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Pros and Cons of Seed Reserves in Ethiopia

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Feed the Future Consortium Partners in the Feed the Future Global Supporting Seed Systems for Development activity:

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Abbreviations and Acronyms

AGRA	Alliance for a Green Revolution in Africa
ARARI	Amhara Regional Agricultural Research Institute
ASE	Amhara Seed Enterprise
BHA	Bureau of Humanitarian Assistance
BoA	Bureau of Agriculture
BMGF	Bill and Melinda Gates Foundation
CGIAR	Consultative Group on International Agricultural Research
CRS	Catholic Relief Services
CSO	Civil society organization
EABC	Ethiopian Agricultural Business Corporation
EIAR	Ethiopian Institute of Agricultural Research
EOSA	Ethio Organic Seed Action
FAO	Food and Agricultural Organization
FGD	Focus group discussion
GoE	Government of Ethiopia
International	International
IQQO	Oromia Agricultural Research Institute
KII	Key informant interview
MoA	Ministry of Agriculture
NDRMC	National Disaster Risk Management Commission
NGO	Non-governmental organization
OSE	Oromia Seed Enterprise
PPB	Participatory plant breeding
PVS	Participatory varietal selection
QDS	Quality-declared seed
RARI	Regional Agricultural Research Institutes
REST	Relief Society of Tigray
S34D	Supporting Seed Systems for Development
SARI	Southern Agricultural Research Institute
SNNPR	South Nations, Nationalities and Peoples Region
SPC	Seed producer cooperative
SSE	South seed enterprise
SSR	Strategic seed reserve
TARI	Tigray Agricultural Research Institute
UN	United Nations
UNDP	United National Development Programme
USAID	United States Agency for International Development

Executive Summary

Recurrent droughts in Ethiopia dating back to 1974 have led to hundreds of million dollars in foreign emergency aid. The Government of Ethiopia (GoE) has thus considered establishing a national seed emergency system and complementary national emergency seed reserve strategy to (1) more effectively respond to emergencies caused by disasters, (2) enable the application of effective responses to specific seed security constraints by relevant stakeholders, and (3) improve the effectiveness and sustainability of existing seed emergency programs organized by the non-governmental organization (NGO) community. Through this study, Feed the Future Global Supporting Seed Systems for Development (S34D) seeks to examine and disseminate findings related to the pros and cons of developing and maintaining seed reserves, and to propose a path forward that would enhance proactive action.

This report draws upon key informant interviews and focus group discussions with Ethiopian and international stakeholders, as well as current literature, to better understand (1) how stakeholders define, compare, and contrast seed reserves and seed banks, (2) factors that necessitate the establishment and operationalization of seed reserves, (3) potential budget and implementation entities, (4) location(s), supply chain and maintenance considerations, risks and mitigation strategies, and other factors associated with seed reserve establishment and operationalization, and (5) related international experiences.

Findings illustrate that both Ethiopian and international respondents have differing definitions for both seed reserves and seed banks, often with a lack of clear distinction between the two. Despite the muddled definitions of these terms, respondents identified key differences between reserves and banks, namely surrounding their purpose, duration of storage, diversity of crops, infrastructure requirements and costs, users, management, and sustainability. Ethiopian respondents indicated that the primary functions of seed reserves are to serve as sources of seed in periods of difficulty and to narrow seed supply and demand gaps, the primary benefit of seed reserves is to create local access to seed and planting materials, and the principle factors that necessitate the establishment of seed reserves are primarily climate-driven (e.g., drought, floods, and disease). Most Ethiopian respondents suggested that the NDRMC/MoA lead and manage the establishment, organization, operation, storage, maintenance, and transport associated with seed reserves, and that public seed enterprises should establish, organize, and operate seed reserves. Several types of entities were suggested as budget sources for the establishment and maintenance of seed reserves, particularly NGOs/CSOs and government organizations. The majority of Ethiopian respondents favoured some kind of decentralized seed reserve system, particularly arranged at the regional level. In terms of geographic location, cool highland areas are preferred by most respondents due to their favourable conditions for effective seed storage. Primary capacity building needs for seed reserves include storage and associated facilities. Ethiopian respondents tended to prefer that reserved seed primarily be used for disasters and shortages and disposed of through sales outside of the community. Primary risks identified by the study include both poor storage conditions and loss of seed germination and viability. Several recommendations are made based on the findings presented in the study, which are as follows:

1. Given that costliness is a key challenge of seed reserve establishment, operationalization, and sustainability, community seed banks are preferred.
2. Community seed reserves and banks should integrate market-oriented seed production – in addition to conservation, seed selection, seed multiplication, seed use, and seed exchange – not only during and after periods of disaster but also in times of stability to promote sustainable outcomes.
3. To foster resiliency, seed systems should be supported and strengthened through (1) the decentralization of seed system support, (2) the promotion of various conservation strategies, (3) the empowerment of individuals and communities to produce and use their preferred crops and varieties, (4) awareness creation, training, and material support to strengthen local seed storage structures, (5) market-oriented support of community-based seed production, and (6) the development of local crop variety value chains.

1. Background

Ethiopia has been witnessing severe recurrent droughts since 1974, leading to hundreds of million dollars in foreign emergency aid (Mera, 2018). As a result, Ethiopia has considered establishing a national seed emergency system to respond to emergencies caused by disasters more effectively, along with a complementary national emergency seed reserve strategy that presents a pathway for creating and maintaining seed reserves. This would enable the application of effective responses to specific seed security constraints by government and non-government organizations as well as other development projects. The strategy would also include approaches that aim to improve the effectiveness and sustainability of existing seed emergency programs organized by the non-governmental organization (NGO) community.

2. Objective of the study

The objectives of the study are to: (1) determine the pros and cons of developing and maintaining seed reserves, (2) disseminate findings to the Government of Ethiopia (GoE) and other relevant stakeholders, and (3) propose a way forward to enhance proactive action.

3. Method/Approach

First, a literature review was conducted to gain insight about seed reserves, including why, how, where and under what conditions seed reserves are used. An empirical study was then undertaken, using a survey questionnaire. After developing checklists (i.e., closed, and open-ended), data were collected using face-to-face focus group discussions (FGD) and key informant interviews (KII), as well as remote means of communication (i.e., emails and telephone calls). The data collection process involved pertinent government organizations, such as the Ministry of Agriculture (MoA) and its affiliated institutions, Ethiopian Biodiversity Institute, four regional bureaus of agriculture (i.e., Amhara, Oromia, Sidama and Southern Nations, Nationalities and Peoples Region SNNPR) and their affiliated institutions, federal and regional research institutions, public and private seed companies, two community seed banks in Oromia, one seed producer cooperative, UN-Organizations (e.g., the Food and Agricultural Organization (FAO)/Ethiopia), and NGOs that are often involved in emergency seed aid in Ethiopia, as well as experts that have led seed provision in the country, including emergency seed aid. Also, an email questionnaire allowed for the collection of information from international professionals in the area of seed reserves/banks, seed security and seed systems, including emergency seed, so as to reflect on the pros and cons of developing and maintaining seed reserves. A total of 38 individuals were contacted, including 30 stakeholders from within Ethiopia and 8 international professionals, and the proportion of respondents exceeded 80%.

Key findings and discussion

Key findings are presented and discussed in the subsequent sections and subsections.

3.1 Definitions

During the study, it became apparent that the involved respondents have differing definitions for both seed reserves and seed banks, often with a lack of clear distinction between the two terms. Their consolidated definitions for each term are provided below.

3.1.1 Seed reserve

Seed reserve is defined by Respondent #3 as "a national strategy to produce and manage a central certified seed stock of improved varieties by the government to address acute shortages of seed during emergency situations that result from natural and/or man-made disasters. It refers to the maintenance and management of carry-over certified seed stocks and rapid responses to overcome any shortfall in seed supply due to crop failures or emergencies." Likewise, Respondent #1 defined seed reserves as, "seed

stock meant for distribution through various means, including sale." Respondent #24 provided a more elaborative description of seed reserve, which reads as: "any seed (improved and/or local cultivar) stored under good condition for future use as seed. It can be used during seed shortages created by natural or man-made disasters (e.g., after war, drought etc.). It can also be used to cover early seed demand of the farmers in the season/off the season, which comes before the seed produced for the year/season is not ready for the market and to cover the gap between the demand and supply, even in normal (good) years. However, it must be managed by people/institutions knowledgeable of seed. Otherwise, it may be disastrous. For example, it may cause issues related to the adaptation and performance of the varieties/cultivars, germination etc."

As opposed to Respondent #24, who recognizes both improved and traditional seed, Respondent #7 viewed seed reserves as only commercial seed, defining them as, "mechanisms by which a certain portion of commercial seed is reserved by the end of major planting seasons for emergency purposes to mitigate problems arising from lack of planting materials in cases of natural or man-made disasters."

Respondent #8 attempted to define seed reserve from a strategic point of view, stating that "a strategic seed reserve (SSR) is a seed stock that is planned for use during periods of seed insecurity and serves as an insurance against seed shortfalls following disasters and their negative impacts (e.g., drought, flood, pest damage, hailstones, etc.). SSRs consider the present and foreseeable future production and seed use by farming and agropastoral communities. They can be designed to address seed insecurity at national, regional, woreda, and community levels as one of the tools of seed policy to address seed system security problems during and after disasters/shocks."

Many respondents have attempted to define seed reserve from why and how the seed is stored or maintained and for what purposes such seeds are used. Invariably, they have indicated that a seed reserve is seed stored, maintained, or kept for a short or long period of time as a means of seed security insurance during and following natural and man-made disasters (e.g., droughts, floods, hail stones, pest and disease outbreaks, fire, conflict, war, etc.), as well as for chronic poverty (Tripp, 2006).

Few respondents (#2, 4, 6, 7 and 22) indicated that seed reserves can be maintained to save genetic resources for future use, thus suggesting that most viewed seed reserves as seed maintained/stored particularly for trying times such as biotic and/or abiotic stresses; loss of market access due to conflicts etc.

Recent developments have revealed that supporting and strengthening local seed systems (e.g., through community seed banks) is more useful than direct seed distribution when a need for emergency seed aid arises (Longley et al, 2002; Remington et al., 2002; FAO, 2004, 2016; Sperling, L., 2008; Sperling et al., 2022). These authorities suggest that even in the case of major disasters (such as a severe drought), grain appropriate for seed is available through select farmers or traders, and the donor should seek to stimulate local trade. In such circumstances, support should center around providing seed vouchers or cash and organizing seed fairs and seed exhibitions, so that needy farmers can purchase seed varieties already adapted to their localities.

