



Potato seed system in Ethiopia: challenges, opportunities, and leverage points

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Potato plays a crucial role in ensuring food security and income for smallholder farmers in Ethiopia. However, the seed potato system faces significant challenges, mainly due to the reliance on low-quality seed potatoes from the informal sector, resulting in low yields. To tackle these issues, it is crucial to comprehend the national and sub-national contexts and assess local constraints and opportunities. A recent workshop organized by SWR-RAISE-FS brought together stakeholders and knowledge partners to exchange insights and experiences regarding the seed potato system in Ethiopia. This working paper highlights the key challenges and opportunities identified during the stakeholder workshop, as well as those revealed through a systematic analysis using a transformation framework.

Keywords: potato, seed, seed system, food systems, Ethiopia

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Preface

Resilient Agriculture for Inclusive and Sustainable Ethiopian Food Systems (RAISE-FS) is a four-year program funded by the Dutch Embassy in Addis Ababa and hosted by Stichting Wageningen Research Ethiopia based in Addis Ababa, to bring about transformation in the Ethiopian food system. RAISE-FS will develop and implement a demand-driven and interdisciplinary approach to Research for Food System Transformation (R4FST) and as such contribute to the Government of Ethiopia's transformational agenda.

RAISE-FS adopts the food system approach as a Theory of Change (ToC), which helps in analysing the drivers and food system activities that contribute to the transformation of the food system by addressing leverage points, resulting in increased productivity, enhanced value chain performance, and improved human nutrition for food security while minimizing environmental impact and ensuring social inclusion.

The project aims to leverage transformation in Ethiopian food systems, covering the spectrum from food-insecure households and regions to better-off households that are food-secure and can realize production surpluses, towards commodity commercialization efforts that contribute to rural and urban consumption demands and export.

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List of abbreviations and acronyms

AARC	Adet Agricultural Research Centre
ARARI	Amhara Agricultural Research Institute
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BW	Bacterial Wilt
CIP	International Potato Centre
CSA	Central Statistics Authority
DLS	Diffused Light Store
DSM	Decentralized Seed Multipliers
EAA	Ethiopian Agricultural Authority
EGS	Early Generation Seed
EIAR	Ethiopian Institute of Agricultural Research
ESA	Ethiopian Standards Authority
FAO	Food and Agricultural Organization
FAOSTAT	Statics Division for the Food and Agricultural Organization
FSG	Farmers Seed Group
FTC	Farmer Training Centre
GARC	Gondar Agricultural Research Centre
HARC	Holetta Agricultural Research Centres
IDM	Integrated Disease Management
IPC-E	Irish Potato Coalition Ethiopia
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
ORDA	Organization for Rehabilitation and Development in Amhara
QDS	Quality Declared Seed
RAISE-FS	Resilient Agriculture for Inclusive and Sustainable Ethiopian Food Systems
SNNPR	Southern Nations, Nationalities and Peoples Region in Ethiopia
SNV	Netherlands Development Organization
SWR	Stichting Wageningen University
TC	Tissue Culture
TPS	True Potato Seed
WARC	Werabe Agricultural Research Centre

Summary

Potato is a crucial crop for food security and income for many smallholders in Ethiopia. Past experiences and recent local level assessments have shown that the seed potato system is operating under complex challenges that can be characterized by utilization of low-quality seed potato dominantly depending on the informal seed system, which frequently results in low yield.

The complexity of the seed system requires an understanding of both national and sub-national contexts as well as the analysis of the nature of local level constraints and opportunities. This has led to the need for detailed stakeholder discussions to systematically analyze and explore opportunities for improved functioning of the potato seed system. Recognizing the significant efforts and experiences of various national and international actors supporting the potato sector along the value chain in Ethiopia, SWR-RAISE-FS organized a workshop in which knowledge partners and other stakeholders shared their insights about the seed potato system from the perspective of the experiences and competence areas. Through discussion and an interactive process, key challenges and opportunities to transform the Ethiopian seed potato sector were identified. Subsequently, the challenges, opportunities and leverage points were systematically analyzed using the integrated sector and food system transformation framework and recommendations were pointed out where investments in research and development could generate positive impacts.

The analysis highlights that the limited functioning of the seed potato sector can be explained by poor performance and inefficiencies in the areas of i) production, ii) value addition and distribution, iii) utilization, iv) service provision, v) stakeholders' organization and collaboration, vi) coordination, and vii) funding of the seed potato sector. The combination of these factors is affecting the seed potato sector outcomes including the development of the varietal portfolio, as well as the use, stability, accessibility, and availability of healthy seed potato for potato producer farmers. Consequently, main leverage points are identified including (i) development and delivery of new varieties, (ii) production of early generation seed potato, (iii) multiplication of clean potato seed and proper storage, (iv) system for quality assurance, (v) enhance functioning of seed marketing and (vi) strengthening collaboration and coordination between relevant stakeholders. Key recommendations related to the leverage points as well as the implications for sector and food systems performance are identified and presented in this document.

