

## Seed systems development to navigate multiple expectations in Ethiopia, Malawi and Tanzania

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### ABSTRACT

The purpose of this study was to assess how multiple expectations of seed systems outcomes, such as closing the yield gap, adapting to climate change, improving nutrition, ensuring equality, enhancing agro-biodiversity, and securing farmers' rights, influence seed systems development in Ethiopia, Malawi, and Tanzania. A comparative approach was used, based on documents and qualitative data, to analyze seed systems in the three countries. In spite of the same categories of actors providing quite similar influence at country levels, the national seed systems have developed in different directions into approaches that can be characterized as pluralism in Ethiopia, dualism in Malawi, and pragmatism in Tanzania. This finding might indicate that various actors' influences on the direction of seed systems development could be less important than what we assumed. At the same time, expectations relating to seed systems outcomes are shaped by competition to receive economic and political support to influence policies and laws. We conclude that seed systems development must address different needs for different crops in different agro-ecologies and different groups of farmers. To achieve this, different approaches are needed to harness the strengths of both formal and farmers' seed systems.

### Introduction

Seed systems are essential elements of broader food systems and are often criticized for performing poorly in Africa, particularly regarding securing affordable access for smallholder farmers to quality seeds in accordance with diverse demands and preferences [1,2]. Seed systems have developed in different directions across various African countries, with specific variations in terms of time and types of crops [3–5]. As new food systems challenges emerge – related to issues such as climate change, healthy diets, and social inequalities – seed systems need to adapt to varying demands and expectations [6,7]

Bèné et al. [8] identify four different narratives explaining the failure of food systems: yield gap, nutrition deficiency, inequality regarding food access, and negative impact on climate and nature. Seed systems are relevant to all four of these narratives – as a farm input contributing towards production increases; as a source for dietary diversity; as a resource with limited accessibility for certain social groups; and as

technology that might contribute to climate adaptation [4,9–12]. In addition, seed systems are expected to contribute to other aspects, such as the target 2.5 of the Sustainable Development Goal (SDG), Zero hunger, regarding the maintenance of genetic diversity in food production [13] and the protection of farmers' rights according to national and international legislation [14,15].

The politics involved in the formulation of national seed policy and legislation often indicate that the types of seed systems to be supported are contested [3,16–18]. In the three African countries included in this study (Ethiopia, Malawi, and Tanzania), different national and international actors have grand expectations of the outcomes of existing and proposed seed systems. However, developing seed systems that can deliver on multiple expectations is challenging, particularly when seed security is already a problem regarding access to preferred, affordable, high-quality seeds for all farmers at all times [4,18–20].

The purpose of this study is to assess how multiple expectations of seed systems' outcomes, such as yield, nutrition, climate, equality, agro-

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biodiversity, and farmers' rights, influence seed system development in Ethiopia, Malawi, and Tanzania. In this context, actors include various categories of men and women farmers, farmer organizations, formal public agricultural institutions, extension, and advisory services, the private sector, civil society, researchers, and bilateral and multilateral donors. More specifically, we ask how and to what degree do expectations relating to seed systems outcomes influence different actors in the type of seed systems they promote? Our theoretical approach is informed by seed systems and sociological expectation theory. We show that the multiple expectations of seed systems outcomes provide arguments to support both formal and farmers' seed systems development.

## Theoretical framework

Increasingly, the concept of *food systems* has gained interest, from both theoretical and practical points of view, as a way of 'connecting the dots' and formulating a holistic tool for analyzing food-related challenges and opportunities [6,21-23]. Seeds play a key role in food production and food security [24]. Important concepts used in the literature to understand new crop variety development, and the production, supply, access and use of seeds, are *seed systems* and *seed security*. There are several different definitions of *seed systems*, with the main focus being on the activities of the actors involved and the ways in which farmers obtain seeds [2,3]. In this paper, we consider *seed systems* to include the interlinked actors and formal and informal institutions involved in crop diversity conservation, variety development, seed production, seed dissemination and use. Seed systems are commonly categorized as *formal* and *informal*, the latter also being referred to as *local* or *farmers'* seed systems [2,3]. In addition, the term *intermediate* seed system is used to describe diverse ways of integrating formal and informal seed systems [4,25]. Farmers' seed systems include ways in which farmers themselves produce, disseminate, and access seed: directly as farm-saved seed; through exchange and barter among friends, neighbors, and relatives; and through local grain markets [26]. *Intermediate* seed systems refer to a combination or an integration of formal and farmers' seed systems through market and non-market-based interventions by farmer organizations. An example of an intermediate seed system activity is *quality declared seed (QDS)* production and marketing, which involves a quality assurance system that is less demanding than the complete seed quality control and certification system used in the formal seed system [27,28]. Seed systems are intended to ensure seed security. *Seed security* is often defined in similar ways as food security, with an emphasis on seed access, and pillars such as availability, access, utilization, stability, agency, and sustainability [24,29,30]. In this study, we use the FAO [31] definition of seed security which "*exists when men and women within the household have sufficient access to adequate quantities of good quality seed and planting materials of preferred crop varieties at all times in both good and bad cropping seasons.*"

In this study, we also discuss the concept of farmers' rights and seed sovereignty. *Farmers' rights* refer to the right farmers have to save, use, exchange, and sell farm-saved seed and propagating material; the right to protect traditional knowledge relevant to seeds; the right to equitably share benefits arising from the commercial use of these resources; and the right to participate in decisions on matters related to the conservation and sustainable use of such resources [14,15]. *Seed sovereignty* and farmers' rights are somewhat linked, as seed sovereignty challenges intellectual property rights and corporate control over seeds, advocating instead unobstructed customary practices of farmers, regarding seed saving and exchange, and the re-use of protected varieties [16,32].