3.1.2 Seed bank

According to Respondent #1, seed bank is defined as, "a localized system that maintains crop diversity and provides access to seeds of diverse crop varieties." An expanded but similar perspective was provided by Respondent #3, who stated that seed banks are "local level strategies to produce and maintain seed stocks of local landraces by the community or NGOs with a focus on conservation and use of available crop diversity for sustainable local food production. It often extends as a mechanism for overcoming chronic shortage of seed due to poverty or lack of access to seed for planting." The remaining respondents defined seed bank through the lens of genetic resource conservation. Some of the

respondents in this category have specified whether the conservation is ex situ[1] (e.g., Respondents #2, 5, 7, 10, 13, 20, 21 and 22) and in situ[2] (e.g., 13, 16, 17 and 18), while the remaining respondents provided more generalized definitions.

All respondents viewed seed reserves as seed kept for periods of hardship and seed banks as seed and genetic resources maintained for the purposes of conservation and crop breeding. These results contrasted with findings from some of our international respondents and the existing body of literature, where distinctions between the two terms are not clear enough (e.g., Feyissa, 2000; Vernooy et al., 2015). The difference arises because of the way the term 'seed reserve' was framed in this study (i.e., 'seed reserve proper', which is kept in store as a proactive means to respond to seed insecurity arising because of disasters). Except for carry-over seed that may be kept by seed companies and maintenance of early generation seeds by breeders (ATA/MoA, 2017; Respondent #3), there is limited or no evidence for seed reserve proper (International Respondent #7) as framed in this study. Rather, both seed reserves and seed banks, particularly when qualified as community seed reserves and/or community seed banks, refer to a broad range of activities, including conservation of diversity, indigenous knowledge, practices, and information, as well as seed selection, seed multiplication, seed use, and exchange. Such seeds are produced from local/farmer varieties and improved ones and used during and post disasters and normal conditions. Also, when the activity of seed reserves/banks involves both community and researchers from research institutions and academia, the local/farmer varieties are improved through participatory plant breeding (PPB) and participatory variety selection (PVS) (Vernooy et al., 2017a; Vernooy R. et al., 2020).

3.2 Similarities and differences between seed reserves and seed banks

A total of 31 respondents have compared and contrasted seed reserves and seed banks. A summary is presented in **Table 1**.

As was illustrated both in respondents' answers and the literature review (Worede, 1991, 1992; Lewis and Mulvany, 1997, Feyissa et al., 2013; Sperling et al., 2004, 2008; Tsegaye and Feyissa, 2017; and Vernooy et al., 2016), the boundary between seed reserves and seed banks is not clear, especially when both are qualified as community seed reserves and community seed banks. However, national governments can consider SSRs to meet seed requirements at the time of seed shortage, mostly triggered by disasters and other conditions (Ministry of Agriculture & Farmers Welfare, Government of India (2016). However, to the best of our information, there is no evidence for the success of this SSR plan. As noted by International Respondent #1, it is government policy without actionable plan on the ground.

[1] Maintenance of diverse plant genetic resources off-farm, such as in gene bank building at different temperature and relative humidity regimes or ordinary store for short-, medium and log-terms or orchards/field gene banks for species having recalcitrant seeds and clonally propagated). It is largely for conservation purposes.

[2] Maintenance of diverse plant genetic resources on-farm for the immediate, short-, medium- and long-term. When managed by community at local level, it is equally used for planting and for conservation purposes.

Table 1. Similarities and differences between seed reserves and seed banks

Parameter	Seed Reserve	Seed bank
Purpose	Maintain seed & propagating materials for future use (anticipating disaster)	Maintain seed & propagating materials for future use (both in periods of stability and hardship)
Genetic material handled	Improved varieties & landraces (i.e., farmers or traditional varieties)	Landraces (i.e., farmers or traditional varieties) & improved varieties
Maintenance of seed viability & germination	Required	Required
Safety/secure storage	Requires safe & secure storage	Requires safe & secure storage
Focus	Bad time (natural & human-made disasters)	Conservation & use (both bad & normal time)
Maintenance & storage duration	Immediate (1-2), & short-term (3-5 seasons)	Short-, medium-, & long-term
Scale of operation	Community & network of communities	Community, national, regional & global
Volume of seed stored	Relatively large for most crops (i.e., first generation certified seed C1)	Relatively small for most crops
Diversity	Relatively low; more of a commodity-oriented setup	Relatively large
Infrastructure requirements	Relatively simple	Relatively sophisticated
Cost (establishment, maintenance & operation)	Relatively low	Relatively high
Immediate users	Often farmers	Often breeders & farmers
Management	Performed at individual farmer, breeder, community & institutional/government level	Managed by the community & government institutions; involves both in situ and ex situ conservation
Sustainability	Both plagued with low level of functionality and cost effectiveness	

3.3 Functions and benefits of seed reserves

A seed reserve function refers to its services and features, while a seed reserve benefit refers to its positive impact on intended customers, particularly smallholder farmers.

3.3.1 Functions of seed reserves

Seed reserves have several purposes (**Figure 1**). The two most dominant functions of seed reserves are to serve as a source of seed in a bad year (21/23 effective respondents) and to narrow the gap between seed demand and supply (19/23 effective respondents). When seed reserves are handled by communities (also known as community seed reserves/community seed banks), the involved farmers can generate income from seed production for sale and/or exchange, which ranks as a third in this study. This supports the proposal by many professionals to strengthen the local seed system (i.e., informal, formal, and integrated seed systems), instead of direct seed distribution (Shrestha, 2019; Sperling et al, 2022). The strengthening of the local seed systems could be supported by organizing seed fairs/exhibitions and provision of cash for seed (Sperling et al, 2022). Other noteworthy functions of seed reserves/banks include the maintenance of landraces (i.e., farmer varieties); preservation of genetic diversity for future use; collection, production, distribution, and exchange of seeds among community members; in situ conservation of agrobiodiversity; and maintenance and exchange of traditional knowledge with regard to seed selection,

production, storage, and use of agrobiodiversity. These findings support the reports of Vernooy et al. (2015a, 2015b), who have been advocating the importance of community seed banks.

On the other hand, Respondent #3 contended that most of the questions in the study questionnaire were related to community gene bank issues rather than to seed reserve issues. This assertion, though viewed from different perspectives, seems true only from an SSR point of view, where certified seed is meant to be centrally reserved and distributed. Evidently, such approach is not sustainable (Sperling et al, 2022; Vernooy et al., 2020). Instead, efforts are needed to strengthen community seed reserves/banks, where local communities are supported to conserve, select, produce, and use seeds. When local seed systems are strengthened, farmers rely on access to seeds from both formal and informal seed systems (Makate et al., 2022), with minimal direct seed distribution even at the time of emergency, contributing to ecological and economic sustainability, in addition to several other advantages.

Our findings lend support to the works of Porcuna-Ferrer (2018), who reported that the main objective of community seed reserves is the provision of seeds for local use, strengthening local systems of seeds and support for conservation of agrobiodiversity in-situ.

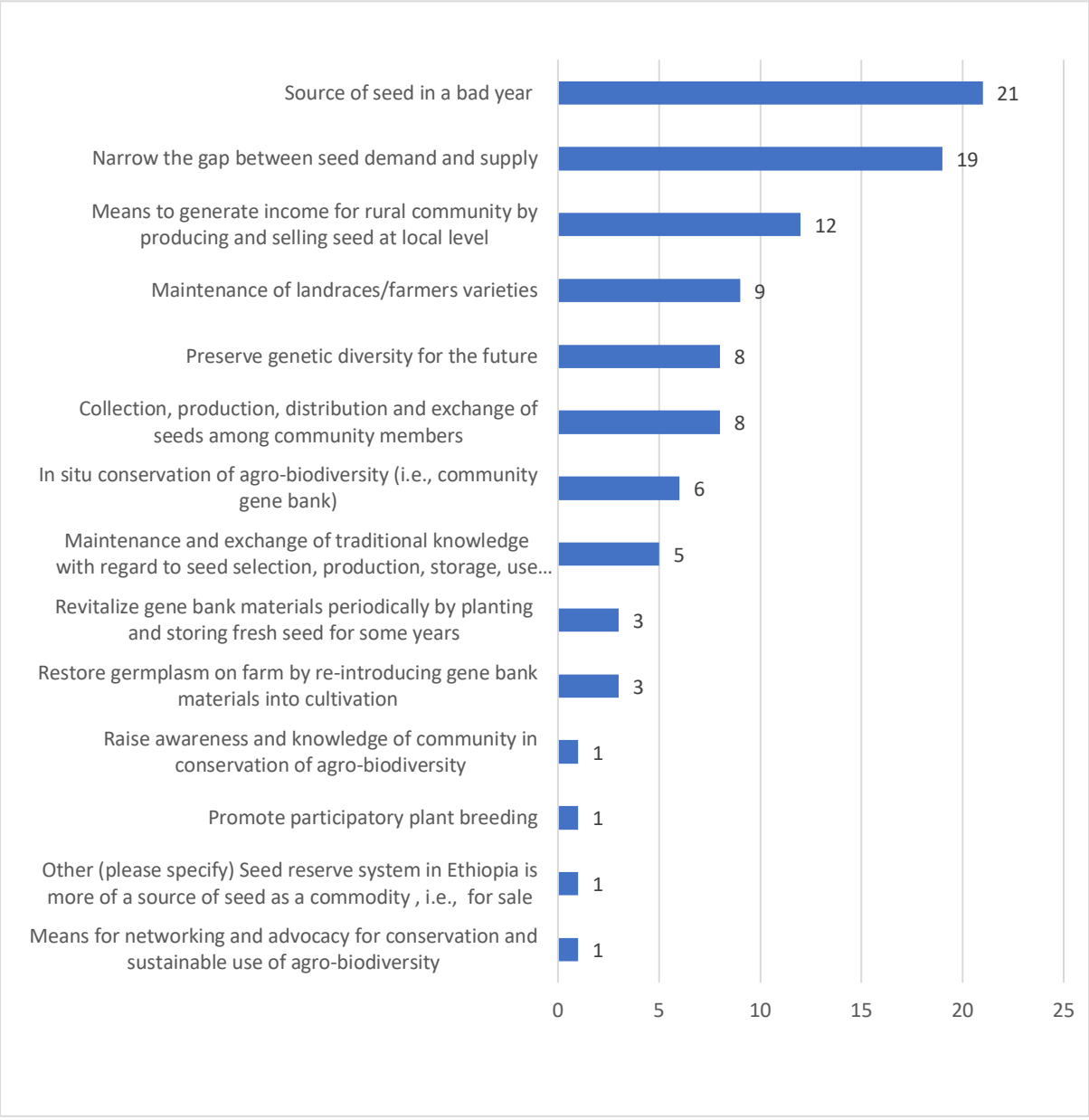

Figure 1. Functions of seed reserve based on 23 respondents

3.3.2 Benefits of seed reserves

The major benefits of seed reserves (**Figure 2**) include: (1) creating access to seed and planting materials at the local level; (2) promoting rural entrepreneurship when seed reserves are sold, distributed and exchanged for profit; (3) promoting community resilience via diversity; (4) creating employment opportunities; (4) contributing to the maintenance of agro-diversity, & thereby mitigating the loss of genetic resources; and (5) increasing rural innovation.