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1 Introduction

Potato has been an important crop in many parts of Ethiopia since its introduction in 1858 by a German Botanist Schimper (Pankhurst, 1964). It is a food security and cash crop for most smallholders in Ethiopia. It has been identified as one of the major commodities common across regions with huge potential to reduce food gap months in food insecure areas and to provide additional income for smallholder farmers in high-potential areas of Ethiopia.

Past experiences and recent local level assessments from a baseline survey and a rapid food system appraisal conducted by RAISE-FS have shown that the seed potato system is operating under complex challenges that have resulted in the overall utilization of low-quality seed potato. This resulted in a low level of productivity (Berga et al. 1994; Limenih and Tefera, 2014), posing a challenge to the sustainability of potato production. National productivity is low at 13.29t ha⁻¹ compared to other countries in which case, 15-45 t ha⁻¹ is achievable (FAOSTAT, 2022). Most problems in the seed potato system are identified to be cross-regional which requires nationally coordinated efforts on one hand. On the other hand, some of the challenges and opportunities are site-specific and, therefore, require an understanding of local contexts.

One of the key challenges that emerges from different analyses of the Ethiopian seed potato system is the limited availability and affordability of high-quality potato seeds at a local level (Tafesse et al., 2020). Formal seed systems, such as those provided by government or private sector seed producers for major cereals and some vegetables, are not available for potato. In addition, most farmers' seed storage practices are suboptimal. Consequently, most potato farmers in Ethiopia use seed from their own harvest which has been stored in poor conditions. Another group of farmers purchases seed from local markets and the informal seed system (Amsalu et al., 2014), taking the risk of planting seed potato that are often of poor quality and could contribute to disease outbreaks and dissemination. Considering the limitations of their potato seed, farmers often apply excessive amounts of fertilizers and agrochemicals in the production process with the intention of mitigating production risks and maximizing potato productivity. These practices all contribute to the potato sectors' environmental impact on the food systems. Furthermore, this makes seed potato production costly, accounting for 40–60% of the cost of potato production (Sharma et al., 2015).

Local relevance is particularly important because potato seed is required in bulk amounts at specific times of the year, whereas inadequate distribution of seeds is also a major obstacle to increasing potato production (Masnenah et al., 2020). The difficulties and related disease dissemination risks associated with transporting high-quality seed potatoes from central locations to rural areas highlight the importance of local seed sovereignty and the need for decentralized production and distribution networks. Nevertheless, such models of seed production and distribution bring their unique challenges as they require decentralized quality assurance mechanisms to avoid the possibility of being potential sources of disease dissemination.

Using these insights, RAISE-FS is implementing a series of pilot and validation studies to validate innovative and decentralized mechanisms to support clean-seed potato production and distribution involving public and private actors, including farmers. Such understanding of the national and sub-national contexts as well as the diversity of local level constraints and opportunities associated with the seed potato system triggered the need for detailed stakeholders' discussions to systematically analyze and explore opportunities for improved functioning of the system.

Recognizing the significant contributions and experiences of various national and international actors supporting the potato sector along the value chain in Ethiopia, SWR-RAISE-FS organized a one-day workshop on December 30, 2022. At this event, invited knowledge partners and other stakeholders to share their reviews, experiences, and assessments of the seed potato system. The workshop included partners and stakeholders from Holleta research centre (EIAR), Adet research centre (Amhara), Worabe research centre (South), Haramaya University, Ethio-Netherlands Seed Partnership (ENSP), the International Potato Centre (CIP), SNV and the Irish Potato Coalition (IPC).

All partners shared their insights about the seed potato system from the perspective of the experiences and competence areas of their respective institutes or centres. The presentations were followed by a discussion and an interactive process, during which partners identified key challenges and opportunities to transform the Ethiopian seed potato sector. In addition to the presentations and dialogues held during the workshop, key informant interviews and literature review were used to systematically analyze the challenges, opportunities and leverage points within an integrated framework. Consequently, the integrated sector and food system transformation framework was used for the analysis and to identify topics and areas where investments in research and development could generate positive impacts.

Therefore, this working paper contains five chapters. This chapter (chapter 1) presents introductory information. Chapter two of this document describes the utilization of an integrated sector and food system framework; which was applied to assess the Ethiopian seed potato sector. Chapter three provides the drivers, challenges, opportunities, leverage points and recommendations of the seed potato sector in Ethiopia and brings together the key insights generated from the use of the integrated sector and food system framework. Chapter four presents an overview of the implications of commonly identified leverage points and recommendations for sector and food system outcomes. Finally, Chapter five provides a way forward.