Seed systems are expected to deliver on multiple dimensions. *Expectations* refer to what we would like to see happen, but in reality, expectations about the future tend to be exaggerated and rarely live up to what is being promised [33]. The politics of expectations include the risks of future expectations becoming hegemonic, or a way of reproducing embedded assumptions [34,35]. Expectations are often linked to technical and institutional *innovations*, but innovations are often faced

with barriers that hinder the uptake and use of the innovation, e.g., adoption of improved varieties (technical) and regulatory flexibility in seed governance (institutional) in the seed systems [36,37]. On the other hand, expectations about the future may circulate amongst policy actors with different material and institutional settings and thus influence the governance of innovations [38]. The analytical framework presented in Fig. 1 includes *expectations* identified in relation to Bènè et al.'s [8] four food systems failures, namely closing the yield gap, nutritional deficiency, inequality regarding food access, and negative impact on climate and nature. In addition, we included expectations relating to the SDG 2.5 target on the maintenance of genetic diversity [12] and the International Treaty on Plant Genetic Resources for Food and Agriculture [14] on the realization of farmers' rights. The analytical framework indicates that these expectations are associated with different categories of actors that influence seed systems development processes. The framed box depicts the different seed systems farmers use with key functions in solid boxes and circles and approaches to support the functions in shaded boxes and circles behind. The governance of seed systems is part of the analytical framework and implies appropriate policies, laws, and regulations, as well as state accountability, capability, and financial resources [39,40]. In this analytical framework, farmers' seed security is the outcome of the performance of the seed systems farmers use.

## Methods

We used comparative methods to compare and contrast seed systems in three African countries – Ethiopia, Malawi, and Tanzania. The three countries were selected because of differences in their seed systems, as well as contextual variations. Qualitative primary and secondary data, such as interviews, observations, and document review, were collected over ten years, from 2013 to 2022, through the following four projects:

- (i) A *long-term institutional collaboration programs* between the Norwegian University of Life Sciences (NMBU) and partner universities in Ethiopia, Malawi, and Tanzania was funded by the Norwegian embassies in these countries. We compiled policy documents and used contextual information for analysis from our project engagement with university colleagues at Mekelle University (MU) and Hawassa University (HA) in Ethiopia, Lilongwe University of Agriculture and Natural Resources (LUANAR) in Malawi, and Sokoine University of Agriculture (SUA) in Morogoro in Tanzania. For instance, in 2014, a qualitative study on seed access was undertaken in Tanzania in 15 districts (Mbeya rural, Njombe, Kilolo, Gairo, Morogoro urban, Kilosa, Singida, Kibaha, Temeke, Ilala, Mkuranga, Mtwara-Mikindani, Unguja, Meru, and Karatu) under the institutional collaboration between SUA and NMBU. In this study, a total of fifteen focus group discussions (FGDs) were conducted. Participants in each FGD comprised eight to sixteen men and women farmers selected by the district staff based on diversity criteria. In addition, around 50 key informant interviews were undertaken with seed producer households, agro-dealers, retailers and distributors, public and commercial seed producers, and suppliers, Agricultural Seed Agency (ASA), Tanzania Official Seed Certification Institute (TOSCI), national and international agricultural research institutions, Civil Society Organizations, and Government officers at national, regional and district levels. In 2022, some of these key informants or their successors were interviewed for updated information by one of the authors of this study.
- (ii) A *Multi-actor Platform (MAP) established by the InnovAfrica project (Innovations in technology, institutional and extension approaches towards sustainable agriculture and enhanced food and nutrition security)*, included seeds and seed systems as one focus area in the project. The project sites comprised Kombolcha and Meta districts in Ethiopia, Mzimba and Dedza in Malawi, and southern highlands and coastal lowlands in Tanzania. The project MAP

