was implemented through various regulations to support commercial farmers, provided an opportunity for smallholder farmers to produce and market QDS [34]. In 2012, Tanzania approved a new Plant Breeders’ Rights Act, which was in harmony with the standards of The International Union for the Protection of New Varieties of Plants (UPOV1991). In 2015, the country became the first least developed country (LDC) in the world to join UPOV1991 [37]. Overall, the described regulatory framework shaping seed systems enables control of the quality of the produced, imported, and exported seed. It creates room for various stakeholders from public, private, and development organizations to facilitate quality seed production and supply to farmers.

3.2. Groundnut Seed Production and Delivery Systems in Tanzania

3.2.1. Seed Production Models Used during the TL and AVISA Projects

Seed producers supplied seed through own and contract seed production models. During the TL and AVISA projects, these models involved various categories of producers to increase the adoption and impacts of available groundnut technologies. Research institute

TARI Naliendele produced groundnut breeder seed using an irrigated research station farm. From 2008 to 2021, 329 tons of breeder seed were produced and delivered to the public seed enterprise, the Agricultural Seed Agency (ASA), and to private seed companies for multiplication, processing, and distribution as foundation seed. At the project inception, the production capacity was below 1 ton per year. Apart from breeder seed, TARI Naliendele also produced basic seed using its own labor and nonlabor inputs [38]. TARI Naliendele used selected, well-trained, and experienced farmer research groups to produce basic seed and QDS through the contract farming model under close supervision [33]. Using this model, TARI Naliendele provided breeder seed to the contracted groups and oversaw the production practice. The basic seed obtained was sold to seed companies, while the produced QDS was used for establishing field demonstrations and other awareness creation activities within farming communities. A total of 3264 tons of basic seed were produced by the selected farmer research groups in different locations of the projects. The ASA produced basic seed on its farms and through contracts. Seed production by the ASA has not been consistent because other seed companies have failed to take basic seed from the public seed enterprise because farmer demand fluctuates annually. Groundnut is a self-pollinating crop, and thus farmers tend to replant their own seed saved from the previous harvest for many years [39]. This practice jeopardizes the groundnut seed demand market and the seed companies' willingness to invest consistently in the crop seed business. During the implementation of the long-term projects, private seed companies also used both their own farms and contract models to produce 420 tons of certified seed. This low figure (0.7%) of the total seed produced shows the small degree of confidence of private seed companies in investing in groundnut seed production because of market insecurity. However, this is a remarkable increase in a short period of time compared to other seed classes where production started after the project inception in 2008. Farmer research groups, individual seed entrepreneurs, agricultural schools, and farmer organizations are the main suppliers of quality groundnut seed, accounting for 92% of the total seed produced. Over time, they have succeeded in producing 57,729 tons of QDS both for public and private seed companies and NGOs under the contract model and for their own use. Overall, the seed production volume figures across seed producers and seed classes have been increasing over time (Table 3). The observed trend would not have been achieved if not for the long-term PPDOP initiative.

Table 3. Seed production (tons) per category of seed producers from 2008 to 2021.

Year	Seed Producers and Subsequent Seed Classes				Total Amount Produced (t)
	Research Institute (TARI Naliendele)	Public Seed Enterprise (ASA), TARI, and Private Seed Companies	Private Seed Companies	Farmer Research Groups, Individual Seed Entrepreneurs, and Others	
	Breeder	Basic	Certified	QDS	
2008	21.4	204	–	2567	2792.4
2009	24.2	210	–	2917.5	3151.7
2010	19.2	212.6	–	3170.4	3402.2
2011	28.3	201.9	–	3665.1	3895.3
2012	30.1	275.6	–	3549	3854.7
2013	34.2	302.6	–	4083.3	4420.1
2014	35	322.8	–	3898.3	4256.1
2015	23	243.6	–	3045.8	3312.4
2016	21.2	325	–	2979	3325.2
2017	40.1	413.1	1.8	3898	4353
2018	30	532.3	2.5	4536	5100.8
2019	12.5	110.3	4.7	4632	4759.4
2020	15.8	215.7	176.4	5193.6	5601.5
2021	17.4	258.7	234.9	4992.8	5503.8
Total	352.4	3828.2	420.3	53,127.8	57,728.7
%	0.6	6.6	0.7	92	100

3.2.2. Promotion Systems for Groundnut Seed and Associated Technologies

The TL and AVISA projects used various approaches to ensure that improved groundnut technologies (seed and agronomic packages) reached a wide audience in agroecological production zones. The program used demonstration plots, field days, seed fairs, agricultural shows, TV and radio programs, and small seed packs. As revealed in a study [40], the push-and-pull approach was tested using demonstrations and field days to intensify the knowledge and adoption of different agricultural practices. These strategies aimed to substantially enhance awareness, fast adoption, and impact of improved groundnut technologies on smallholder farmers.