2 Using an integrated sector and food systems framework to assess the Ethiopian Potato seed sector

To capture and analyze the complexity of the Ethiopian seed potato sector, the integrated sector and food system framework, as developed by Borman et al (2022), was utilized. As can be seen in Figure 1, the framework integrates elements of the food system framework (socio-economic drivers, environmental drivers and food system activities) with specific sector activities (regulation, coordination, investment, stakeholder organization, service provision, production, value chain development consumption). In addition, the framework links specific sector outcomes with food system outcomes.

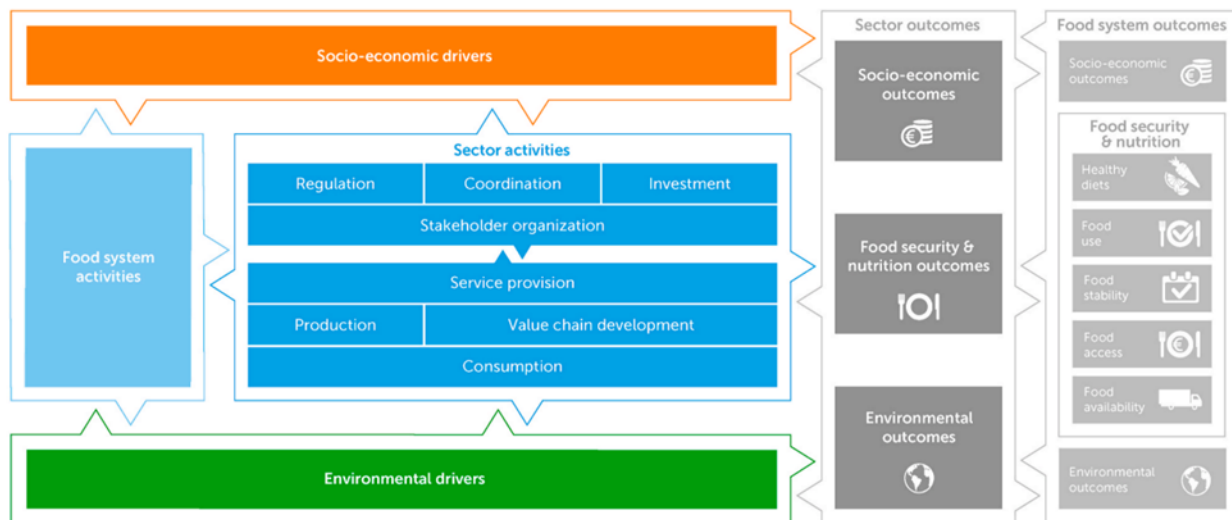


Figure 1 Integrated sector and food system framework (source Borman et al., 2022)

For this analysis, the integrated sector and food system framework was used as a tool to map out the diversity of stakeholders involved in the sector, current policies influencing the sector and, existing research, knowledge and investments in seed potato innovation and development. Insights from different experts and knowledge institutes working with the seed potato sector in different areas of Ethiopia were plotted in the integrated sector and food system framework. By doing so, emerging and reoccurring issues affecting the functioning of the Ethiopian potato seed sector were identified. The integrated sector and food system framework was instrumental in structuring the analysis as it allowed reflecting on the functioning of the potato seed sector whilst contemplating its contribution towards the potato value chain and its contribution to Ethiopian food system outcomes. The insights generated from the use of the integrated framework helped structure the reflections and recommendations in section 3.3.

3 Drivers, challenges, opportunities and leverage points of the potato seed sector in Ethiopia

3.1 Socio-economic and environmental drivers, and opportunities for improving seed potato system

Ethiopia's potato sector is rapidly developing and creating investment opportunities. Many of these opportunities strongly rely on an effective and operationally improved seed potato system. Some of the driving socio-economic and environmental factors that are generating increased opportunities for the seed potato system are:

- Expansion of potato production in Ethiopia due to suitable agro-ecology.
- Increased demand for potatoes, both locally and internationally.
- Improvement of seed potato production technologies, although most are at piloting and project scale.
- An increasing number of user-preferred potato varieties developed through participatory breeding by the national and international potato research institutions.
- Increasing efforts on public-private partnerships to enhance seed potato production and distribution.
- Improving trends in the use of better storage facilities, such as the DLS system, to maintain seed quality.
- Growing efforts to create sustainable market opportunities linking seed and ware potato production.
- Capacity building and infrastructural development for actors involved in the seed potato supply chain has been improving supported by research centres and projects.
- Opening of potato chip factories.

3.2 Challenges in potato seed sector activities and functions in Ethiopia

3.2.1 Production

The EGS of potato, unlike the EGS of legumes and cereals, are susceptible to carrying seed-borne infections. These infections are present in latent form in the seed and manifest in the progeny crop often causing severe effects on the quantity and quality of yields resulting in a high accumulation of diseases. An aggravating issue affecting the quality of the seed potatoes is the lack of proper crop rotation practices, leading to disease build-up. The overall effect has huge consequences on the sustainability of seed potato production.