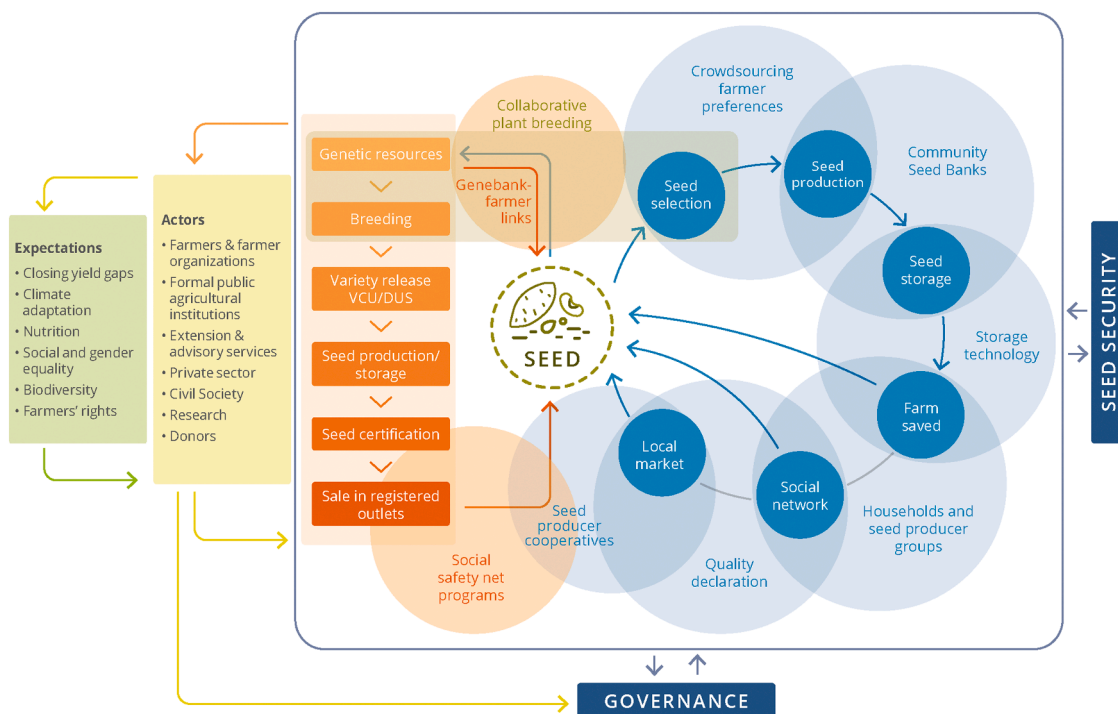


Fig. 1. Analytical framework: Seed systems, actors and governance. The formal seed system is depicted in orange and farmers' seed systems in blue (Author's own figure).

meetings, which gathered about ten to fifteen people from the public and private sectors, farmer organizations, and non-governmental organizations, generated information on the countries' seed systems and seed security.

(iii) *The project Access to Seeds: From Emergencies to Seed System Development.* In February 2020 and May 2022, altogether 19 key informants were interviewed in Malawi as part of this project. The interviewees in 2020 included InnovAfrica MAP and InnovAfrica partner members, comprising four district agricultural officers, three civil society representatives, one representative from the farmer union (NASFAM), one local chief and three researchers. In May 2022, four civil society actors, two at the district level and two at the national level, as well as four individuals involved in the formal seed system at the national level were purposively selected and interviewed. The informants' roles spanned all key functions in the seed systems farmers use, as depicted in Fig. 1.

(iv) A Ph.D. fieldwork that was undertaken in Ethiopia by one of the authors. In addition to information obtained through institutional collaboration programs and InnovAfrica MAP meetings, primary and secondary data (from published sources and gray literature) were collected as part of a Ph.D. project on crop diversity and seed system governance. In 2017 and 2018, the Ph.D. project generated primary data from surveys with 432 households and sixteen FGDs in two districts (Gindabarat and Heexosa) in the central highlands of Ethiopia. In addition, qualitative information was collected by interviewing fifty key informants. The key informants include individual representatives from public seed enterprises, private seed companies, decision-making and regulatory bodies, NGOs, agro-dealers, farmer organizations, and extension service providers. In addition to key informant interviews, participatory observations were used in two national seed policy meetings. These meetings were a one-day Workshop on the Assessment and Identification of Constraints to Private Seed Sector Development in Ethiopia in February 2018 and a one-

day National Seed Policy Consultation Workshop, which gathered several key seed system actors in March 2018.

Regarding data analysis, secondary data, such as policy and legal documents, were analyzed through document review. Primary qualitative data were analyzed by making summaries of discussions and interviews, highlighting patterns, and seeking categorization as well as main trends. The analysis was based on the analytical framework described above in Section 2.

**Results**

The result section includes three main sub-sections. The first sub-section is on seed policy and legislation. This sub-section is primarily based on literature and document review and provides background seed-related policy information. Based on the analytical framework, the second and third sub-sections use both literature review and primary data and present expectations of different actors to seed systems outcomes. The second sub-section explores to what degree and how these expectations influence various actors in the seed systems, they tend to promote, and the third sub-section examines and compares the various types of seed systems in the three countries.

*The seed policy landscape*

Seed systems are shaped by agricultural sector policies and governed by seed policies, legislations, and plant variety protection laws. These policies and legislative instruments can apply at different levels, including regional and international mechanisms, e.g., The African Regional Intellectual Property Organization (ARIPO), Harmonized Regional Seed Trade Regulations in Economic Community of West African States (ECOWAS), the Common Market for Eastern and Southern Africa (COMESA), and the Southern African Development Community (SADC) and the International Union for the Protection of New Varieties of Plants (UPOV). In addition, other international agreements are relevant, such as the International Treaty on Plant Genetic Resources for

Food and Agriculture (ITPGRFA) and its multilateral system of access and benefit-sharing, the Convention on Biodiversity (CBD) and its Nagoya Protocol on bilateral access and benefit-sharing, and the UN Sustainable Development Goals. Table 1 provides a brief overview of policy documents and legislation in Ethiopia, Malawi, and Tanzania that are important for seed systems development.