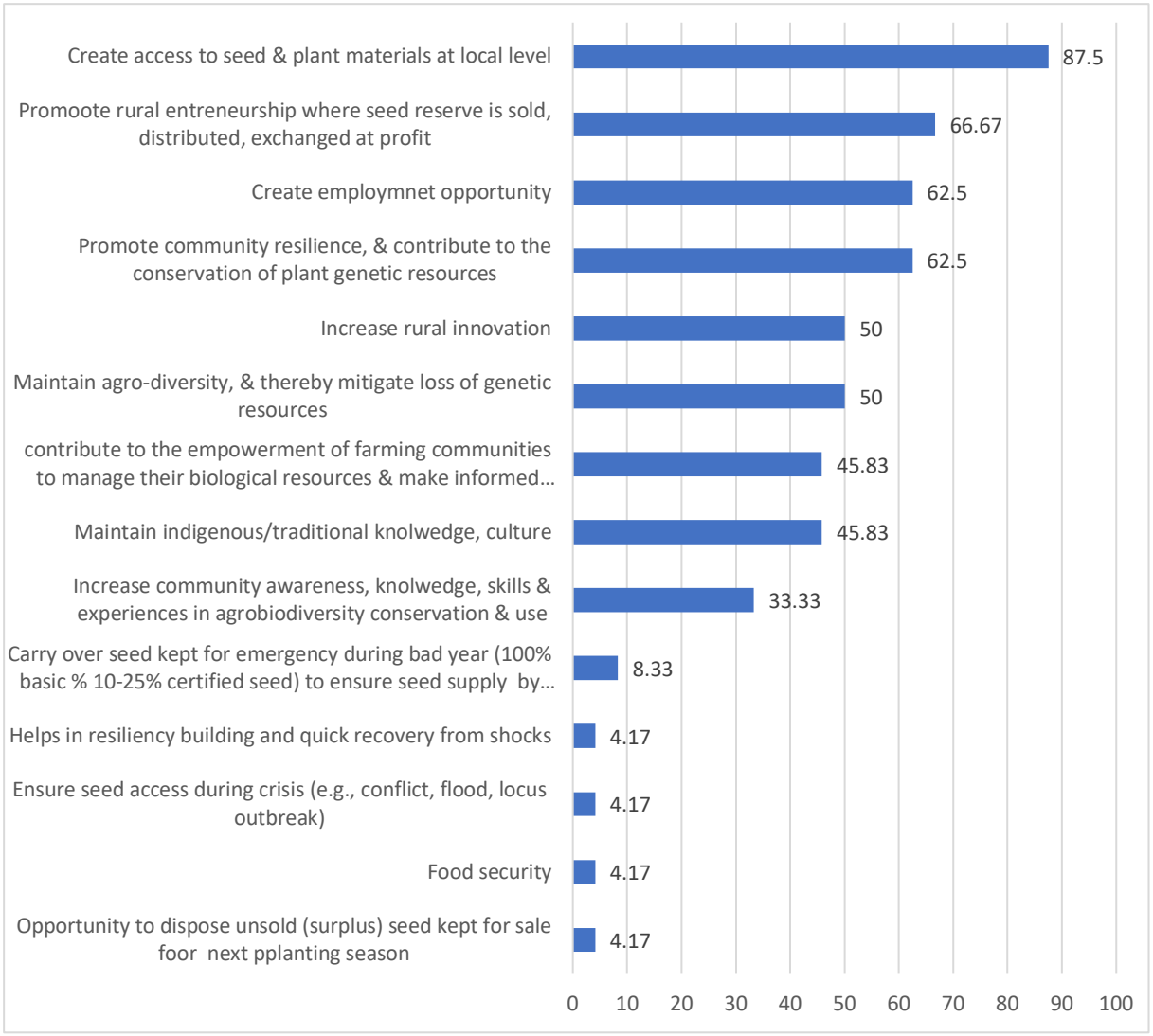

Figure 2. Benefits of seed reserves (% respondents)

3.4 Factors necessitating establishment, organization and operation of seed reserves

There are several disasters and certain positive factors that necessitate the establishment, organization, and operation of seed reserves (**Figure 3**). Droughts, floods, incidences of pests and diseases, and social conflict/war were identified by respondents as primary negative factors necessitating the establishment, organization, and operation of seed reserves. The maintenance of indigenous or traditional knowledge associated with seed selection, production, storage, use, and exchange was identified as a primary positive factor by respondents and is closely followed by conservation of agrobiodiversity. It is interesting that similar benefits of community seed reserves/banks have been reported across different contexts (e.g., India, Nepal, Uganda, and Zimbabwe) (Oxfam International, 2016; Vernooy et al., 2017b; Vernooy et al., 2019).

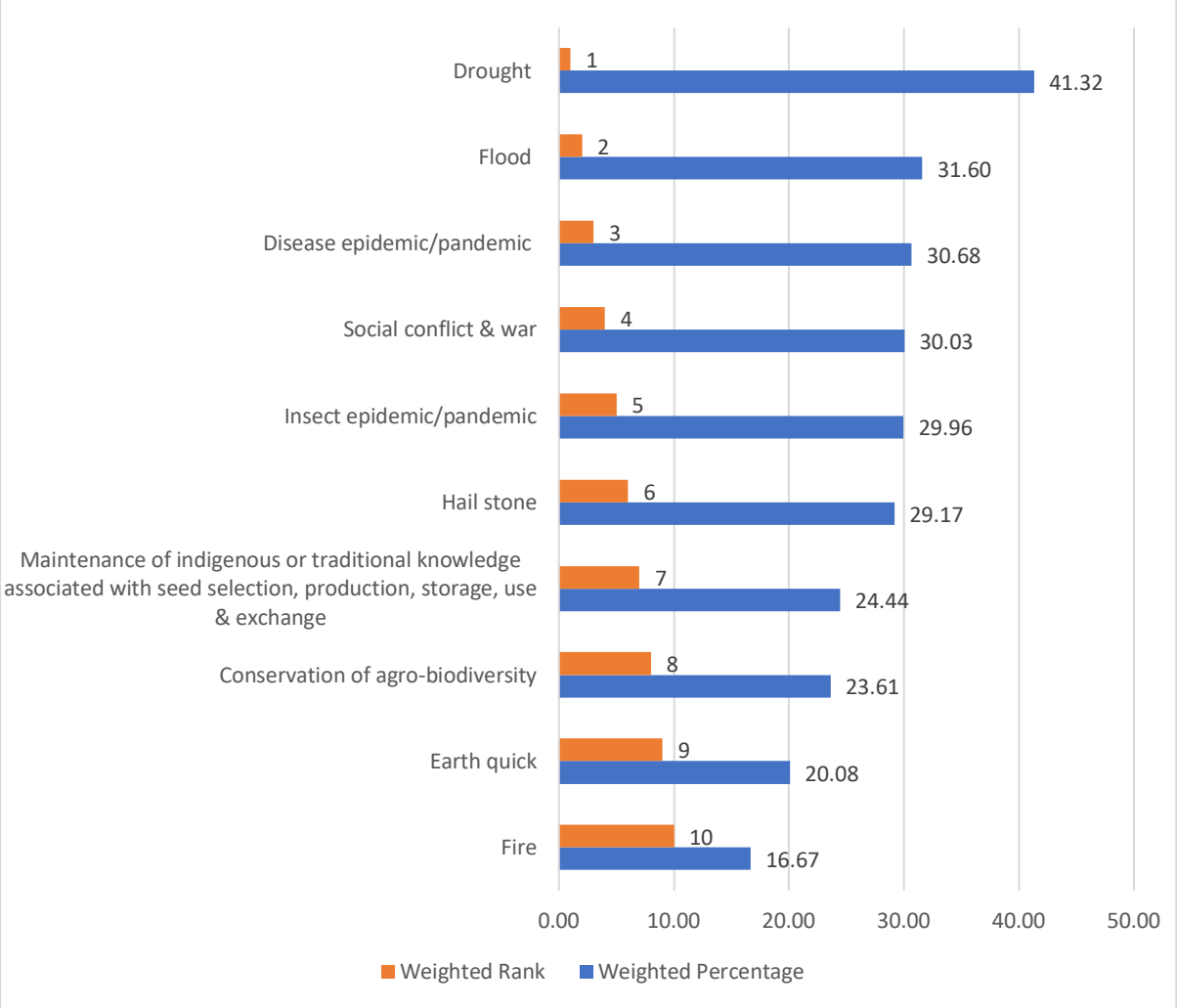

Figure 3. Factors necessitating establishment, organization, and operation of seed reserves.

3.5 Lead, manage, establish, organize, operate, store, maintain, and transport seed reserves

For this section and sub-sections, certain respondents preferred to give general remarks rather than answering individual questions. For instance, Respondent #24 proposed that MOA, National Disaster Risk Management Commission of Ethiopia (NDRMC), public seed companies, unions, interested NGOs, and research institutions – including the Ethiopian Biodiversity Institute – must discuss and build consensus around which activities should be undertaken by which institution, depending on their strengths and experiences. Respondent #24 went further in adding that seed reserves may require considerable budgets for the establishment of infrastructure and other costs, and to maintain it sustainably. Hence, cost benefit analyses must be conducted prior to operationalizing/starting this initiative. NGOs who are willing to engage in topics surrounding existing seed challenges must closely work with local government institutions, particularly with local public seed companies because inappropriate seed distribution due to knowledge limitations may negatively impact millions of peasant farmers' lives and the country (International Respondent #1, International Respondent #7).

3.5.1 Leadership and management in the establishment, organization, and operation of seed reserves

Many respondents proposed that the NDRMC/MoA should lead and manage the establishment, organization, and operation of seed reserves. Respondent #4 added that the newly established Ministry of

Irrigation and Lowlands may be a good option since the lowlands of Ethiopia are often prone to natural disasters such as drought. Most respondents proposed more public organizations than private or public-private partnerships for the leadership and management of such initiatives. Respondent #3 remarked that private sector investment in seed reserves is doubtful.

Table 2. Potential entities to lead and manage the establishment, organization, and operation of seed reserves

Entity	Frequency of responses (n=24)
NDRMC, MoA	17
Crop Production State Minister, MoA	14
Public seed enterprises (EABC, OSE, ASE, SSE)	12
EIAR, Crop Research Program	11
Private sector	11
EIAR, Technology Multiplication & Centre Development Directorate	10
Public-private partnership	10
Ethiopian Biodiversity Institute, MoA)	9
Regional BoA, Agricultural Inputs Directorate	9
Agricultural Inputs and Outputs Marketing State Minister, MoA	8
Regional BoA, Crop Production Directorate	8
Ethiopian Agriculture Authority, MoA	7
NGO/CSO	5
RARI (ARARI, IQQO, SARI, TARI), Crop Research Program	4
RARI (ARARI, IQQO, SARI, TARI), Technology Multiplication & Centre Development Directorate	4
Other: Ministry of Irrigation and Lowlands	1

3.5.2 Establishment, organization, and operation of seed reserves

Public organizations are also favored for the establishment, organization, and operation of seed reserves, with the highest score for public seed enterprises (**Table 3**).