Limited capacity to produce sufficient EGS from disease-free tissue culture sources as well as limited knowledge and skills in improved seed potato propagation techniques is constraining the volume of early generation seed production.

Poor participation of the private sector and limited involvement of large industrial players in EGS production have made it difficult to improve seed potato production through a decentralized seed system. Furthermore, public seed enterprises are not engaged in seed potato production. This is attributed to several constraining factors, amongst others, the limited supply of disease-free starting materials, the bulky seed rate, the perishable nature of potato, related high investment requirements for transportation and storage facilities, and limited experience in seed production and marketing.

3.2.2 Sector and value chain development

The potato sector and respective value chains are in their initial stages of development. The limited number of agro-processing industries for potato as well as limited opportunities for local level utilization do not generate sufficient incentive for entrepreneurs to invest in improved and healthy seed for increased productivity. Consequently, the involvement of public and private actors in decentralized early-generation seed potato multiplication, service provision, value addition and distribution is very limited. There is a low willingness, among potato producers, to pay for the improved and disease-free quality seed potato mostly associated with the fear of lack of market opportunity for their surplus produce, and the relatively poor storability of potato.

Given the bulkiness, perishability, and need for large quantities of seed potato to plant per unit area, costs associated with the transportation and marketing of seed potato are exorbitant. This is particularly important given the low level of utilization of storage facilities for seed and ware potato that leaves farmers with not much opportunity but to sell their produce at low prices at the time of harvest resulting in less incentive for the use of improved seed. Developing the value chain of the potato sector could play a vital role as a driver for increasing production which in turn drives the willingness to use improved and clean seed. Consequently, there is a need for a decentralized potato seed system and associated facilities for EGS and certified or Quality Declared Seed (QDS) potato in Ethiopia.

3.2.3 Utilization of potato seed

While potato is an important crop for food security and income generation in Ethiopia, its productivity is constrained by the limited utilization of quality (disease-free, and high-yielding) seed. The goal for producing quality seed potato is to use it to improve the yield and quality of ware and processing potato which is described by stakeholders as the limiting factor for most processing factories to produce to the best of their capacity. However, most farmers rely on informal sources of seed that are often infected with diseases, especially bacterial wilt, and late blight.

It was identified that the formal seed system, which is supposed to provide certified seed, is underdeveloped and inefficient. Limited availability and access to basic seed for EGS producers that mainly depend on research centres is identified as one of the key problems resulting in a lack of early generation planting materials (G2 and G3) affecting seed business and hindering the extensive production, marketing and utilization of quality seed by farmers, private actors, cooperatives, or groups. Consequently, the informal seed system remains the major supplier (98%) of potato seed (Hirpa, 2010), and alternative seed systems such as quality-declared seed (QDS) and farmer-based seed production, have emerged to address the seed quality and quantity gap (Hirpa et al. 2016; Schulz et al. 2013). Poor level of use of postharvest technologies for seed potato storage usually leads to physical damage, reduced sprouting capacity, and decreased market acceptance of seed potatoes. Thus, it amplifies the challenges associated with the utilization of highly productive disease-free seed potato across potato production areas (Tewodrose et. al., 2014).

3.2.4 Service provision

Service provision and business support services such as extension and advisory services, marketing information and financial credit service providers need to be put in place to support the proper functioning of seed potato system. Many farmers lack access to customized information, training and extension services on improved seed potato technologies and practices. Consequently, inefficient extension service provision emerged as one of the factors affecting the functioning of the seed potato system. The lack of seed marketing information and infrastructure that considers the unique features of seed potato creates challenging conditions for distribution service provision. These conditions, in turn, affect the timely distribution of quality

seed. Consequently, stakeholders raised the importance of making potato growing hotspots self-sufficient in terms of the production and distribution of healthy seed potato supported by well-functioning quality assurance and regulatory services.