Demonstration Plots

Demonstration plots (demos) were among the strategies used to increase awareness of improved groundnut technologies (seed and agronomic packages) among smallholder farmers. Using the PPDOP approach, the projects widened the coverage and reached more stakeholders throughout the country with improved groundnut technologies from 2008 to 2021. Though most of those demo plots were 10 m by 10 m (100 m²) in size, other demo plots were between 0.25 and 0.5 acres. The demo plots were hosted by individual farmers and/or groups of farmers and were used as learning platforms on improved groundnut technologies for farmers. During the TL (2008–2019) and AVISA (2019–2021) projects, a total of 3048 demonstrations were established in the project districts. These demo plots were established using the PPDOP approach, where seed companies (MHEG, Temnar, Alssem, Lima Africa, Rieta AgroSciences, Pavig Agro, and the ASA), the research institute (TARI), and extension offices played a major role. Other partners in the demo plots were NGOs (World Vision Tanzania, FIPS-Africa, and RECODA), a farmer organization (DASPA), and farmer research groups (FRGs). Similarly, through PPDOPs, the platform succeeded in directly reaching 10,808 farmers, of whom 47% were women, who visited those demo plots on different occasions (Table 4). Usually, these technologies were tested and compared with the traditional varieties in different agroecological zones under the supervision of agricultural extension officers within the respective districts and communities. The knowledge gained through these demo plots enabled farmers to apply it on their own individual farms.

Table 4. Number of demonstration plots established at the project sites in 2008–2021.

Year	Number of Demo Plots	Number of Attendees of Demo Plots		Total
		Women	Men	
2008	44	111	143	254
2009	55	244	300	544
2010	72	119	157	276
2011	84	209	442	651
2012	92	305	398	703
2013	97	377	402	777
2014	99	408	314	722
2015	137	583	621	1204
2016	184	611	527	1138
2017	195	714	866	1580
2018	404	1187	1324	2511
2019	324	692	496	1188
2020	396	282	466	748
2021	413	2189	2533	4722
Total	3048	11,242	12,466	23,708

Field Days

Most smallholder farmers produce below their potential yield because of limited knowledge and adoption of modern technologies [41]. Between 2008 and 2021, under the

projects, 128 field days were organized in different districts within groundnut production areas. A total of 11,871 participants were directly reached, including 5539 (47%) women (Table 5). The organization of field days over a long period helped farmers improve their knowledge on using improved groundnut seed of varieties Mnanje 2009, Mangaka 2009, Nachingwea and Naliendele 2009, and Naliendele 2016. Through these field days, more farmers showed interest in adopting and producing the new varieties. Similar findings were reported by Nyabundi and Kiprono [42] in that field days provided a platform to expose farmers to various agricultural technologies. Farmers benefited from the skills and knowledge shared by peers and experts to enhance their productivity. Wray and Spielmaker [43] also revealed that field days increased agricultural literacy among farmers and other agricultural professionals. During field days, farmers took part in a wide variety of activities with fellow farmers, extension workers, subject matter specialists, seed system researchers, NGOs, private seed companies, and other related actors. In general, these actors shared their knowledge, experience, and results with others to increase the adoption of new production technologies and practices. For instance, during the events, successful farmers delivered speeches and provided evidence to their fellows on how adoption of new production technologies could achieve success. Thus, the long-term implementation of the projects delivered the technology to farmers in a consistent manner (Table 5).

Table 5. Number of field days conducted in 2008–2021.