Table 3. Potential entities for the establishment, organization, and operation of seed reserves

Entity	Frequency of responses (n=24)
Public seed enterprises (EABC, OSE, ASE, SSE)	24
Public-private partnership	23
Private sector	21
Crop Production State Minister, MoA	21
Agricultural Inputs and Outputs Marketing State Minister, MoA	20
NDRMC, MoA	21
Ethiopian Agriculture Authority, MoA	11
Ethiopian Biodiversity Institute (affiliated to MoA)	13
Regional BoA, Crop Production Directorate	16
Regional BoA, Agricultural Inputs Directorate	20
EIAR, Crop Research Program	21
EIAR, Technology Multiplication & Centre Development Directorate	21
RARI (ARARI, IQQO, SARI, TARI), Crop Research Program	19
RARI (ARARI, IQQO, SARI, TARI), Technology Multiplication & Centre Development Directorate	19
NGO/CSO	18
Other: Ministry of Irrigation and Lowlands	10
Establish a responsible national institute with mandate to do seed reserve	2

3.5.3 Storage, maintenance and transportation of seed reserves

Table 4 further illustrates that the different public organizations play greater roles in the storage, maintenance, and transportation of seed reserves.

Table 4. Potential entities for the storage, maintenance, and transport of reserve seed

Entity	Frequency of responses (n=24)
NDRMC, MoA	23
Ethiopian Agriculture Authority, MoA	23
Regional BoA, Agricultural Inputs Directorate	23
EIAR, Crop Research Program	23
Public seed enterprises (EABC, OSE, ASE, SSE)	23
Private sector	23
Public-private partnership	23
EIAR, Technology Multiplication & Centre Development Directorate	22
RARI (ARARI, IQQO, SARI, TARI), Crop Research Program	22
Agricultural Inputs and Outputs Marketing State Minister, MoA	21
Ethiopian Biodiversity Institute, MoA)	20
RARI (ARARI, IQQO, SARI, TARI), Technology Multiplication & Centre Development Directorate	19
NGO/CSO	17
Crop Production State Minister, MoA	16
Regional BoA, Crop Production Directorate	14
Other: Establish new independent organization	1

Results illustrate that public entities are favored over private and public-private sector entities for the leadership, management, and operation of seed reserves and banks. However, community engagement in seed reserves/seed banks could be market-oriented through the collective action of community members, as evidenced by efforts in Nepal, South Africa, Uganda, Zimbabwe (Oxfam International 2016; Mokoena et al., 2019; Vernooy et al., 2020).

3.6 Expected budget sources for establishing and maintaining an effective seed reserve system in Ethiopia

Annex 1 presents government and non-government organizations that are considered as potential sources for establishing and maintaining an effective seed reserve system. Respondent #3 doubts if any private sector is interested in funding seeds reserve beyond maintaining their seed stock, which supports the very lean list of private institutions in Table 3. Certain respondents listed farmer cooperatives and primary seed producer cooperatives to engage in community seed reserves/banks, especially for commercial oriented seed production. Often seed producer cooperatives have dual roles, i.e., serving communities from which their members are drawn and making reasonable amount of profit to sustain seed production (Sisay et al., 2017), and such cooperatives are known to receive support from government organizations, NGOs, and development projects. In the present study, no respondent proposed public-private partnerships to fund the establishment and operation of seed reserves, though Respondent #19 (KII) and members of Bora Dambel Seed Union expressed that old improved varieties (bread wheat, e.g., Hawi; teff, e.g., Cr307) and traditional varieties (e.g., Marrie and red varieties of chickpea, black barley, and black durum wheat varieties) are fetching premium price, albeit on a small scale. Incorporating market-oriented seed and grain production in the activities of seed reserves would contribute to financial sustainability by exploiting niche market at local level and for industries as well. Many reports have indicated that NGOs such as Ethio-Organic Seed Action (EOSA), SeedChange, Norwegian Development Fund, CARE/Ethiopia, REST/Tigray, CRS through the local Catholic Secretariat office, Self Help Africa, Oxfam, Farm Africa, MELCA-Ethiopia, World Vision, Goal/Ethiopia, and Mercy Corps have contributed to community seed banks for the purposes of

ensuring local seed security and conservation of agrobiodiversity (Development Fund, 2011; Feyissa, 2007, 20012; Feyissa et al., 2017; Worede, 2011). Most of these NGOs, the UN-organizations such as FAO, and the UN Development Program (UNDP) and development partners have directly or indirectly contributed to community seed reserves/banks as well as greatly to emergency seed aid in Ethiopia (Development Fund, 2011; Feyissa, 2007, 20012; Feyissa et al., 2017; Worede, 2011).

3.7 Where to establish and operationalize seed reserves

3.7.1 Centralized vs. decentralized seed reserves

A decentralized seed reserve system is favored by 60.87% of the effective respondents (**Table 5**). The main reasons for a decentralized seed reserve system include: (1) crop production and seed systems in Ethiopia are diverse; therefore, challenges and potential interventions vary spatially and temporally (Respondent #1); (2) the operationalization of seed reserves are better handled at the regional level, taking into account cross-regional clusters of zones with moisture stress than targeting each zone/woreda/kebele level in each region (e.g., adjoining lowlands with moisture stress from different regions) (Respondent #3); and (3) to enable the ease of management at a regional level, the use of the right warehouse and other resources, risk minimization, and commodity-based seed storage based on the potential crop produced across different regions (Respondents #4, 6, and 23).

Table 5. Seed reserve system centralization preferences

Category	Sub-category	Frequency (N=23)	Percentage (%)
Centralized	Federal	9	39.13
Decentralized	Region	10	43.48
	Zone	2	8.70
	Kebele	0	0.00
	Drought/emergency prone areas	1	4.35
	Cool areas (temperature)	1	4.35
Total respondents		**23**	**100.00**

Those respondents who favored a centralized seed reserve system have reasoned that: (1) maintaining the national seed reserve is a costly operation, as centralized planning and coordination is required to save on costs and meet the national needs most effectively (Respondent #3); (2) a large portion of the seed should be reserved through a centralized system to reach all needy citizens fairly and ensure reasonable quantities are available at the regional level (Respondent #9); (3) sustainability would be ensured, as need varies from region to region and more resources (e.g., infrastructure) are available at the federal level (Respondents #11, 12, 13, 16, 17, 19, 22, & 23). Respondent #3 went further in elaborating that, "If the reserve is for local cultivars/landraces, the reserve can be at the woreda or zonal level, where good storage facilities can be constructed and maintained sustainably. Also, the work must focus only in the areas where it is needed, for example, in drought affected areas. The reserve can be at zonal level if the majority of the zone is frequently facing the problem but, if few districts of the zone are facing the problem frequently, the reserve can be at district level. It may be difficult to get experts and infrastructure at the kebele level with the current development status of Ethiopia and keep the seed viable for 1-3 years. However, it is good to conduct a study and consult knowledgeable people/institutions before making the decisions."

In any case, many respondents emphasized the need for having adequate infrastructure, such as warehouses for seed storage, be it for short- or long-term storage system, regardless of centralization or decentralization (Respondents #4, 17, 23). Storing seed in key mountainous areas that offer the benefit of cool temperatures to preserve seed viability relatively longer, as well as transporting the seed to where it's needed, could be preferred (Respondent #4), though it may be costly for transportation. Carry-over seed of certified seed, which could be used during the next planting season, can be stored at the regional,

zonal, woreda or kebele level where the warehouse of the company is located (Respondents #17, 23). Typically, seed companies carry out such activities based on cost and benefit analyses (Respondent #23).

Close to two-third of the respondents (64%) are in favor of establishing seed reserves at the regional level rather than at the federal, zonal, woreda or kebele levels (**Figure 4**). The main reasons for this preference include: (1) the relatively stable availability of technical capacity at regional level to manage and coordinate the operation of the seed reserve; (2) the availability of infrastructure and hence cost efficiency; (3) the relatively high safety and security; and (4) the ability to distribute seed wherever and whenever it is needed. Those in favor of the zonal and/or woreda levels noted their relatively close proximity to potential beneficiaries, and thereby the timely provision of services at a reduced cost.

This broad preference for a decentralized level of establishment (i.e., regional and zonal) and operation of seed reserves supports the seed policy and regulatory frameworks of Ethiopia. For instance, the 2020 seed policy promotes integrated seed sector development that recognizes the complementarity between the country's different seed systems (MoA, 2020). Likewise, the Pluralistic Seed System Development Strategy, released in 2013 and adopted in 2017, provides the basis for the co-existence of formal and informal seed systems (MoA and ATA, 2017). It also includes provisions to support interventions in both formal and informal systems and promote an emerging 'intermediate' system. The intermediate seed system has grown considerably under the new strategy and includes Seed Producer Cooperatives (SPC) producing certified seed or Quality Declared Seeds (QDS) of improved varieties (Sisay et al., 2017).

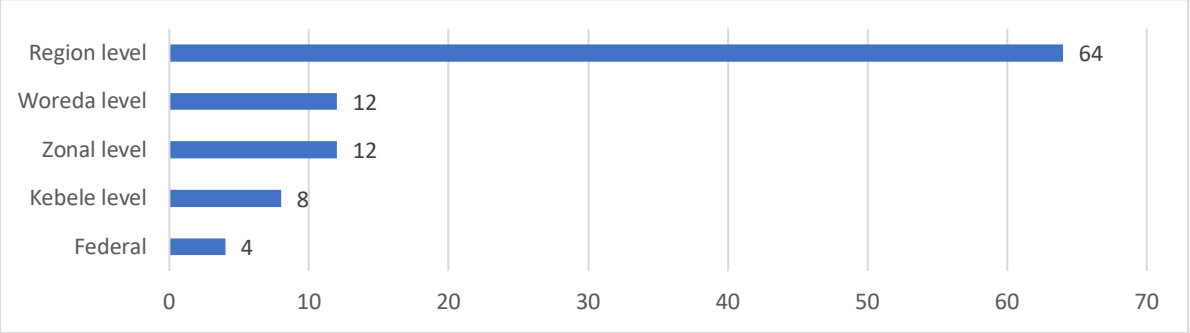

Figure 4. Where to establish seed reserve under decentralized system (respondents in %)

3.7.2 Suitable altitude for establishment and operation of seed reserves

In Ethiopia, higher altitudes generally have lower temperatures. Relatively low temperatures and humidity levels are known to prolong viability of seed. In the lowland, storage pests (e.g., grain weevils) are causing severe damage to seed (Respondent #19), requiring frequent fumigation. About three-fourths of the respondents have recommended that seed reserves be established in highland environments (i.e., cool areas) of the country in order to extend the viability of seeds (**Table 6**). While acknowledging the preference for establishing seed reserves in highland environments, Respondent #3 and 10 remarked that the storage location should be relatively close to where the crop is intended to be grown to minimize the cost of transportation of both raw and processed seed.