3.2.5 Stakeholder organization (collaboration & linkage)

The production, distribution and utilization of high-quality seed potatoes of improved varieties, requires coordination and collaboration among different actors in the potato value chain. However, stakeholders identified that there is a lack of public-private partnerships for seed potato value chain. This means that the public sector (which is responsible for providing basic seed and quality assurance, certification, and regulation) and the private sector (which is involved in the multiplication, distribution, and marketing of seed potatoes) do not work together effectively to ensure the availability and accessibility of quality seed potatoes for farmers. The key stakeholders that need to collaborate within the seed potato system include:

- **Farmers** who produce and consume potatoes and sell them to the market or other farmers as seed or ware potatoes. They are also involved in EGS production.
- **Seed potato cooperatives** that multiply and distribute early-generation seed potatoes to their members and other farmers using mini-tubers from screen houses or tissue culture plantlets obtained from research centres.
- **Research centres** that develop, test, validate, demonstrate and release improved potato varieties, produce tissue culture plantlets and mini-tubers, and provide technical support to seed potato producers.
- **NGOs** which implement projects to promote climate-smart potato technologies and practices, enhance early-generation seed availability and accessibility, and strengthen the capacity of stakeholders in the potato value chain.
- **Private** companies that invest in potato processing and marketing, and source potatoes from farmers or cooperatives.
- **Government agencies** that provide policy guidance, regulation, certification, quality assurance, scaling and extension services to the potato sector.

Experience shows that national coordination specifically for potato exists only within the research system. However, the current level of collaboration and linkage across stakeholders is very poor.

3.2.6 Regulation

When assessing the regulatory frameworks, the seed potato system in Ethiopia faces several challenges that affect its productivity and sustainability. The four key challenges are:

A: Weak regulatory body leading to circulation of infected and adulterated seed: The Ethiopian Agricultural Authority (EAA) is responsible for regulating the seed sector, but it lacks the capacity and resources to effectively monitor and enforce the seed quality standards customized for potato. As a result, many farmers receive low-quality seed that reduces their yield and makes them susceptible to pests and diseases.

B: Lack of certification schemes: There is a weak formal certification system for seed potato in Ethiopia, which means that farmers have no guarantee of the genetic purity, quality, or health status of the seed they buy from various seed potato producer groups. This also limits the access of smallholder farmers to improved varieties and seeds and could potentially be the cause of potato disease dissemination.

C: Poor control of the quality of seed: The quality of seed potato depends on several factors, such as the source of the seed, the storage conditions, the handling practices, and the environmental conditions during production and distribution. However, there is a poor quality control mechanism for seed potato in Ethiopia, which leads to adulteration and distribution of low-quality seeds resulting in high variability and inconsistency in the performance.

D: Seed quality regulations: The existing regulations for seed quality in Ethiopia are not customized to meet the needs of the potato sector. For example, they do not specify the tolerable disease incidence, the acceptable

level of physical damage for seed potato and recommended land use/rotation to mitigate disease. The existing regulations do not include mechanisms to ensure the traceability and “safety” of the seed.

Overall, enhanced functioning of the regulatory system is required to improve the sector's functioning as well as to achieve improved seed sector outcomes including seed stability and availability. Enforcement of seed quality regulations can potentially strengthen the trust and willingness to pay potato producers for high-quality and disease-free seed potato.

3.2.7 Coordination among value chain actors

One of the challenges in the seed potato system in Ethiopia is the lack of coordination among the different actors involved in the production, distribution, and utilization of quality seed. This leads to inefficiencies, duplication of efforts and resources and gaps in the supply chain.

The low level of stakeholder engagement in the seed potato system, especially among smallholder farmers who are the main producers and consumers of potato is one of the major challenges. Improving this would require enhancing the capacity of farmers and the coordination between stakeholders through participatory approaches, such as farmer field schools, improved market linkages (e.g., through contract farming schemes), strengthened seed potato cooperatives, and seed potato innovation platforms. There is a need to review the roles and responsibilities of the different stakeholders in the seed potato system, to clarify their mandates, expectations, and contributions towards the functioning of the system. This would help to avoid conflicts of interest, ensure accountability and transparency, and foster collaboration within the sector. Improved stakeholder coordination is a fundamental element for improving sector outcomes in terms of seed use and seed access.

A possible suggested strategy is to bring together relevant stakeholders from the public and private sectors, as well as farmers, civil society organizations and other development partners. One of the opportunities to facilitate enhanced coordination is the strengthening of the newly established Irish Potato Coalition in Ethiopia.

3.2.8 Investment

Limited funding from public and private stakeholders is one of the factors affecting the functioning of the seed potato system in Ethiopia. The decentralized production and bulking of disease-free early-generation planting materials, that need to be made available for seed producers, requires investments in infrastructures such as tissue culture (TC) laboratories and storage facilities. These investments require sustainable funding to ensure their effective and long-term operation. This funding will need to be sourced from public and private partners whilst making sure to strengthen the coordinated functioning of research institutes and private sector stakeholders, following feasible business models. The inability to generate a sustainable model and strategy for funding could potentially challenge the efforts to strengthen the seed potato sector outcomes, including improving the varietal portfolio and the availability of healthy seed.

3.3 Leverage points and recommendations for transformation of the seed potato sector in Ethiopia

Based on the insights from diverse stakeholders a series of leverage points and opportunities with high potential to transform the Ethiopian seeds potato system have been identified and corresponding recommendations were formulated.