Year	Number of Field Days	Participants		Total
		Women	Men	
2008	2	87	103	190
2009	3	110	126	236
2010	3	77	92	169
2011	5	142	160	302
2012	7	150	184	334
2013	5	98	103	201
2014	7	207	303	510
2015	5	138	169	307
2016	10	324	441	765
2017	11	977	1032	2009
2018	22	1296	1356	2652
2019	10	126	219	345
2020	12	340	516	856
2021	26	1467	1528	2995
Total	128	5539	6332	11,871

Seed Fairs/Agricultural Shows

Seed fairs and agricultural shows are an effective way to exchange knowledge by showcasing and sharing the best varieties among farming households. Through seed fairs and agricultural shows, farmers have a chance to discover new varieties, observe the advantages of using quality seed, and discuss the advantages and disadvantages of the new improved varieties versus the currently grown ones. Furthermore, farmers have increased opportunities to discuss among themselves the price of the seed that gives them the best value for their money. Seed fairs and agricultural shows offer sellers and seed companies the opportunity to gather information about farmers' preferences and tastes, about their specific production, agroecology and other information/feedback that is valuable for those involved in seed production and dissemination [44]. Between 2008 and 2021, PPDOPs conducted a total of 55 seed fairs/agricultural shows in different locations through the TL and AVISA projects (Table 6). Most of these seed fairs were conducted in villages and involved researchers, FRGs, seed companies, NGOs, extension officers, agro-dealers, and individual farmers. A total of 31,741 farmers, of whom 49% were women, as well other

key stakeholders were exposed to the different improved technologies displayed by actors during the seed fairs and agricultural shows. The large number of farmers attending these events resulted in increased knowledge about and interest in improved farming practices. The fact that the number of women who visited the displays was almost 50% of the attendees was probably because rural women often manage complex and multiple household activities for the family wellbeing, hence increasing their engagement in farming, trading, and marketing activities [45]. In addition, key officials from local government authorities (LGAs), the Ministry of Agriculture, and other policymakers were invited to the opening and/or closing ceremonies and gave key messages about the improved agricultural technologies that were being showcased. The consistent participation of policymakers represents an advantage for the enhanced adoption of novel technologies. Policy architects are the key decisionmakers for farming communities. Their support for the promotion of improved varieties enhances food security within their localities [46,47].

Table 6. Number of seed fairs conducted in 2008–2021.

Year	Number of Seed Fairs/Exhibitions Organized	Number of Participants		Total
		Women	Men	
2008	1	144	166	310
2009	2	209	199	408
2010	3	296	304	600
2011	2	222	262	484
2012	2	279	330	509
2013	3	402	515	917
2014	4	1186	708	1894
2015	1	347	414	761
2016	4	1212	929	2141
2017	5	3351	3998	7349
2018	7	1623	1892	3515
2019	8	564	676	1240
2020	6	2499	2890	5389
2021	7	3133	2991	6124
Total	55	15,467	16,274	31,741

Small Seed Packs

To adapt the seed demand to smallholder farmers' purchasing capacity, small seed packs were used. Small seed packs represent tailored means to make new varieties available to farmers at a low price for observational trialing on their farms. Through the TL III and AVISA projects in Tanzania, small seed packs of groundnut in 1–5 kg packaging were promoted for sale and as free samples. The implementation was successful from 2015 onwards using farmers' research groups (FRGs) facilitated by the TARI, seed companies, and NGOs, with a total amount of 8147 tons of certified seed and QDS transacted in small packages (Table 7). During seed fairs and agricultural shows (Table 7), other packages of 0.1 kg, 0.5 kg, 1 kg, and 2 kg were used and distributed to farmers for their farms as samples of improved varieties, and about 50 tons were given out free; 135 tons of produced QDS were sold in small packs of 1–5 kg (27,000 packs), while 217 tons were sold in 25 kg packs, and 536 tons were sold in other packages between 50 and 100 kg, mainly to large and commercial farmers. Packing groundnut seed into small packages affordable for every smallholder farmer is a successful strategy because it is easy to monitor its viability in storage. However, the selected packaging materials must be appropriate for the length of time that the seed will be stored to maintain the viability of the packed seed as shelled groundnut lose viability in a short period of time. This was referred to in several studies of the effects of packaging materials on the storability of groundnut [48–50].

Table 7. Amount of seed sold in small packs in 2015–2021.