Table 6. Altitudinal wise location for establishment and operation of seed reserves

Category	Respondents (%)
Highland, cool places	72.00
Midland, cool places	24.00
Low land, drought prone areas	4.00
Total	**100.00**

3.8 Capacity needs to establish and operate seed reserves

The major capacity building requirements to establish and run seed reserves are seed store and associated facilities, office facilities, capital and operational budgets, and human capital, including technical support and coaching and access to utilities (**Table 7**). In order to reduce costs, certain respondents suggested options, such as: (1) the use of an existing office from BoA/MoA (Respondent #24); (2) the use of existing government employees for the majority of the seed reserve activities (Respondent #24); (3) hand washing for small volumes of seed and seed cleaning machines once volumes reach a certain threshold (Respondents #10, 11, & 12); and (4) the potential need for roads and bridges depending on where the seed reserve is established (Respondent #14). Although Respondent #3 is of the opinion that these capacity needs are more for seed banks than for seed reserves, the body of literature (Feyissa et al, 2013; Vernooy 2015a, 2015b, 2015c and Vernooy et al 2016; Worede 2011) indicates that it is difficult to delineate between seed reserves and seed banks, except that the former targets seed security while the latter focuses on conservation of genetic resources and seed use. In terms of strengthening the local seed system, which addresses seed security, biodiversity, and other needs, both are complementary and supplementary to each other (Vernooy 2015a, Anna Porcuna Ferrer (2018).

Table 7. Capacity building needs to establish and run seed reserve

Capacity building needs	Frequency of responses (N=24)
Seed store & associated facilities	23
Office facility	22
Budget (capital & operational)	20
Human capital	19
Technical support & coaching	19
Access to utilities (esp. power source, water pipeline)	18
Seed cleaning machine	17
Managerial logistics	16
Road & bridge	16
Other: Facilitation of access to market	1

3.9 Frequency of reserved seed use

As shown in **Table 8** below, the frequency of reserved seed use is primarily decided by the occurrence of disasters that disrupt the normal performance of local seed systems and whenever seed shortages occurs. Certain localities are more prone to chronic disasters and poverty and are, therefore, particularly in need of seed reserves to improve the seed security of the communities, and thereby supporting improved food and nutrition security, the recovery process, and building assets (Tripp, 2006).

Table 8. Frequency of reserved seed use

Frequency of reserve seed use	Frequency of responses (N=24)
Whenever disaster disrupts usual ways of operation of seed systems in the locality	18
Whenever seed shortage occurs	18
Demand-supply relationship decides	9
Every season	4

3.10 Disposal of reserve seed

Respondents identified key means of surplus reserve seed disposal (**Figure 5**), including: (1) selling beyond the community as seed, grain, or both; (2) preserving for 3-5 seasons/years under good storage

conditions; (3) planting for refreshing the seed (also known as germplasm rejuvenation when done for conservation purposes) and selling off the rest; and (4) selling within the locality as grain/seed.

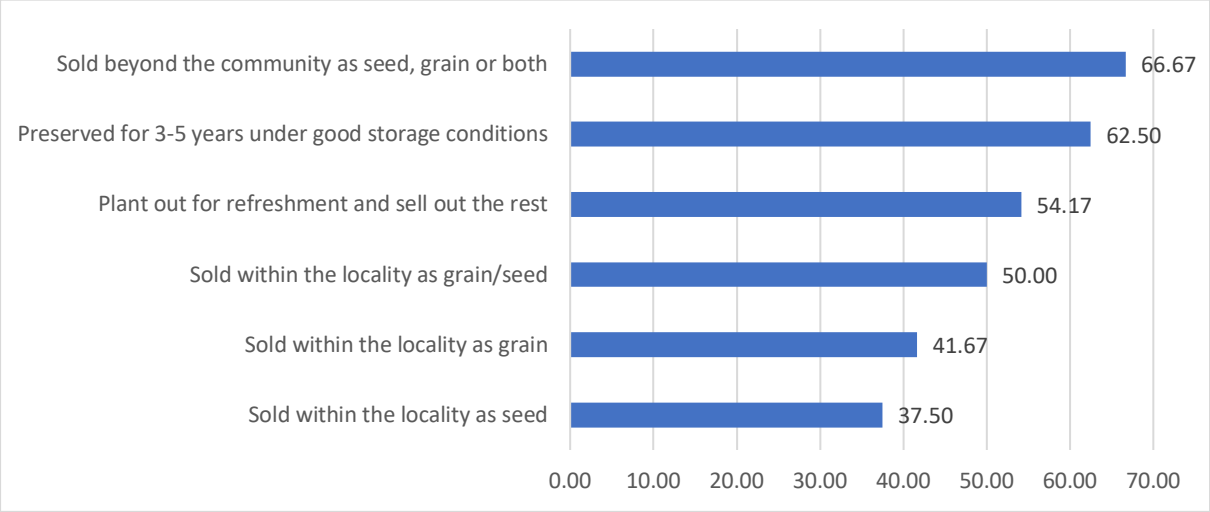

Figure 5. How surplus reserve seed is used (% respondents)

3.11 Possible risks affecting functioning of seed reserve and mitigation strategies

3.11.1 Risks

The possible risks influencing the proper functioning of seed reserve are shown in **Figure 6**. Primary risks as identified by respondents include: (1) poor storage conditions and, consequently, loss of viability and seed germination and (2) disasters, which can be naturally occurring and/or man-made. Additional factors include a lack of sustained partnerships and funding as well as operational costs and expenses; with regards to the former, most activities for community seed reserves/banks are supported by NGOs and development projects and, when such support draws to an end, the operations of community seed reserves/banks often decline.

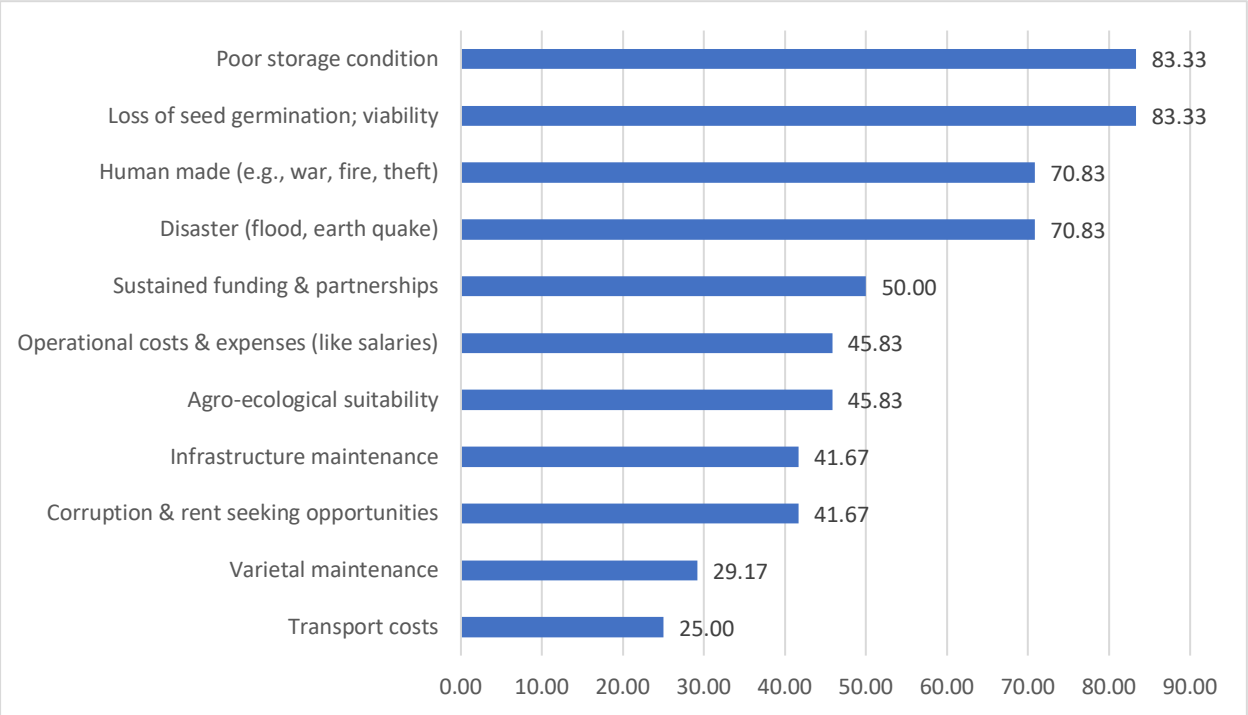

Figure 6. Possible risks affecting functioning of seed reserve (% respondents)

3.11.2 Mitigation strategies

As indicated in **Annex 2**, the most important risk mitigation strategies include: (1) regular monitoring of seed viability and germination; (2) selection of sites for seed reserve establishments to avoid damage due to natural disasters; (3) strengthening partnerships and collaboration to mobilize resource for the maintenance of seed reserves with respect to infrastructure development; and (4) convening governments to increase public investment for seed reserve development.

3.12 Other countries that have successfully executed seed reserves

Several countries are noted to have successfully implemented seed reserves (**Table 9**). The most frequently mentioned is India, followed by Nepal, Norway, and the Netherlands. This finding supports the reports of Vernooy et al. (2015; 2020), who reported that countries such as Bangladesh, Brazil, Ethiopia, India, Nepal, Nicaragua, the Philippines, and Zimbabwe pioneered the establishment and operation of various types of community seed banks. In the north, a particular type of community seed bank emerged known as a seed-savers network. Such networks were first established in Australia, Canada, the UK and the USA before spreading to other countries (Vernooy et al., 2015).

In the present study, Respondent #3 remarked that, "in Cyprus, barley growers may expect three normal, four average, two poor, and one very poor season in every 10 years due to climatic variations. Barley grain with good seed quality (tested and stored) is retained until the next sowing period is completed as an insurance against planting failure. Therefore, barley seed for large-scale planting comes from 'certified seed' in normal years and 'grain' in drought years. Given that there is only one variety, the problem with varietal mixture is minimal." Additionally, Respondent #22 noted that the CGIAR centers like ILRI, CIAT, IITA, and IRRI are maintaining seed banks for germplasm and re-introduction into the farming system, especially in the case of Biodiversity International. Likewise, Respondent #24 has indicated that private seed companies maintain seed reserves for improved varieties. Supporting these latter cases, the Ethiopian Seed Sector Development Strategy (MoA and Ata, 2017) also proposes the need to keep reserve of early generation seeds (i.e., breeder seed, pr-basic seed and basic seed).