As mentioned, the seed potato system in Ethiopia is functioning poorly due to the complex challenges affecting the crop and varietal portfolio, seed use, seed accessibility and seed availability. The identified challenges (section 4.3) could be clustered into the following general categories of leverage points: (i) Variety development and delivery; (ii) Production of Early Generation Seed (EGS); (iii) Seed multiplication and storage facilities; (iv) Quality assurance, and (v) Seed marketing. Based on the synthesized reflections and the insights generated a series of recommendations have been formulated. The recommendations point at the required innovation

pathways, and bundling of innovative practices, institutional innovations and innovative policies and regulations. Descriptions for each of the identified leverage points have been formulated.

3.3.1 Variety development and delivery

Improving the limited availability of varieties for the diverse agroecology and farming systems of Ethiopia is one of the leverage points to diversify the varietal portfolio. In the current situation, the *Gudenni* is the most dominant variety in use throughout a wide range of geographies despite the release of about 40 varieties by the research system as of 2022. Furthermore, the claimed adaption range described in release documents does not often match the reality on the ground resulting in low level of adoption in most varieties. Stakeholders associate this with the challenging variety release system in place that is characterized by a low level of end-user participation in variety development and release process particularly early in breeding and selection cycles to enhance acceptance and adoption of varieties as well as narrow breeding objectives usually focusing on high yield and disease resistance.

Recommendations

- Improve characterization of the existing varieties and enhance the capacity of the variety release system to provide more varietal options (suitable for different agroecologies and environmental conditions) also taking into account resistance to various biotic and abiotic factors.
- The research system needs to stay up to date with the latest research and developments in seed potato production and delivery to create competitive seed production processes. There is a need to diversify research centres with improved capacity to deliver disease-free foundation seeds or plantlets to private and public seed producers.
- Policy support for the implementation of the plant breeders' right proclamations and regulations that create incentives and encourage innovation to improve the availability and accessibility of competent technologies towards a diversified and improved varietal portfolio.
- Invest in rapid development and release of user-preferred varieties using participatory breeding methods to enhance adaptability across different agroecologies and production systems. For improved delivery of improved varieties, targeting additional production objectives including participatory variety selection for climate change and wider environmental adaptations, breeding for better processing qualities, and bio-fortification aiming at enhancing nutritional composition are important.

3.3.2 Production of Early Generation Seed (EGS)

The effort to produce quality EGS has been challenged by the vulnerability and high level of prevalence of diseases and pests in potato production. There is a need to improve the capacity to produce sufficient EGS from tissue culture sources as well as to improve the knowledge and skills in improved seed potato propagation systems by involving actors beyond a few research centres such as Holleta and Adet. Thus, enhancing the participation of the private sector in EGS production is an important consideration of this leverage point.

Restricting the free delivery and handouts of EGS by uncoordinated stakeholders as well as improving the willingness of producers to pay for, and invest in, quality seed are expected to increase the sustainable availability of EGS.

Recommendations

- Improve the efficiency/functioning of disease-free EGS production by creating and enabling an attractive investment environment for private sector stakeholders and operationalizing innovative financial credit provision mechanisms supporting farmers (cooperatives) to acquire the right seed and production infrastructure.
- Improve the involvement of the private sector, including cooperatives, in the production and multiplication of clean seed potato from tissue culture sources as a business.
- Demonstrate and scale up sustainable business models for the production of disease-free seed potato including the use of GAP such as IPM, ISFM, land management and storage to break the disease cycle.

- Conduct a needs assessment of decentralized seed regulatory bodies to enhance their effectiveness and efficiency to achieve a supply of quality EGS.
- Strengthen regulations on seed quarantine, inspection, transportation/dissemination, control, and the overall certification system and the traceability of seed potato providing certificates of quality assurance for specified seed producers.
- Improve the willingness of potato producers to pay for quality seed by improving market opportunity for the additional production that may be obtained as a result of quality seed and associated production technologies.

3.3.3 Seed multiplication and storage:

Decentralized seed potato multiplication plays a pivotal role towards strengthening localized seed security. Although efforts were made to organize farmers to multiply seed potato in some areas such as in Jeldu *Woreda*, the lack of sufficient numbers of seed producers and diseases accumulation from repeated use of infected farmer-saved seed with low replacement rate in the same fields have hindered the multiplication of clean seed. As mentioned, public seed enterprises are not engaged in seed potato production.

Therefore, this leverage point is aimed at enhancing the value chain of seed potato, including amongst others, seed potato multiplication and distribution supported by innovative strategies that lower the cost of producing disease-free mini-tubers making the sector more accessible and affordable for seed multipliers. The use of effective storage and handling practices will reduce the risk of seed degeneration and will increase the availability of high-grade seed potato for potato producers contributing towards positive seed sector outcomes.