Seed Type	Amount of Seed Sold per Year (t)							Total (t)
	2015	2016	2017	2018	2019	2020	2021	
Certified seed and QDS	65.0	343.5	1670.8	887.9	1544.6	2061	1574	8146.8

TV and Radio Programs

Television and radio programs were among the communication channels used by the TL and AVISA projects to promote improved groundnut varieties to different value chain actors in crop agroecological zones. This method was recognized as an effective means of mass communication [51]. The TV and radio programs increased the awareness of groundnut stakeholders, including smallholder farmers, of the desirability of gaining agricultural knowledge. These programs were made by researchers (TARI Naliende) in collaboration with seed companies, representatives of farmer groups, and successful farmers. The programs were aired in the form of short news reports, documentaries (success stories and agronomic practices), and direct interviews on radio and TV stations. Some of the TV stations used were the Tanzania Broadcasting Corporation (TBC1), Independent Television Tanzania (ITV Tanzania), Star TV, Azam TV, Channel 10, and Clouds TV. Likewise, the radio stations engaged were those with national coverage such as TBC Taifa and regional coverage such as Voice of America (VoA), the Swahili (Tanzanian national language) program. Other radio stations used were those with community coverage such as Pride FM, Safari FM, Jamii FM, Mashujaa FM, Radio Free Africa, and Mbeya FM. During the TL and AVISA projects (2008–2021), a total of 30 TV and radio programs were aired. Some of the topics aired included “groundnut is my employment”, “groundnut crops for youth economic liberation”, “contribution of oilseed crops to oil production”, “groundnut agronomy”, “groundnut pests, diseases, and their mitigation strategies”. The study revealed that the programs with different media coverage directly reached around 213,597 groundnut value chain actors throughout the country, as shown in Table 8. These findings concur with those of Berg et al. [52] who reported that radio and television stations have a great potential for reaching many audiences within a short period of time to disseminate agricultural technology in developing countries such as Tanzania.

Table 8. Number of TV and radio programs used and audience reached.

Year	Number of Programs		Media Used		Estimated Audience		Total Number of People Reached
	TV	Radio	TV	Radio	TV	Radio	
2008	1	3	TBC1	TBC Taifa	2145	2316	4461
2009	1	4	TBC1	TBC Taifa	3100	2593	5693
2010	2	4	TBC1	TBC Taifa	1007	3098	4105
2011	2	3	TBC1	TBC Taifa	3866	2244	6110
2012	3	4	TBC1 and Channel 10	TBC Taifa	4889	3978	8867
2013	2	5	TBC1 and Channel 10	TBC Taifa	3214	6892	10,106
2014	3	5	TBC1 and Channel 10	TBC Taifa	4239	7749	11,988
2015	7	3	Chanel 10, ITV, TBC1, and Star TV	Mashujaa FM, Safari FM, and RFA	5922	8812	14,734
2016	10	7	Chanel 10, ITV, Star TV, and Azam TV	Mbeya FM, Pride FM, and Mashujaa FM	9211	6791	16,002
2017	10	14	Chanel 10, ITV, Star TV, and Azam TV	Jamii FM, Safari FM, and Pride FM	8120	10,974	19,094
2018	12	5	Azam TV, Channel 10, and TBC1	TBC Taifa, Safari FM, and Pride FM	8856	9389	18,245
2019	9	11	TBC1 and Channel 10	VoA, TBC Taifa, and RFA	6988	18,287	25,275
2020	10	12	ITV, ETV, TBC1, Clouds TV, and Star TV	Fadhila FM, Uhuru FM, RFA, and TBC Taifa	19,781	13,683	33,464
2021	19	10	Channel 10, Abood TV, and ETV	TBC Taifa, Jamii FM, and Mbeya FM	20,315	15,138	35,453
Total	91	94	–	–	101,653	111,944	213,597

3.2.3. Effectiveness of the Seed Production and Delivery System

The strengths, opportunities, weaknesses, and challenges (SWOC) analysis was conducted using the existing documentation and through brainstorming sessions. The analysis was used to assess the effectiveness of seed production and seed promotion models, as well as of the awareness creation systems used during the TL and AVISA projects as presented in Table 9. The SWOC analysis revealed the effectiveness of the seed production and promotion approaches used, the high cost of the awareness creation activities, and poor marketing linkages as the main points to address in future interventions.