Table 9 presents countries that have applied seed reserves/banks for conservation and/or seed security. Nearly all countries that have applied seed reserves/banks for both conservation and seed security purposes are those with rich biodiversity, where farmer varieties, indigenous knowledge, practices and information are being maintained, though alarmingly declining due to disasters, modernization of agriculture, increasing urbanization and infrastructure as well as due to climate change. On the other hand, a majority of countries that primarily apply seed reserves/banks for conservation are developed countries, with strong institutions for the maintenance of plant materials using both *in-situ* and *ex-situ* conservation strategies. Some respondents expressed their concern for lack of financial sustainability in the efforts of the former countries, largely due to dependency on project/NGO support. The way out is to make the operation of seed reserves/banks market-oriented, as is practiced in Uganda, South Africa, and Zimbabwe (Community Technology Development Trust and OXFAM, 2016; Vernooy et al., 2020). When seed reserves/banks are market oriented, the conservation of biodiversity, seed selection, multiplication, storage, and distribution go hand in hand. There is also on-going improvement of crop varieties through PPB and PVS, which entail support from research institutions (national & CGIAR) and academia, as well as community-based organizations.

Table 9. Countries that have applied seed reserves/banks for conservation and/or seed security

Countries that have applied seed reserves/banks for conservation and seed security		Countries that have applied seed reserves/banks primarily for conservation
• Bangladesh • Bhutan • Brazil • Cyprus • Ethiopia • Guatemala • India	• Nicaragua • Nepal • Philippines • South Africa • Uganda • Zimbabwe	• Canada • Japan • Netherlands • Norway • Thailand • UK • USA

4. International experiences

4.1 Definitions of seed reserve and seed bank

International Respondent #1 defined seed reserves and seed banks in a variety of ways (**Table 10**).

Table 10. Definitions of seed reserve and seed bank

Category	Definition	Respondent #
Seed Reserve	A quantity of seed or grain that is deliberately set aside from the current harvest and held in a secure place for the purposes of being available for use in the following season if there is shortage of seed for some reason. The term may also refer to the depository where the seed is kept securely. I think the term seed reserve is usually used for more official interventions made as a matter of policy, for example where a parastatal corporation is/was required to retain x% of its stock for the following season.	International Respondent #1
	A quantity of seed that is designated for storage and not allocated for immediate use, which is available in case of urgent (emergency) need. A seed reserve thus would normally include authorities involved in planning, seed production, and seed storage. Seed storage may be managed more by official authorities in relatively few centralized locations, than by seed producers; in the case of the latter, authorities would likely have records of what is in storage and be able to requisition the seed if needed.	International Respondent #2
	The primary aim is to promote the availability of seed. This typically occurs at a regional level and requires particular emphasis on centralized warehousing/quality control given the scale and associated risk of storing large quantities of seed.	International Respondent #3
	A seed reserve is a seed storage practice undertaken by communities, governments, and humanitarian agencies to support farmers by providing access to planting materials at times of calamities. Such calamities range from the death of livestock and family member that affect timely field preparation and seed planting due to war and natural catastrophes that disrupt seed sourcing channels.	International Respondent #4
	The ability of the government to respond to seed insecurity by providing quality seed of the appropriate varieties to seed insecure farmers being affected by a crisis.	International Respondent #5
	Seeds of local and improved varieties maintained for local use in farming systems for direct benefit of the community in response to natural and man-made disasters.	International Respondent #6

Category	Definition	Respondent #
	Usually government-controlled reserves that are dispensed in periods of shortage. Reserves usually exist for grain rather than for seed (e.g., in the case of India). Seed reserves promote dependency. They are also expensive to manage and can focus on a very narrow set of crops and varieties. Problems with keeping reserves viable are formidable.	International Respondent #7
Seed bank	The term seed bank may be used to refer to the same idea/purpose as a seed reserve BUT it may also refer to a location where biodiversity is actively maintained, by keeping traditional/local varieties securely for farmers who may wish to use them. This brings in an element of a gene-bank. There can be confusion between these two concepts. I think the term seed bank would normally be used for local/village level initiatives rather than for high-level policy procedures.	International Respondent #1
	Any location that stores seeds or planting materials for a short or a longer period. Seed banks can have diverse goals (conservation of genetic resources, increasing the availability and accessibility of seed for members or for vulnerable farmers, maintaining farmers' knowledge, or promoting agricultural practices or community cohesion, etc.). This range of goals makes it hard to generalize about how a seed bank may function – it could have strong links to the formal seed sector and to new varieties, for example, or be committed to self-reliance and to farmers' varieties/landraces.	International Respondent #2
	The primary aim is to promote the availability of seed. This typically occurs at a regional level and requires particular emphasis on centralized warehousing/quality control given the scale and associated risk of storing large quantities of seed.	International Respondent #3
	Seed banks are medium to long-term storages of genetic diversity in a cold room facility to preserve the genes that plant breeders and farmers use to develop improved varieties with improved traits. Seed banks have different scales, which include local seed banks that farmers use to store parts of seeds they collectively produce as part of their local seed production and dissemination and on-farm experimentation, such as PPB and PVS. They can also include national gene banks for collecting and conserving genetic resources and global gene banks such as the Millennium Seed Bank and Svalbard Global Seed Vaults that store copies of germplasm from national gene banks of different countries as safety duplicates or backup.	International Respondent #4
	Seed banks refer to two organizations. One is seed reserves at the community level of the varieties that are appropriate to farmers in that particular community to help them in periods of seed insecurity. At the national level, a seed bank is a germplasm collection that contains the agricultural germplasm that is significant for the country but for which there is only small quantities of seed of each crop and variety.	International Respondent #5
	High standard seed storage used to preserve genetic diversity. It is the same as gene bank.	International Respondent #6
	Banks can exist at varied levels, from community-based to national. At the community level, they may be used for quantities of seed for members but also for safeguarding of plant genetic resources. At the national level, they tend to focus on PGR issues	International Respondent #7

4.2 Similarities and differences between seed reserves and seed banks

International respondents compared and contrasted seed reserves and seed banks based on several parameters (**Annex 3**), such as types and purposes for which seed is stored, standards of stored seed, quality and volume of seed stored and so forth.

4.3 Functions of seed reserves

The international respondents outlined several functions of seed reserves.

International Respondent #1, "The only primary function I can think of is the obvious one of having seed available for distribution when farmers say that they have nothing to sow, but I must say that this is a risky strategy because what goes into a seed reserve may not be what farmers in a particular location actually need. It is difficult/impossible to manage a seed reserve in a way that is sensitive to the diverse needs of farmers, especially in a country like Ethiopia with many agro-climatic niches. This is a justification for organizing seed reserves/banks at a more local level, where the contents may reflect the actual needs of farmers."

According to International Respondent #2, the functions of seed reserve are: (1) to hold available stock for quick purchase and distribution; (2) to re-supply market outlets and stabilize availability; and (3) in (extreme) cases of early-generation seed failure, to serve as the basis for rebuilding seed value chains.

International Respondent #3 outlined three functions of seed reserve, including: (1) to re-enforce existing power structures and strengthen formal seed systems; (2) to promote seed availability; and (3) to incentivize and subsidize formal seed production.

International Respondent #4 indicated the following as functions of seed reserve: (1) seed availability within reach; (2) seed access at planting time; and (3) affordable seeds for poor farmers.

Based on International Respondent #5, the functions of seed reserve are to: (1) provide seed of locally adapted varieties of food crops to seed insecure farmers at planting time; (2) produce and/or purchase seed of significant crops and varieties every year; (3) manage the reserve which would mean monitoring the crops varieties that may be in demand as well as discard old seed in the reserve so as to have seed of high quality; and (4) monitor the seed security situation and work with the seed companies and seed markets to ensure seed can be provided in the case of seed insecurity.

International Respondent #6 listed the following functions of seed reserves: (1) reduce the risk of crop variety loss; (2) enhance seed security; (3) facilitate seed access to farmers; (4) improve food security and sustainable economic development; and (5) ensure farmers rights.

International Respondent #7 did not perceive there to be any function of seed reserves, stating that "…there are none. Seed reserves are a very bad idea and a waste of time. They encourage repeated emergency aid rather than the building of sustainable seed systems that serve the poor and vulnerable areas (and that can render accessible climate-smart and nutritious crops and varieties on a continuous basis). Ethiopia has had near continuous seed aid since 1974. This current proposal is very short-sighted. They promote backward rather than forward seed system thinking, essentially promoting bad practice. They foster seed aid and direct seed distribution – even when it may not be needed."

In terms of budget source for establishing and maintaining effective seed reserve systems in developing countries (e.g., Ethiopia), International Respondent #1 considers only the public as a plausible source, stating that, "If organized at a national/state level the cost is very high and cannot be carried by any organization except a government agency. Even for parastatal organizations, this was often problematic because of the valuation of carryover stocks." In this regard, International Respondent #2 stated that "this is difficult to estimate – I have not seen an effective seed reserve in operation."

The cooperative set up in Ethiopia – particularly wheat – should be looked at to understand the 'cost', as 90% of all seed that is produced and stored by Ethiopian cooperative is wheat and the main functional purpose of the cooperatives is for seed reserves (International Respondent #3).

Establishing a national seed reserve, including creating an independent institution to lead seed security assessments and interventions and strengthen quality control measures for emergency seeds, can cost millions of dollars (though it is challenging to give concrete numbers). However, satellite seed reserves

connected to such seed reserves might cost less. This is again based on my experience with the cost of establishing community seed banks in Ethiopia, Malawi, Zambia, and Nepal (International Respondent #4).

International Respondent #5 stated that the budget sources for the establishment of seed reserve "depend on the specific objectives of the seed reserve and how severe the seed insecurity is. The costs can be considerable, and, for sake of stability, funding should come from the national government. If it externally funded, a decrease in funding may affect the successful functioning of the reserve. In my view the high recurrent cost of facilities, seed production, storage, and distribution of a seed reserve are a major constraint to seed reserves."

In the opinion of International Respondent #6, the sources of budget for establishing and operating seed reserve are: (1) government institutions (research centers, universities, biodiversity institutions, etc.); (2) local communities; (3) religious institutions; (4) NGOs; and (5) international partners/donor agencies (USAID, Oxfam, UKAid, BMGF, etc.).

4.4. Pros and cons of seed reserves

Annex 4 depicts the pros and cons of seed reserves from the perspective of international respondents, considering such parameters line seed security, cost efficiency and investment required, seed security (see availability, access, quality), seed production planning, crop-variety portfolio, market development, involvement of private, suitability, and overall sustainability.

4.5 Other countries that have successfully executed seed reserves

International respondents provided generally skeptical responses to this question. For instance, International Respondent #1 said, "I really do not have recent information on this; I think Bangladesh did operate an official scheme for a while through the parastatal Bangladesh Agricultural Development Corporation, but I think it was managerially and financially inconvenient because of the cost of maintaining seed quality and/or the risk of disposing of seed that had deteriorated during storage. That is the real challenge of seed reserves – how to instate them in a way that is sustainable and financially secure without incurring high costs. If the normal arrangement is to purchase seed at the market price and then distribute it free of charge to poor farmers, then someone has to bear the cost of that. I believe there were successful example of village seed banks in Senegal under a USAID project many years ago, but I do not know the details."