Furthermore, the existing system doesn't have a geographically informed production plan or a seed tracing information system that takes into account local and regional demand, bulky seed rate, and transportation requirements. Consequently, most potato producing areas in Ethiopia either depend on the seed multiplied and transported from Jeldu area of central Ethiopia, or on recycled seed with a low replacement rate as well as the use of ware potato for seed.

Recommendations

- Improve the availability and affordability of EGS through the involvement of private actors.
- Improve the land management regulations and protocols for seed potato production to mitigate disease accumulation in the soils and dissemination through infected seeds.
- Improve the decentralized seed demand assessment and planning system.
- Demonstrate and scale up sustainable and feasible seed storage systems such as low-cost DLS.
- Demonstrate and scale ware potato production to stimulate seed demand and foster the growth of this segment in the potato value chain.
- Redesign the decentralized seed multipliers model to improve efficiency, affordability, and seed quality for smallholders. This can include innovative credit and finance mechanisms to support agri-entrepreneurship in seed potato production.
- Invest in long-term human and decentralized infrastructural capacity development for all actors in the seed potato supply chain.

3.3.4 Quality assurance

The vulnerability and high level of prevalence of diseases and pests in seed potato production require a strong and customized regulatory mechanism. However, there is low attention as well as limited capacity (manpower, logistics, facilities) for potato and seed potato quality assurance in the existing regulatory system as the major focus is on cereals. Currently, the system lacks disease load standards (observation-inspection is considered a minimum requirement). Consequently, adulteration is a common phenomenon. Thus, improving the effectiveness of the existing quality assurance mechanism is a crucial condition for the production of quality seed. This requires strengthening the capacity of the regulatory authority and stakeholders to design and

implement customized quality assurance services based on standard operating procedures would help attain a feasible quality assurance system that can contribute to improving clean seed use.

Recommendation

- Complementary support towards effectively decentralizing the production, multiplication, storage, and quality assurance mechanisms for seed potato.
- Establishment of regional and rural networks for quality assurance procedures to support producers and users in increasing the quality and control over quality seed material.
- Quality assurance framework that would require all EGS producers to:
 - Modernize seed quality assurance.
 - Revitalize phytosanitary services.
- Policy and institutional innovation, and regulations for decentralized quality control to ensure the seed potato produced are of high quality and disease-free. Support the regulatory system for QDS and beyond to take into account the unique nature of seed potato.
- Advocate for improved law enforcement to mitigate adulteration disease transmission.

3.3.5 Seed marketing

Seed marketing is one of the leverage points to improve the seed potato sector. There is a lack of seed potato market information and a lack of standard packaging and handling regulations and guidelines. The involvement of middlemen and traders who fix the prices of seed potato making sure they retain a high share of the total market value, results in high costs for seed which discourages producers from purchasing and using clean seed. The high price for seed potato together with poor regulation has promoted the selling of ware potatoes as seed.

Recommendation

- Improve potato seed marketing and pricing system.
- Improve seed potato information system.
- Improve the standards and guidelines for packaging and handling.
- Develop an effective marketing plan to reach out to potato farmers in Ethiopia.
- Establishing a strong brand image that can promote products through various channels to reach target customers.
- Develop a seed sector investment plan involving diverse stakeholders.
- Undertake profitability analysis for various stages of seed value chain production and value addition to support both public and private sector actors in an integrated and sustainable manner.

3.3.6 Collaboration and coordination

Improving collaboration and coordination among stakeholders is key to better functioning of the seed potato system. Better coordination could be achieved through the established potato coalition¹ and through the enhancement of collaborative engagement of stakeholders based on their excellence and comparative competence areas.

Recommendations

- Collaboration with multi-stakeholders, and linkage with other seed producers, suppliers, and industries to expand the network and reach more customers.
- Establish the Seed Potato Partnership Platform, facilitate dialogue regularly to analyze specific problems and design sustainable strategies to improve the system and address challenges collectively.

- Formalize and strengthen potato platforms, such as the Irish Potato Coalition for Ethiopia (IPCE), to enable business-oriented growth and stimulate public-private partnerships within the potato value chain.
- Create sustainable market opportunities through strong linkages between tissue culture producers, mini-tubers producers, seed potato multiplier associations, regulatory organs, and ware potato producers.

Revisit the roles and capabilities of public research centres and involve proactive private sector actors in supplying Early Generation Seed (EGS) and foundation seeds.

4 Implications for sector and food system outcomes

The recommendations point to the necessity to address the challenges, opportunities and corresponding leverage points in the seed potato sector in an integrated manner. Any type of intervention will need to bundle efforts to improve stakeholder collaboration, implement innovative practices at field level and implement institutional innovations, driven by forward-looking policies and regulations that seek to address the key challenges. Bundled socio-technological innovations will have the largest potential to effectively contribute to systemic improvements (Barrett et al., 2022). For example, recommendations related to variety development and delivery inevitably require coordination, stakeholder organization, and regulations on one hand and, on the other hand, also require effective measures to support production and service provision. The bundling of socio-technological interventions and associated recommendations can form the basis to charter transformation pathways for the seed potato sector.