**Ethiopia:** Seeds systems in Ethiopia are governed by the National Seed System Development Strategy 2017, the Plant Breeders' Rights Law 2017, the Seed Law 2013, and the National Seed Policy 2020. The Plant Breeders' Law was approved, but regulation is yet to be developed, and implementation lags behind desirable levels. The 2020 National Seed Policy aims to address longstanding issues of the seed trade harmonization regulations in the Common Market for Eastern and Southern Africa (COMESA). These issues include the registration of varieties approved in other member countries and the need to establish an independent entity (separate from government institutions) for variety registration and release. The policy also aims to establish independent seed certifying authorities at national and regional levels, and to enable regional and federal bodies to authorize private seed inspectors.

**Malawi:** The National Seed Act adopted in 2022 regulates certified seed in the formal seed sector but does not regulate farmers' seed systems and also does not have provisions for intermediate seed system approaches such as QDS. The proponents of the 2022 Seed Act – such as the Government of Malawi, some farmer organizations, certain civil society organizations, the private sector, and the Alliance for Green Revolution in Africa (AGRA) – regard the law as a way of increasing farmers' access to quality seed. These proponents consider that the Act will create a conducive environment for the seed industry, contributing to the

regional harmonization needed for market integration, and safeguarding farmers from purchasing counterfeit seeds.

**Tanzania:** Tanzania does not have a specific seed policy, but the Seed Act serves as a seed policy and has regulated the seed sector since 2003, with later amendments. Between 2013 and 2015, several amendments were made to seed laws and plant variety protection, to align with the harmonization of regional seed regulations. In particular, the 2014 amendment to the Seed Act of 2003 created debate about making the sale of uncertified seed illegal. Later developments have opened up opportunities for expansions of intermediate seed systems development. For example, in 2020, new QDS guidelines were approved, extending the QDS area beyond the Ward to the District level and strengthening the mandate of seed inspectors. The Tanzania Organic Agriculture Movement (TOAM) and the Tanzania Alliance for Biodiversity are working towards seed sovereignty and agro-biodiversity conservation in Tanzania by promoting indigenous seeds and the rights of farmers to save, use, exchange, and sell their seed in accordance with ITPGRFA [14]. There are also initiatives, including from the government, to replace imports of certified seed with domestic seed production and use the National Agricultural Research Institutes (TARI) more directly in seed production and delivery.

#### Multiple expectations, diverse actors and various seed systems

Having assessed the seed policy landscapes, in this section, we apply the analytical framework described in Fig 1, assessing the expectations of different actors to seed systems outcomes and exploring to what degree and how these expectations influence various actors in the type of seed systems they tend to promote as well as what kind of seed systems that have evolved in the three countries.

#### Yield gap

In sub-Saharan Africa, yield levels are far below those in high-income countries, e.g., in 2019 the average yield level for cereals in Ethiopia was 2.83 tons/ha, in Malawi 1.68 tons/ha and in Tanzania 1.88 t/ha, while in the USA and some European countries this level was more than 8 t/ha [41]. The recent food price crisis due to Covid-19, climate change, and conflicts such as the war in Ukraine, has contributed to an increased focus on closing the yield gap by improving productivity in low-income countries, in particular among smallholder farmers [42,43]. From the vantage point of the yield gap expectation, enhancing seed security entails seed system formalisation to ensure effective breeding and delivery of high-yielding varieties. Interviews reveal that for some key informants, the meaning of 'quality seed' is synonymous with certified seed from formal seed systems.

Actors in favor of giving priority to formal seed systems development argue that this will be more efficient in closing the yield gap regarding the quality of seed used, yield potential, and increased efficiency of the delivery mechanisms offered by private companies and agro-dealers. These actors tend to favor the 'Green Revolution' kind of agricultural sector modernization; they promote formal seed systems development through the private sector as part of a development path involving increased productivity with the aim of delivering affordable food to urban citizens and rural net consumers.

On the contrary, opponents of formal seed systems development argue that smallholder farmers cannot afford the certified seeds sold by agro-dealers and that some of the available certified seeds are not well adapted to farmers' local agro-ecological conditions. Further, opponents criticize formal seed systems based on evidence of seed unavailability at planting time, lack of certified seeds for most crops (except for a few, such as hybrid maize), and the cost of associated inputs such as chemical fertilizer which is needed for e.g., hybrid maize to perform well. They argue that the formal seed systems development model has created a dependency on private companies, often involving the import of expensive seeds. Actors supporting these arguments lean in the direction of supporting farmers' seed systems and intermediate seed systems.

**Table 1**  
Seed policy and legislation in Ethiopia, Malawi and Tanzania.

	Ethiopia	Malawi	Tanzania
<b>Agricultural policies</b>	2016 Growth and Transformation Plan 2016–2020. 2020 Home-grown Economic Reform Program (2020–2030).	2016 National Agricultural Policy.	2015 Agricultural Sector Development Strategy 2015/16–2024/25.
<b>Seed policies</b>	2017 National Seed System Development Strategy (replaced the earlier 2013 strategy). 2020 National Seed Policy.	2018 National Seed Policy (replaced the earlier 1993 version).	No overall seed policy but matters involving seeds are handled by the Seed Law.
<b>Intellectual Property Rights (IPR) legislation</b>	2017 Plant breeders' rights (PBR) law (replaced the earlier 2006 proclamation). Not a member of UPOV.	2018 Plant Breeder's Right Act based on the African Regional Property Organization (ARIPO) Plant Variety Protection Protocol	2013 New Plant Varieties Act (replaced the earlier 2003 version). 2015: Full member of UPOV (1991).
<b>Seed laws</b>	2013 Seed Proclamation No 782/2013 (replaced the 2000 version). 2015 Ministerial Quality Declared Seeds (QDS) directives were issued to regulate the intermediate sector. 2022 Suggestions to change the 2013 Seed Law to accommodate private sector better.	2022 National Seed Act.	2014 Amended version of the 2003 Seed Act. 2020 Supplement to the Seed Act by expanding Quality Declared Seeds (QDS).