Likewise, International Respondent #2 pointed out that, "I do not know of one that has had 'success' – only examples I know of are expensive failures. I'm afraid I struggled to find anything positive to say about them. Checking with another FAO seeds colleague, we could only think of three countries where these might have been implemented and felt that the risks and costs far outweighed any possible benefits from national seed reserves."

International Respondent #3 was "not familiar with seed reserve success stories."

International Respondent #4 shared that, to their knowledge, "the concept of seed reserves is still limited to the academic circle, and the practice of establishing a reserve is not common; however, some governments, including Ethiopia and Zimbabwe, view carry-over seeds (including hybrid maize) as seed reserves."

International Respondent #5 stated that, "Mauritius had a seed reserve, but only for vegetable seed and, because of a small agriculture sector, the seed could be stored low temperatures. I think India has a seed reserve, but I am not sure how it managed."

International Respondent #6 regarded Zimbabwe (especially in eastern provinces) as an example of a country that successfully established and operated a seed reserve.

4.6 Countries not successful in establishing and operating seed reserves

International Respondent #1 responded that, "I have heard several 'anecdotal' stories of village seed banks that failed; they were established by NGOs as community-based initiatives and everyone was very pleased about that; however, they depended on a key individual, or a source of funding and they failed when that support ended." Similarly, International Respondent #2 pointed out that "one was proposed in Ethiopia in the 1980s, but never enacted to my knowledge. Understanding why it was never put into practice may be important to know. But it's such a limited and risky idea that it is not surprising it did not attract funding. Note that these proposals were distinct from the Community Seed Banks operated via REST in the 1990s, and some NGOs since. Those seed banks have a range of different goals, and important operating costs. How many seed banks have continued without external support (e.g., from projects, NGOs, local governments) is an important question to ask. Colleagues have heard stories about Morocco, Uzbekistan, and Cambodia, but we cannot confirm if they implemented this."

International Respondent #3, "Malawi and Zambia maize seed reserves use to support long standing government subsidized input programs - these programs are plagued with political interference, corruption with regard to who gets production and storage contracts."

International Respondent #4 noted that, "many countries with seed shortages and experiencing disasters have not established seed reserves. I believe that awareness is low both due to limited research on this topic and the lack of resources allocated for seed system resilience in disaster areas."

International Respondent #5, "Many countries express interest in seed reserves but after considering the costs and benefits they decide against it. A few final thoughts related to Ethiopia – in a country with diverse crops and varieties, maintaining a seed reserve with the range of crops and varieties would be very challenging. Also, it assumes that the government knows what crops and varieties the farmers need, which is not always the case. The seed that is not used every year or perhaps longer would need to be sold and replaced to maintain seed quality specifically seed germination. This is a major consideration and constraint to a seed reserve. The logistics of central seed reserves for production, storage, and distribution would be costly. Some experts have suggested to keep basic seed in controlled storage that could be multiplied during the off-season using irrigation and then distributed to farmers thereby reducing storage costs and the need to renew the seed supply every year. A more appropriate and cost-effective method may be a more decentralized approach at the community level that involves vouchers, which farmers could use to purchase the crop varieties they want from local seed companies or local markets. Research and surveys have demonstrated that local markets are a significant source of seed for farmers."

5. Conclusions and recommendations

Drawing on the present study, with primary data from national and international stakeholders as well as literature review, the following serve as key conclusions and recommendations:

- Distinctions between seed reserves and seed banks are not clear, especially when both are qualified as community seed reserves and seed banks.
- The most critical problem associated with the establishment, organization, and operation of seed reserves are their costliness. To mitigate cost-associated challenges and constraints, our results and most literature sources are in favor of community seed banks to seed reserve proper (i.e., maintaining quality assured seed in store, anticipating occurrence of disaster).
- To be financially sustainable, community seed reserves and banks need to integrate market-oriented seed production, along with conservation, seed selection, seed multiplication, seed use, and seed exchange during and after disaster as well as during normal seasons. This implies that community seed reserves and banks would be sustainable ecologically, culturally, socially, and financially when and where market-oriented seed production of improved and farmers varieties is undertaken; traditional foods and drinks are promoted; and these two are combined with conservation, seed selection, seed multiplication, and seed distribution.

- Seed systems should be supported and strengthened to foster resiliency, rather than reserving seed for off years and providing direct seed distribution. Our literature review revealed community seed reserves and banks need to be more resilient in cases such as the COVID-19 pandemic, which disrupt national and international supply chains, including seed trade. Strengthening local seed systems requires the decentralization of support to formal, informal, and integrated seed systems; the promotion of in situ and ex situ conservation strategies; the empowerment of farmers and communities to produce and use their preferred choices of crops and varieties; the strengthening of local seed storage structures at the individual and community levels through awareness creation, training and material support; the support of community-based seed production in a market-oriented way; and the development of a complete value chain for local crop varieties through PPB, PVS, and promotion of traditional foods and drinks for market.
- Our findings provide support to a growing body of evidence from seed system security assessments that seed is available in areas exposed to disasters and, hence, creating means to access seed from the local seed systems is preferred to direct seed distribution as emergency seed aid. This can be done through seed vouchers and/or cash for seed, and further supported by organizing seed fairs/exhibitions at the time of planting.
- Ethiopia should continue strengthening local seed systems (informal, formal, and integrated), with support from government, private, and development partners.

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Annex 1. Expected budget/funding sources for establishing and maintaining effective seed reserve systems in Ethiopia

Government organization	UN Organizations	NGOs/CSOs	Development Partners	Private sector
NDRMC	FAO	CARE/Ethiopia	Resilient Agriculture for Inclusive and Sustainable Ethiopian food systems/ Netherlands	Farmer Cooperative Unions
Ministry of Irrigation and Lowlands	World Food Program	Mercy Corps	European Union	Seed producer cooperatives
Research Institutions (EIAR & RARIs)	UNDP	Goal/Ethiopia	United States Agency for International Development (USAID)	Private research institute
Public seed enterprises (federal and regional)	World Bank	World Vision	Feed the Future	Private seed multiplication companies
Ethiopian Seed Enterprise and Regional Seed Enterprises		Self Help Africa	Alliance for a Green Revolution in Africa (AGRA)	
Regional BoA		Irish Aid	Consortium of International Agricultural Research Centers (CGIAR)	
MoA		OXFAM	International Fund for Agricultural Development	
Agricultural Transformation Institute		International Committee of the Red Cross	Agricultural Growth Project	
Ethiopian Agriculture Authority, MoA		German Agency for International Cooperation	Bill and Melinda Gates Foundation (BMGF)	
Ethiopian Biodiversity Institute		CRS		
Federal and regional Agriculture input output, MoA/BoA		Food for the Hungry (FHI)		
Universities		Christian Relief and Development Association		
		REST/Tigray		
		Organization for Rehabilitation and Development in Amhara		
		EOSA		

Annex 2. Mitigation strategies for the risks and uncertainties in operation of seed reserve

Risks	Suggest mitigation strategies	Reference Respondent #
Natural disasters (droughts, floods, earthquakes)	Select location less prone to natural disasters; Seed reserve site establishment should be decided based on feasibility study and risk assessment; Use at least 10 years climate data & information; Check the area in advance and avoid such places based on observation & evidence	3, 6, 9, 18, & 19
	Keep/maintain duplicate samples in different places	22
Human made calamities (e.g., war, fire, theft)	Ensure community benefits are maximized and the local community is empowered and has owned the seed reserve	6
	Insurance for fire and theft	9
	Raise awareness of target beneficiaries and stakeholders	17
	Select relatively safe place and put under proper safeguarding	18 & 21
	Use multiple places; diversify places within and between regions	19 & 24
Loss of seed germination; viability	Store mature, healthy well dried seeds	18
	Use appropriate/good storage facilities	5 & 17
	Regular monitoring of seed quality and condition (i.e., fumigate) storage facilities. Take sample and check viability periodically, requiring resources (human and material)	3, 6, 9, 11, & 17
	Store under highland cool conditions or establish the cooling system in the store	24
	Sell out as a grain	22
Poor storage condition	Storage should be clean, dry, free from rodents, insects	3 & 18
	Should be managed and led properly	5 & 9
	Use improved storage structures and supportive facilities	10 & 17
	Take the necessary precaution	22
	Construct standardized stores where rodents and pests can be protected as in any seed store	24
Agro-ecological suitability	Cool areas with low temperature	3
	Identify appropriate varieties that suits to agrology that are near by the seed reserve center	5
	Pre- establishment study or feasibility study prior to the establishment and technological support	6 & 17
	Should be managed and leaded properly	18
	Use only for suitable climate	22
	Seeds must be distributed where they are adapted. Therefore, NGOs must work with the knowledgeable local institutions like public seed companies/research institutions.	24
Varietal maintenance	Increase the number of varieties or species as much as possible	17
	Replant to rejuvenate and purify	22

Risks	Suggest mitigation strategies	Reference Respondent #
	For improved varieties research institutions and seed companies can maintain but for local cultivars or landraces it needs discussion among the stakeholders to decide who will maintain them.	24
Corruption and rent seeking opportunities	Good management and committed leadership; should be managed and leaded properly	6 & 18
	Good bylaw and ensuring good governance (create ownership); High control	10 & 15
	Create awareness and or community-based management	17
	NGOs must work with government institutions. Protocol of operation must be prepared & followed	24
Infrastructure maintenance	Strengthen partnership and collaboration to mobilize resource for the maintenance of seed reserve	3, 6, & 18
	Generate income for the seed reserve to self-sustain	10
	Convincing government the need of seed reserve, so as to allocate capital & operational budget	15, 17, & 22
	Projects/NGOs can cover the cost for the first 5-10 years. But the local institutions must overtake over the long term. It must be designed from the beginning.	24
Operational costs and expenses (like salaries)	Maximize resource mobilization and wise use of available resource	6
	Convincing government the need of seed reserve	15
	Capacitate to operate as a small seed business	17
	Should be establish based on full information & proper planning	18 & 22
	Use existing government staff/institutions for majority of the work. This will also help for sustainability.	24
Sustained funding/partnerships	Organized a platform and partnership that can dedicated a resource in a sustainable way	3 & 5
	Working with potential donors and sponsors and maximize internal income generation	6
	Convincing government the need for seed reserve	15
	Linkage to international support	17
	Strengthening network of different actors	18
	Projects/NGOs can cover the cost for the first 5-10 years, but the local institutions must overtake over the long term. It must be designed from the beginning.	24
Transport costs	Decentralized locations	3
	Decentralize as close as possible to where the seed is produced and utilized	6