Table 9. SWOC analysis.

	Strengths	Weaknesses	Opportunities	Challenges
Seed production models				
Own farm seed production	Availability of investors through projects and programs to support the production Government support for the oilseed sector	Labor problems during peak seasons	Awareness of quality standards Support from development partners (AGRA and CGIAR centers and credit from banks)	Requires more investment capital Labor shortage Climate change
Contract-based seed production	Provision of improved varieties (foundation seed) and advisory services from contractors Seed quality is controlled by the producers	If not properly supervised, seed quality can be compromised	Assured market for produce Learn good agricultural practices Increased income levels	Scarcity of labor during peak periods
Seed promotion models				
Field days	Improve interactions with farmers and strong linkages with agricultural officers Easy connections between actors	Limited number of participants High participation cost	Greater assurance that seed is available for those most in need	Opportunity for women to go is limited
Demo plots	Encourage farmers to use recommended and good farming practices Technology demonstrations in farmer fields Offer farmers a greater exposure and choice of seed to replenish their stocks	Poor maintenance of some plots by group members	Added value to farmers and knowledge systems	Vulnerability to climate change affecting the actual technology value
Seed fairs/agri-shows	Increased interactions with seed producers concerning seed of stress-tolerant varieties Opportunity to get free seed for trialing Bring relevant information to smallholder farmers	Expensive to implement Limited participation of farmers in remote areas	Chance for seed traders to showcase, sell, and exchange technologies with development organizations Establishment of networks Improve crop biodiversity Establishment of new market linkages	High cost Require multi-actor collaboration to organize
Radio/TV	Direct messages to a large number of farmers at once Overcome the literacy barrier Broadcasts can be repeated many times Mass audience	One-way communication Interference cannot be avoided Unavailability of radio or TV to some farmers	Indirect/spillover effects beyond the target areas/groups	Radio and TV unaffordable to farmers because of high prices Difficult to reach farmers in non-covered zones
Small seed packs	Improve access to quality groundnut seed Quick dissemination of improved varieties	Only a few seeds are given More time needed to bulk seed for large areas	Seed producers expand their market share and adoption increases	High cost of implementing at scale

4. Area for Further Research

The previous reports of the TL and AVISA projects showed that more of the released groundnut varieties produced and disseminated to farmers until then were old varieties released between 1983 and 2009. The varieties released from 2015 to 2018 started to gain farmers' confidence during the AVISA project. Therefore, any efforts that will accelerate the dissemination of the recently released groundnut varieties will be vital to complementing farmers' and post-farm operators' seed choices.

5. Conclusions

The present study indicated that the groundnut seed production and delivery systems in Tanzania are constrained by biotic and abiotic stresses, low adoption of improved groundnut varieties, limited supply of seed, high cost of seed, poor coordination of groundnut seed value chain actors, and poor access to seed. Joint efforts by various actors over time have brought significant changes to the groundnut seed production and delivery systems. The long-term PPDOP model adopted by the groundnut program of the TL and AVISA projects from 2008 to 2021 increased accessibility and availability of improved groundnut technologies to value chain actors. Recent studies indicate that adoption rates stand between 27% and 35% [53]. The number of seed producers has increased approximately 10-fold, from 84 in 2008 to 816 in 2021, while the amount of seed produced in all seed classes increased from 35 to 41,036 tons in the same period. PPDOPs have also maintained the seed dissemination strategies used by the groundnut program. They have increased the synergy among all legume value chain actors thanks to enhanced coordination and interactions over the long time period of the projects. The SWOC analysis showed the effectiveness of the seed production and promotion approaches, high cost of the awareness creation activities, and poor marketing linkages among the key players. The study recommends continuous technical capacity building on good agricultural practices (GAPs) and developing entrepreneurship skills among all seed producers and farmers. Groundnut intensification would require labor-saving technologies such as planters, harvesters, and threshers to reduce farmers' drudgery, especially for women farmers. This would allow them to spend time on other economic activities. In the same vein, connecting seed producers to markets would increase the quantity of seed produced because of a guaranteed market. There is a need for increased support for consumer-oriented research that will meet the diverse needs of farmers and, most importantly, of the demand market.

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