In all three countries, similar actors appear to favor private sector-based, formal seed systems development as the best approach for seeds to contribute towards closing the yield gap. These actors include external international organizations such as the World Bank (WB), the Bill and Melinda Gates Foundation (BMGF), some bilateral donors, international seed companies, parts of the CGIAR organization, AGRA, parts of international academia, and some international NGOs as well as COMESA and the African Union (regional level). However, some of these organizations might also support intermediate seed systems such as QDS projects. At the national level, actors such as governmental institutions (Note Section 4.1 which state that Ethiopia recognizes pluralism and that Tanzania's formal seed system includes both public and private approaches), national agricultural research institutes, national seed companies, seed trader associations, agro-dealers, universities (mixed views), some NGOs, farmer organizations, farmers (mixed views) favor private sector-based formal seed systems. However, for some of these actors, it is not necessarily an either-or, but a both depending upon contextual factors such as crop and type of farmer.

### Nutrition

According to international agencies, more than three billion people in the world cannot afford a healthy diet, approximately 22 percent of children under five worldwide are stunted, and around two billion people are overweight or obese [22,44]. The formal seed systems in Ethiopia, Malawi, and Tanzania offer seeds and planting material from a rather limited number of crops and crop varieties, such as maize. In addition, African formal seed systems provide certain vegetable seeds that are in high demand among African farmers [45,46].

Key informants expressed that in general, farmers' seed systems might be considered better than formal systems as regards delivering seeds necessary to ensure the crop diversity needed to enable healthier diets. Both farmers' and intermediate seed systems appear to be recognized as being able to serve small-scale farmers in supplying a wide range of different crops and varieties (including vegetables) and neglected and underutilized crops in general [47,48].

An attempt to contribute to better nutrition through the formal seed system is the introduction in several African countries of certified seeds of biofortified crops promoted by some CGIAR centers, such as sweet potato seeds high in Vitamin A content, and bean seeds high in micronutrients such as iron [49,50]. From informant discussions, biofortification comes with high expectations among several actors of being a cost-effective way of combating malnutrition in low-income countries, given that the seed is both available and accessible for smallholder farmers as well as in accordance with their preferences. At the same time, other informants warn against biofortification and would rather promote healthy dietary diversity based on traditional crops and knowledge.

Largely the same actors that favor formal seed systems to contribute towards closing the yield gap also favor formal seed systems to promote healthier diets. Proponents of farmers' and intermediate seed systems to enhance nutrition include in Ethiopia, actors such as MoA (regional level), ISSD, agricultural universities, cooperative seed producers, national and international NGOs, Bioversity International, FAO (e.g., through ITPGRFA), farmer groups, and local farmers. In Malawi and Tanzania, similar actors as for Ethiopia, favor farmers' and intermediate seed systems including community-based seed banks and MAgNet in Malawi; and in Tanzania QDS schemes, the Tanzania Organic Agriculture Movement (TOAM) and the Tanzania Alliance for Biodiversity (TABIO).

### Equitable access

Inequalities in the food system are most often illustrated by the increasing number of hungry people in the world – up to 828 million in 2021 [22], and the number of people being in a situation of acute food insecurity – about 193 million in 2021 [51]. The SDG 2.3 is about doubling the agricultural productivity and income of small-scale food

producers, particularly emphasizing women's secure and equal access to land, other productive resources, and inputs such as seed, knowledge, services, markets, and opportunities for value addition and non-farm employment [13]. The United Nations Food System Summit (UNFSS) has confirmed the commitment made in SDG 2 in the action track on advancing equitable livelihoods, decent work, and empowered communities [6].

To enhance equality in food systems, Neufeldt et al. [52] underline the need for changes in power relations and in discriminatory and exclusionary structures. In accordance with SDG 2.3 and UNFSS Action Track 3, seed systems are expected to deliver improved access to quality seeds by groups of poor men and women smallholder farmers who currently lack such access. Seeds from formal seed systems are not available nor affordable for these groups, considering the low profitability or subsistence role of their farming activities.

In Malawi, seeds have been subsidized through agricultural input subsidy programs to improve their affordability and thereby access by smallholders; however, insufficient farmer coverage and the main focus on maize seeds have been limitations along with other challenges. Proponents of formal seed systems advocate several ways of making certified seed more affordable for men and women smallholders, for example, through increasing markets for certified seed, and regional harmonization and trade.

In Tanzania, public, certified seed production through ASA and direct supply by TARI have increased the affordability of certified seed. However, since formal seed systems still are criticized for providing unaffordable and poorly adapted seeds to smallholders, farmers' and intermediate seed systems offer alternative solutions, e.g., men and women farmer quality-controlled seeds from community banks, and QDS from cooperatives and other seed producer groups. Such initiatives aim to improve access to quality seeds for diverse crops and crop varieties both for men and women smallholder farmers.