Annex 3. Similarities and differences across seed reserves and seed banks

Parameters	Similarities	Differences
Seed	Both hold seed (International Respondent #3)	One focuses on promoting access to seed varieties (small quantities) and the other on promoting seed availability (large quantities) (International Respondent #3)
Material stored	Both store seeds (International Respondent #4)	Seed reserves store limited species (primarily field crops – cereal, legume, oil crops) while seed banks store all plant genetic resources (plant species with orthodox seeds + cells and tissues of recalcitrant species) (International Respondent #4)
Types of materials	Conservation, maintenance (International Respondent #6)	Seed reserves: Improved materials that can be used for planting by farmers (International Respondent #6) Seed bank: Genetic diversity conservation of plant species, in any form, for future use in crop improvement (International Respondent #6)
Purpose	• Seed security for a following season (International Respondent #1) • Both aim to increase farmers' access to seeds (International Respondent #4)	Seed reserves aim to make seeds available during disasters/acute shortages of planting material while seed banks aim to make a diversity of seeds available for medium (seasonal to few years) and long-term use (International Respondent #4)
Usefulness for seed insecurity		Seed banks would be useful at the community level, but a seed reserve should serve the entire country (International Respondent #5)
Standards used		Seed reserves are based on seed security assessment (by humanitarian actors) and seed quality standards (governments) in specific areas/regions while seed banks are based on gene bank standards (International Respondent #4)
Planning	Needed to determine storage conditions and location, what quantities, how stocks used, rules (International Respondent #2)	Seed reserves are more likely to be linked to regional/district planning processes, and to emergency co-ordination (International Respondent #2)
Storage	Store seed for some future need (International Respondent #2)	Reserves tend to be more centralized, more likely to have technical inputs (temperature control, inputs), and used to store seed for longer periods (1-3 years) (International Respondent #2)
Storage facilities required	Well-managed storage facility (International Respondent #6)	Seed reserve: Modest cold rooms or other safe seed storage facilities can be used (International Respondent #6) Seed bank: High-standard or high-tech storage facility required (International Respondent #6)

Parameters	Similarities	Differences
Year of storage		Seed reserve: Few years (International Respondent #6) Seed bank: Several years (can be in excess of 100 years) (International Respondent #6)
Location		Seed banks can be at the community or national level. Seed reserves in central storage locations (International Respondent #5)
Amount stored/facility	Both target storing seeds in a better storage facility than an average smallholder farmer (International Respondent #4)	Seed reserves store large volumes of seeds of improved or local varieties of different crops for immediate crop production needs by farmers (usually in warehouses). Seed banks store small samples of seeds representing a population of a given genetic resource for characterization, evaluation, and multiplication for later use by researchers, breeders, and farmers. Seed banks store seeds in a well-equipped cold room facility, except in the case of local seed banks. (International Respondent #4)
Quality of seed stored		The quality of seed stored in reserves tends to be poor, while the quality of seed stored in banks tends to be good (International Respondent #4)
Seed quantity		• Small quantities in seed banks, large quantities in seed reserves (International Respondent #5) • Seed reserves have a relatively larger quantity to serve as the initial seed for seed multiplication or direct production. Seed bank have relatively smaller quantities/samples that are kept in jars. (International Respondent #6)
Germplasm /varieties		Reserves are not a consideration. May apply to more local level seed banks (International Respondent #1)
Crops/varieties	Both are likely to reflect staple crops of region (International Respondent #2)	• Seed banks may include more local varieties, wider range of secondary crops, depending on the wider goals (International Respondent #2) • Seed reserves: Focus on widely grown crop species and varieties • Seed banks: Have as many as possible crop species and accession within a given species that can be sampled (International Respondent #6) • Seed banks have a wide range of crops and varieties whereas a seed reserve contains large quantities of seed of significant crops and varieties (International Respondent #5)

Parameters	Similarities	Differences
Management	• Some oversight is important to manage information, oversee quality, decide on who gets to access the seed and on what terms (International Respondent #2) • Both require strong management. (International Respondent #3) • National seed banks and seed reserves are managed by government entities at the national level (International Respondent #5)	• Reserves are policy managed. Banks are often community managed – even with a key held by a respected individual to control access (International Respondent #1) • Seed banks likely to be more decentralized, for example overseen by a local management committee (though may be federated or linked to existing formal institutions, like co-operatives) (International Respondent #2) • Seed reserves are centralized, whereas seed banks are decentralized (International Respondent #3) • Community seed banks would be locally managed but perhaps not have sufficient resources (International Respondent #5)
Actors and their practices	Both are supported by donors who aim to increase global food security International Respondent #4)	Seed reserves are rooted in social-cultural practices and local institutions in addition to humanitarian work (seed aid) (Mulesa et al., 2021), whereas seed bank interventions target countering genetic erosion caused partly due to Agricultural modernization by conserving genetic resources (on-farm and ex-situ) and also to serve the formal breeding and dissemination of new varieties (International Respondent #4)
Scale of operation		Reserves are generally large-scale and national. Banks are generally small-scale and local (International Respondent #1)
Finance	Both require recurring finance to cover operating costs (International Respondent #3)	• Reserves form part of the budget for the responsible organization. Banks normally depend on community support/commitment and thus have fewer financial implications (International Respondent #1) • Seed reserve requires much more financing. The opportunity cost of unsold seed needs to be financed with seed reserves, but this is not a cost for seed banks, as the quantity is small. (International Respondent #3)
Information	Record-keeping essential (e.g., what crops/varieties, what quantities, where, quality control, how used, etc.) (International Respondent #2)	Who gathers and uses information, and how widely it is shared (International Respondent #2)

Parameters	Similarities	Differences
Sustainability	Both plagued with low level of functionality/cost effectiveness (International Respondent #3)	Seed reserves are more likely to involve corruption/financial mismanagement/political interference. Seed banks are more likely to involve in-effective day to day management - poor storage conditions/varieties not replenished (International Respondent #3)
Documentation/ Lessons learned	Best practices and case studies of functional and dysfunctional seed reserve schemes and seed banks are not well documented and/or socialized. (International Respondent #3)	Seed banks - even as a source of genetic diversity/in situ conservation - are slowly regarded and understood by donors and most seed aid practitioners. Seed reserves - despite examples of political interference, cost, corruption - have a much higher positive profile among seed aid practitioners and donors. (International Respondent #3)

Annex 4 . Pros and cons of seed reserves (based on response of international professional respondents)

Parameter	Pros	Cons
Seed security	• Seems like a good idea – 'politically correct' – government can be seen to do something in a crisis situation but…. (International Respondent #1)	• difficult to manage; the tendency may be to put the lowest quality seed into the reserve because it is natural to use the highest quality for sowing now (International Respondent #1) • Will have limited impact, as emergency seed aid provides only a small fraction of the seed actually sowed by small farmers in stress-prone countries. Even the massive (32,000 Mt) seed aid provided in 2016 only provided a small percentage of the seed farmers actually sowed that year, according to the Seed Security Assessments conducted by FAO or CRS in 2016. Locks emergency seed response into direct distribution, which is not targeted to the most common constraints of seed security. (International Respondent #1)
Cost efficiency and investment		• Can be very costly (International Respondent #1) • Cost of maintaining a seed reserve is high (International Respondent #5) • High – this is a sunk cost, which may not get used before seed expires, or is directed to varieties or locations where there is no immediate need. Possibility of inflated prices, or of 'rent-seeking' (a polite word for profiteering or collusion) in purchase. (International Respondent #2) • Establishing seed reserves in many areas of a country without a good assessment of demand and needs and prior knowledge of seed aid history may not be economical. (International Respondent #4) • Requires high investment for infrastructure development/ establishment (International Respondent #6)
Seed production planning	May smooth supply in formal sector channels (seed production and marketing chain) in years of extreme flux	It places demand on seed production that is to be directed at authorities for possible future use, and not towards meeting clients' needs and building a relationship with them (International Respondent #1)
Seed quality	• Small-seeded crop species can be stored longer and less susceptible to insects and also has good physiological quality (International Respondent #4) • Quality seed provided to seed insecure farmers. Seed can be cleaned and properly stored (International Respondent #5)	• Often poor, due to storage conditions and insufficient renewal of the reserve stock (International Respondent #1) • Big risks – large amounts of seed will need to be stored in central locations over long timeframes, with associated costs and risks of attracting pests such as rodents, moisture, etc. It will need to be renewed periodically – and what happens to the almost-expired seed that needs to be 'offloaded'? Dumping seed (be it subsidized or free) on vulnerable farmers will pass risk on to them and presents a significant reputational risk to authorities. (International Respondent #2) • The quality of seeds from community seed reserves is poor, as the contribution comes from households and gets mixed (Mulesa et al., 2021). It can cause crop loss if care is not given. Good quality seeds of major seeded species cannot be maintained for long. (International Respondent #4) • After one year, seed may have to be sold as food grain and replaced in order to maintain seed quality (International Respondent #5) • Less quality seeds produced and supplied (International Respondent #6)

Parameter	Pros	Cons
Availability	Seeds of some crops are available locally (International Respondent #4)	Not seeds of all crops that farmers need can be made available (International Respondent #4)
Access	Locally accessible without traveling far and can be affordable for the poor. No travel cost for farmers. It can be helpful in areas where improved varieties from the formal seed system do not reach farmers and areas experiencing frequent natural disasters, e.g., countries with a history of war and drought. (International Respondent #4)	Elites can capture seeds stored in reserves unless good governance is in place (International Respondent #4)
Crop varieties	May only provide improved varieties of a limited number of crops (International Respondent #5)	• These crops and varieties may not be what farmer need (International Respondent #5) • May not be applicable for cross- pollinated varieties (International Respondent #6)
Market development		Does not work with the channels that fill gaps in availability in times of crisis, which are mainly informal market channels. As such, a centralized seed reserve may actually weaken the traders' capacity to move adapted 'potential seed', still the most significant source of seeds in normal times and after disasters (International Respondent #2)
Seed business (if seed reserves managed by community)	Ease access to farmers (International Respondent #6)	Discourages seed production business of commercial seed companies (International Respondent #6)
Flexibility of response		Leave this to a few actors (with limited abilities to cover the range of agroecological zones or diverse farmers' needs). Selection of crops and varieties will likely be supply-driven and may reflect vested interests. Planning and logistics will be subject to bureaucratic processes. More rapid and flexible responses are needed that provide diverse range of crops and varieties (International Respondent #2)
Impacts on the private sector	May be easier and less costly to involve the local seed companies and seed providers at local markets and provide vouchers for seed purchase (International Respondent #5)	Seed reserves can have a negative effect on seed companies and local seed markets (International Respondent #5)
Sustainability	Subsidies to formal seed production can support more sustainable formal seed	Susceptible to political interference and corruption (International Respondent #3)

Parameter	Pros	Cons
	production of less commercial crops (International Respondent #3)	
Suitability	Participatory seed acquisition from trusted sources (e.g., government and local sources farmers know) can lead to the storage of preferred seeds and varieties, i.e., demand-led seed stocking (International Respondent #4)	Supply-driven direct seed distribution can lead to crop failure by distributing wrong varieties and poor-quality seeds (International Respondent #4)