The transformation pathways for the seed potato sector must contemplate, at a larger scale, the contribution of the seed potato sector towards the potato sector and the contributions towards the Ethiopian food system. Integrated sector and food system transformation pathways would require being explicit when defining aspired outcomes by merging three domains of outcomes:

- i. socio-economic outcomes – assuming that the seed potato sector supports livelihood diversification for seed producers, and service providers (for example marketing agents, storage providers, and quality assurance regulators);
- ii. food and nutrition security outcomes – resulting from increased production and productivity of seed and ware potato through improved accessibility, affordability, and availability of a diverse portfolio of high-quality, disease-free seed potatoes that contribute to enhancing the availability, accessibility and utilization of ware potato to diets. It also contributes to increasing nutrition security by enhancing farmer's income, enabling them to acquire additional food products from the market
- iii. Environmental outcomes – assuming that the utilization of disease-free seed along with good land use planning and agricultural practices reduces the accumulation of soilborn disease in farmers' fields, as well as reduces the use of pesticides which could otherwise damage the environment.

Together with partner organizations, the RAISE-FS project is piloting and demonstrating various innovative technologies and business models to generate evidence of the potential for enabling decentralized clean seed potato production. The demonstrations include the production of mini-tubers from tissue culture sources using mini-screen houses at household level, improving the capacity of seed producing farmers groups to multiply clean seeds from mini-tuber sources, low-cost seed potato storage systems along with the cost and benefit analysis for each and market linkage between the actors involved in seed potato supply chain. The stakeholders' discussion also revealed that the experience and excellence of various stakeholders is a huge opportunity for bundling of additional evidence and scaling up of demonstrated innovations. This, along with the implementation of sustainable production and storage practices would eventually lead to increased productivity and production of ware potato, consequently, improving the food security and income of households, and contributing to sector and food system outcomes.

The integrated sector and food system framework proved to be instrumental in assessing the current functioning of the seed potato sector in Ethiopia. The framework provided a helpful analytical structure which guided both the analytical part of this assessment and the narration of the forthcoming recommendations. The framework proved to be particularly useful to analyze the dynamics of a sector and how it is governed (Borman et al., 2022). The multi-level analytical framework guided the formulation of actionable insights following the structure of the framework. The recommendations that come forth can be used to consider and

support decision-making when thinking about appropriate innovations, investments, and strategies to develop and transform a specific sector.

The integrated sector and food system framework has proven to be a functional and user-friendly framework to capture and assess the complexity of a given agricultural sector. The ability of the integrated framework to link sector functions to sector-level outcomes and then to the three interrelated domains of food system outcomes has been very valuable for the assessment of the seed potato sector and can potentially be applied to assess other sub-sectors within the Ethiopian food system.

5 Way forward

As a way forward, the following key strategic directions are identified as important.

- Build up on demonstrated evidence and scale promising innovations that support the production and utilization of clean potato seed
- Revisit the roles and capabilities of public research centres and involve proactive private sector actors in supplying Early Generation Seed (EGS) and foundation seed.
- Invest in rapid development and release of user-preferred varieties using participatory breeding methods to enhance adaptability across different agroecologies and food systems.
- Redesign the decentralized seed multipliers model to improve efficiency, affordability, and seed quality for smallholders.
- Conduct a needs assessment of seed regulatory bodies. This could help identify leverage points to enhance their effectiveness and efficiency in discharging their role.
- Invest in long-term human and infrastructural capacity development for all actors involved in the seed potato supply chain.
- Undertake profitability analysis for various stages of seed value chain to support both public and private sector actors in an integrated and sustainable manner.
- Promote improved storage facilities like Diffused Light Stores (DLS) for better seed tuber preservation.
- Create sustainable market opportunities through strong linkages between seed and ware potato production, marketing, and credit access for growers as a driver for enhanced use of disease-free seed potato and increased productivity.
- Focus on ware potato production to stimulate seed demand and foster the growth of this segment in the potato value chain.
- Formalize and strengthen the existing potato platforms, such as the Irish Potato Coalition for Ethiopia (IPCE), to facilitate the engagement of all relevant stakeholders according to their competence to take responsibility towards the implementation of the recommendations suggested across the identified leverage points.
- Create an enabling environment to operationalize business-oriented seed potato production, and to stimulate public-private partnerships within the potato value chain.

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implement a demand-driven and interdisciplinary
approach to Research for Food System Transformation
(R4FST) and as such contribute to the Government of
Ethiopia's transformational agenda.