In general, the same actors as mentioned in the previous two sections perceive intermediate and farmers' seed systems as being better options for addressing inequality and exclusion concerning seed access.

### Climate change

As with the global situation, African farmers have to adapt to the changing climate. Cultivar adjustment is seen as an effective strategy to do so, for example, through increased use of drought-resistant seed varieties [53]. Adapting to climate change can be seen both as an argument for formal seed systems – through breeding varieties better adapted to climate change – and for farmers' own selection of locally adapted planting material that can resist the adverse effects of climate change impacts. Climate change itself tends to call for increased production and productivity, as scarcity threats are associated with a changing climate. Due to African farmers only to a limited degree using formal seed systems, new initiatives championed by e.g., agro-ecological farming initiatives, are promoting the revival of orphan or neglected and underutilized crops. Such crops – native to Africa – are distributed across farming landscapes, often resulting in low yields due to almost no investment into research, development, and marketing of these; and yet, as bearers of stress tolerance, they might still be key to climate change adaptation. MAP meetings and key informant interviews revealed increased interest in adapted seeds in general due to climate change and the need for climate adaptation.

### Genetic diversity and farmers' rights

In SDG 2.5, the 2020 target was “to maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed” [13]. SDG 2.5 includes maintaining the genetic diversity of seeds, both in long-term conservation facilities, as well as by

monitoring the proportion of local varieties or landraces at risk of extinction [13]. The formal seed systems' breeding and supply of new varieties of staple crops (maize, rice, and wheat) are criticized for leading to erosion of agro-biodiversity, while farmers' seed systems are seen as a way of conserving local agro-biodiversity [54,55].

In Tanzania, seed sovereignty movements actively contest the national seed legislation that makes it criminal to sell uncertified seed and advocate the promotion and protection of domestic seed varieties, in order to promote agro-biodiversity. Such movements exist in the other two countries but are less visible there. Some NGOs, farmer organizations, and members of academia view the increased tendencies towards monopolies and corporate control over seed in formal seed systems as a threat both to agro-biodiversity and to farmers' rights.

Protecting farmers' rights is about the rights of farmers to save, use, exchange, and sell seed/planting material, as well as their need for recognition, protection of traditional knowledge, benefit-sharing, and participation in decision-making [14]. There are worries that seed policies and legislation will not recognize the rights of farmers as stated in the ITPGRFA, examples being the Tanzania 2014 Seed Act amendment to the Seed Act of 2003 which made the sale of uncertified seed illegal, and the Malawian Seed Act of 2022 that covers only the formal seed sector and thereby does not explicitly confirm farmers' rights. The same proponents as mentioned above, who promote intermediate and farmers' seed systems, are of the opinion that these seed systems will be the best options for securing genetic diversity and protecting the rights of farmers.

#### Seed systems development

After having assessed the expectations of different actors regarding seed systems outcomes and explored to what degree and how these expectations influence various actors in the type of seed systems they tend to promote, in this section we examine and compare the types of seed systems that exist in the three countries.

Farmers in Ethiopia, Malawi, and Tanzania to a large degree use their own farm-saved seeds and seeds from social networks [10,19,29]. Except for maize and some vegetables, farmers' seed systems are the main seed source used by smallholder farmers [56,57]. McGuire and Sperling [58] found that in six countries including five African countries among them Malawi, farmers obtained around 90 percent of their seed from farmers' seed systems, for over forty different crops.

Thus, in spite of decades of promoting formal seed systems, smallholder farmers, to a large degree, continue to rely on farmers' seed systems [2,59]. Accordingly, the seed systems in the three countries in this study consist of different blends of formal, intermediate, and farmers' seed systems, showing similarities and differences, as well as in-country variations across crops, locality, and time. In the following section, we compare the three national seed systems (in Ethiopia, Malawi, and Tanzania), which we categorize respectively as *pluralistic*, *dualistic*, and *pragmatic*, to illustrate the differences between the three countries.

#### Ethiopia: pluralistic seed systems

Ethiopian seed systems are based on the concept of *pluralism* that was coined and has been promoted by the Integrated Seed Sector Development (ISSD) program in Africa, supported by the Dutch Government [5]. Pluralistic seed systems imply that formal, intermediate, and farmers' seed systems are all recognized in policy documents, namely the Pluralistic Seed System Development Strategy [60] and the National Seed Policy from 2020. Seed producer cooperatives were established as an important mechanism to supply farmers with quality declared seeds, in addition to certified seed from the formal seed system provided by federal and regional seed enterprises and private seed companies. In spite of the adoption of a pluralistic seed system by the Ministry of Agriculture (MoA) in 2017, Ethiopian seed systems have been criticized for still being one-sided, in favor of the formal seed production and

supply system that is dominated by the public sector. This creates limited space for both the private sector and farmer-based seed production and supply systems [5]. With the recent home-grown economic reform program, discussions are continuing, with the aim of giving a more prominent role to the private sector in terms of seed supply. For instance, by adopting COMESA regional seed trade harmonization regulations, the 2020 National Seed Policy aims to incentivize national and international private seed companies [61]. Transforming the seed sector is seen by some actors as being pivotal in the modernization and commercialization of the Ethiopian agriculture sector [60,62]. However, due to the Covid-19 pandemic and the civil war in the country, seed systems reforms and agricultural sector transformation have been put on hold [63].

#### Malawi: dualistic seed systems

Malawian seed systems can be characterized as *dualistic*, including the government's focus on formal seed sector development, as well as reliance upon the private sector in terms of seed production and delivery [64,65]. However, the government recognizes that certified seeds provided by formal seed system are out of reach for many smallholders, and therefore, different subsidy programs, such as starter packs, the Farm Input Subsidy Program (FISP), and the Affordable Inputs Program (AIP), have made certified seeds more affordable and increased their use among smallholders [66,67]. The farmers' seed systems are supported through some NGOs, for example, in the form of community seed banks or direct seed distribution, with the condition of sharing harvested seed with neighbors. Malawian seed systems illustrate the duality between formal and farmers' seed systems, in that only the formal seed system is recognized in the agricultural policy, investment plan, and the 2022 Seed Act, yet both the formal and informal seed systems have strong proponents. The Civil Society Agriculture Network (CISANET) supports this Seed Act, while the Malawi Agrobiodiversity Network (MAGNET) was against the Act [68]. MAGNET's current strategy is not to defeat the 2022 Seed Act, but to work for the approval of an additional Seed Act that addresses *agro-biodiversity and farmers' rights*. The Government has signaled that such an additional Seed Act might be feasible. According to MAGNET, such a new Act could create a better balance between formal and farmers' seed systems as well as protect the farmers' rights to save, use, exchange, and sell their seed. In Malawi, there seems to be limited interest in ways of integrating seed systems or promoting intermediate seed system approaches such as QDS.

#### Tanzania: pragmatic seed systems

The Tanzanian seed legislation seems quite hostile towards the farmers' seed systems and e.g., farmers' rights to save, use, exchange, and sell seed [14]. However, in practice, the seed systems appear to function in a more pragmatic way than what the law indicates. The formal seed system does not only include seeds procured through private companies, but also through public institutions such as the Agricultural Seed Agency (ASA) and National Agricultural Research Institutions (TARI). Despite advice to stop public seed production in order not to compete with the private sector, the Government maintains ASA and signals the expansion of seed production through TARI. At the same time, seed harmonization in the region has been prioritized to fast-track seed variety release and make certified seed less costly; and the price of certified seed is monitored by the government with the aim of making it more affordable for farmers. The new 2020 QDS guidelines suggest that farmers' seed systems might be perceived in a more favorable way than what is stated in the seed law. The current wording in the seed legislation might have contributed towards awareness raising as a seed sovereignty movement has emerged that advocates the production and distribution of improved indigenous Tanzanian seed varieties, decreasing the dependency on trans-national seed companies, and not least, changing the Seed Act to legalize the farmers' right to sell uncertified seed. As an example of this movement, in 2015, the *Seed for Freedom* project started which promotes farmer-managed seed systems,

explains the challenges they face, and seeks opportunities for improvement – including removing policy barriers to farmers' rights, and policy advocacy [69]. Thus, in spite of the seed legislation, we find that Tanzania in practice has a rather pragmatic attitude towards including several different seed production and delivery approaches in a search for better seed systems that can improve access to quality seed for all farmers. Regarding the role of seed legislation, FAO—Commission on Genetic Resources for Food and Agriculture (CGRFA) [70] found no indication that commercialization of farmers' unregistered varieties/landraces was restricted through the implementation of seed laws except in some incidences regarding high-value crops such as soybeans and certain vegetables.

### Discussion: seed systems development to address multiple expectations

#### *Pluralism, dualism, and pragmatism*

Seed systems in Ethiopia, Malawi, and Tanzania have developed in somewhat different directions, although the type of actors that have influenced the seed development process, and their expectations of the seed systems appear to be quite similar in the three countries. Still, the seed systems, at least on paper, vary in the three countries. The Ethiopian case illustrates progressive pluralism recognizing formal, intermediate, and farmers' seed systems in policy documents; Malawi illustrates the duality between formal and farmers' seed systems only recognizing the formal seed system in their Seed Act; and Tanzania's case is in practical terms, rather pragmatic to several different approaches, but with the wording in an amendment to the Seed Act that makes the sale of uncertified seed illegal. Possible ways of explaining the differences among the seed systems could be that actor influence is not all that important; that politicians want to formulate their own national seed policy somewhat independent of e.g., international seed politics; or that regardless of what policy being formulated, politicians recognize that the farmers' seed systems will continue to be the most important source of seeds for a majority of smallholder farmers in their countries. However, despite the differences in national seed systems, the governments and policy documents in the three countries appear to favor the modernization of the agricultural sector and view formal seed systems by the private sector as an essential element of such a modernization strategy.

Politics and policy processes related to developing national seed systems might be viewed in two ways: (i) as governments in constant search of better seed systems that can provide quality seed to all farmers in accordance with the seed security shortcomings underlined by Almekinders et al. [1] and Sperling et al. [2]; or (ii) as a process in which the most influential and powerful actors get the seed systems of their preference [16,71,72]. The three countries in this study make use of various combinations of seed systems, but none appear to be able to secure sufficient seed access, as per seed security definitions. For example, Mulesa et al. [29] illustrate that in Ethiopia, "farmers are navigating between eroding farmers' seed systems and dysfunctional formal seed systems." Pertinent questions to ask regarding the effectiveness of the current seed systems relate both to governance and to what extent there might be better alternative seed systems [2-4,10,73-75].

Various actors advocate different models for seed systems development [2,17,18]. However, instead of respecting differences and appreciating complementary approaches, the trend has been unproductive competition and somewhat conflicted implementation processes [10,20]. In practice, seed material from formal seed systems is spreading through farmers' seed systems, as illustrated by Sperling et al. [76], who found that over 60 percent of yellow bean seed in farmers' seed systems in Tanzania came from improved varieties. Similarly, a study in Ethiopia traced 63 percent of maize seed in farmers' seed systems to CGIAR's improved varieties [77]. The dichotomy between formal and farmers'

seed systems might be changing as there is increasingly the view that there is not necessarily an 'either-or' option, but rather 'both', thus, underlining flexibility, integration, coexistence, and complementarities between systems [18,74,78].

#### *Expectations and exaggerations*

Proponents of formal seed systems appear to base their arguments on expectations relating firstly to closing the yield gap, secondly, adapting to climate change, and to a certain degree, contributing to healthy diets, for example, through biofortification. On the other hand, proponents of farmers' seed systems appear to emphasize protecting farmers' rights, promoting agro-biodiversity and equal access by gender and social groups, but also, to a certain degree, climate adaptation, and healthy diets. The expectations for outputs appear to be quite substantial, and the promises are difficult to live up to, as many studies have shown that access to quality seed is a significant challenge for African farmers [1,2,9,10,18]. Seed as a farm input is important for yield, food security, and income. However, farmers' harvests, income, and food security depend upon several other biophysical and socioeconomic factors, besides access to quality seeds, such as soil fertility, fertilizer use, rainfall, pest management, access to land, access to labor, access to markets, farm gate prices, social and gender equality, and the possible impact of different kinds of conflicts.

The expectation of closing the yield gap through formal seed systems covers several aspects: (i) trust, stability in delivery and affordability of certified seed in relation to profitability of farming [19]; (ii) how to address the problem of access to land and shrinking farm size [79]; (iii) the ability to meet diverse seed demands, instead of promoting only a few crops [18]; (iv) the feminization of agriculture, gender inequality and limited labor availability [80–82]; and (v) farmers' rights and social inclusion, which are often overlooked in relation to seed access [15,18].

Proponents of both formal seed systems and farmers' seed systems appear to overstate the expected outcomes, as claimed by the theory of Borup et al. [33] that expectations about the future tend to be exaggerated and rarely live up to indicated predictions. Despite 50 years of promoting a technology-based, green revolution narrative in sub-Saharan Africa, based on using chemical fertilizers and certified seeds from the formal seed sector, the results have so far not lived up to expectations [9,83]. On the other hand, the narrative of farmers' seed systems being *the solution* might as well have difficulties living up to expectations considering the rural food insecurity and poverty situation in sub-Saharan Africa [22,84].

Seed initiatives funded by donors come with demands of delivering quick results that might lead to exaggerations and competition in seeking to own the dominant narrative and secure future funding [34,35]. Expectations relating to seed systems outcomes appear to influence the actors not only in the types of seed systems they are promoting but also in the type of agri-food system development model they support. In spite of limited results, powerful international actors promote the technology-based green revolution narrative in Africa based on farm inputs provided by the private sector, and a one-size-fits-all narrative, without recognizing the political economy of agricultural development [9,83]. In such a technological and political economy setting, navigating the multiple dimensions of seed systems development to promote access and prosperity puts tall demands on country-level governance.

### Conclusion

In this study, we assessed how multiple expectations of seed systems outcomes – such as closing the yield gap, adapting to climate change, improving nutrition, ensuring equality, enhancing agro-biodiversity, and securing farmers' rights influence different actors in the type of seed systems they promote in Ethiopia, Malawi, and Tanzania. Despite the same categories of actors providing quite similar influence at country levels, the national seed systems have developed in different

directions into approaches that can be characterized as pluralism in Ethiopia, dualism in Malawi, and pragmatism in Tanzania. This finding might indicate that various actors' influences on the direction of seed systems development could be less important than what we assumed. At the same time, expectations relating to seed systems outcomes are shaped by competition to receive economic and political support to influence policies and laws. We conclude that seed systems development must address different needs for different crops in different agroecologies and for different groups of farmers. To achieve this, different approaches are needed to harness the strengths of both formal and farmers' seed systems.

### Author contributions

All authors have read and agreed to the published version of the manuscript.

### CRedit authorship contribution statement

**Ruth Haug:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Joseph P. Hella:** Methodology, Formal analysis, Writing – review & editing. **Teshome Hunduma Mulesa:** Conceptualization, Methodology, Formal analysis, Writing – review & editing. **Mayamiko Nathaniel Kakwera:** Methodology, Formal analysis, Writing – review & editing. **Ola Tveitereid Westengen:** Conceptualization, Formal analysis, Writing – review & editing, Project administration, Funding acquisition.

### Declaration of Competing Interest

None.

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