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From Genebanks to Farmers. A study of approaches to introduce genebank material to farmers' seed systems

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Photo (cover): Farmer in groundnut multiplication plot in Malawi. By T. Hundama.
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Foreword

The objective of the current study is to map and analyze different approaches to facilitate access to genetic resources for farmers and to draw lessons for future development initiatives aiming at connecting *ex situ* conservation with sustainable use of genetic resources on farm. This is a study undertaken by the Norwegian University of Life Sciences (NMBU) and supported by the Norwegian Agency for Development Cooperation (Norad). The report is commissioned over the frame agreement between Norad and NMBU.

Community Seed Bank in India. Photo: Development Fund Norway.

List of abbreviations

AfricaRice	Africa Rice Center
ANDES	Association for Nature and Sustainable Development
ASBP	African Unions' African Seed and Biotechnology Programme
BDA	Breeding, Delivery and Adoption (Conventional plant breeding pathway)
BUCAP	Biodiversity Use and Conservation Asia Programme
CARDI	Cambodian Agricultural Research and Development Institute
CATIE	Tropical Agricultural Research and Higher Education Center
CBD	Convention on Biodiversity
CBM	Community Biodiversity Management
CBO	Community-based Organization
CDI	Centre for Development Innovation (at Wageningen UR)
CIAT	International Center for Tropical Agriculture
CIAP	Cambodia-IRRI-Australia Project
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
COMESA	Common Market for Eastern and Southern Africa
CSB	Community Seed Banks
Embrapa	Brazilian Agricultural Research Corporation
ESGPA	Ethiopian Seed Growers and Processors Association
ETC group	Action Group on Erosion, Technology and Concentration
FAO	Food and Agriculture Organization of the United Nations
GMO	Genetically Modified Organism
GR	Green Revolution
IARC	International Agricultural Research Center
ICARDA	International Center for Agricultural Research in Dry Areas
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics

IDLO	International Development Law Organization
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIA	National Institute of Agrarian Innovation (Peru)
INIA	Institute of Agricultural and Livestock Investigations (Chile)
INIAP	National Institute of Agricultural and Livestock Investigation (Ecuador)
INRA	National Institute for Agricultural Research (France)
IRRI	International Rice Research Institute
ISSD	Integrated Seed Sector Development in Africa
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
MLS	Multilateral System (of the ITPGRFA)
NGO	Non-Governmental Organization
NMBU	Norwegian University of Life Sciences
Norad	Norwegian Agency for Development Cooperation
NordGen	Nordic Genetic Resource Center
PGRFA	Plant Genetic Resources for Food and Agriculture
PPB	Participatory Plant Breeding
PVS	Participatory Varietal Selection
RAFI	Rural Advancement Foundation International (Now ETC group)
SD=HS	Sowing Diversity, Harvesting Security program
SMTA	Standard Material Transfer Agreement
UNORCAC	Union of Peasant Organizations in Cotacachi
UPWARD	Users' Perspectives with Agricultural Research and Development

Executive Summary

Genebanks conserve key resources for increasing global food security and adapting to environmental change. The conventional way genetic resources are deployed to farmers goes through a linear pathway of breeding, delivery and adoption (BDA) of improved varieties. However, over the past 30 years a number of other pathways from genebanks to farmers' fields have been tested and operationalized. This report reviews strategies, methodologies and projects that exist to facilitate direct access to genebank material for farmers. Based on a literature review, a survey as well as interviews and data collection from key actors in conservation and development oriented seed system work, we trace trends in the field and develop a typology of approaches.

Data from the CGIAR genebanks show that farmers, farmer organizations and NGOs comprise a substantial user group, e.g in 2015 these groups received more than 7% of the seed samples distributed in 2015, on par with the number distributed to the commercial sector. We categorize the approaches to make direct use of genebank collections on farm into six categories: (1) Reintroduction, (2) Community Seed Banks (CSB), (3) Participatory Plant Breeding (PPB), (4) Emergency Seed Interventions, (5) Variety Introduction and (6) Integrated Seed System Approaches. However, the approaches overlap and there are no clear boundaries between them. The historical trend in genebank-farmer work goes from an early emphasis on conservation (e.g. collaboration to link *ex situ* conservation with *in situ* and on farm conservation efforts) towards an increasing emphasis on use of diversity for enhanced agricultural outcomes. This trend is visible in the literature as a shift from a perspective on farmers as *custodians* of crop diversity towards a focus on farmers as *users* of crop diversity and the functions of *farmers' seed systems*. Farmers' and formal seed system literature comprises analyses of seed systems across scales and ranges from basic research to explicitly development oriented research. Figure 1 illustrates how the categories of approaches analyzed here relates to the formal and the farmers' seed system.

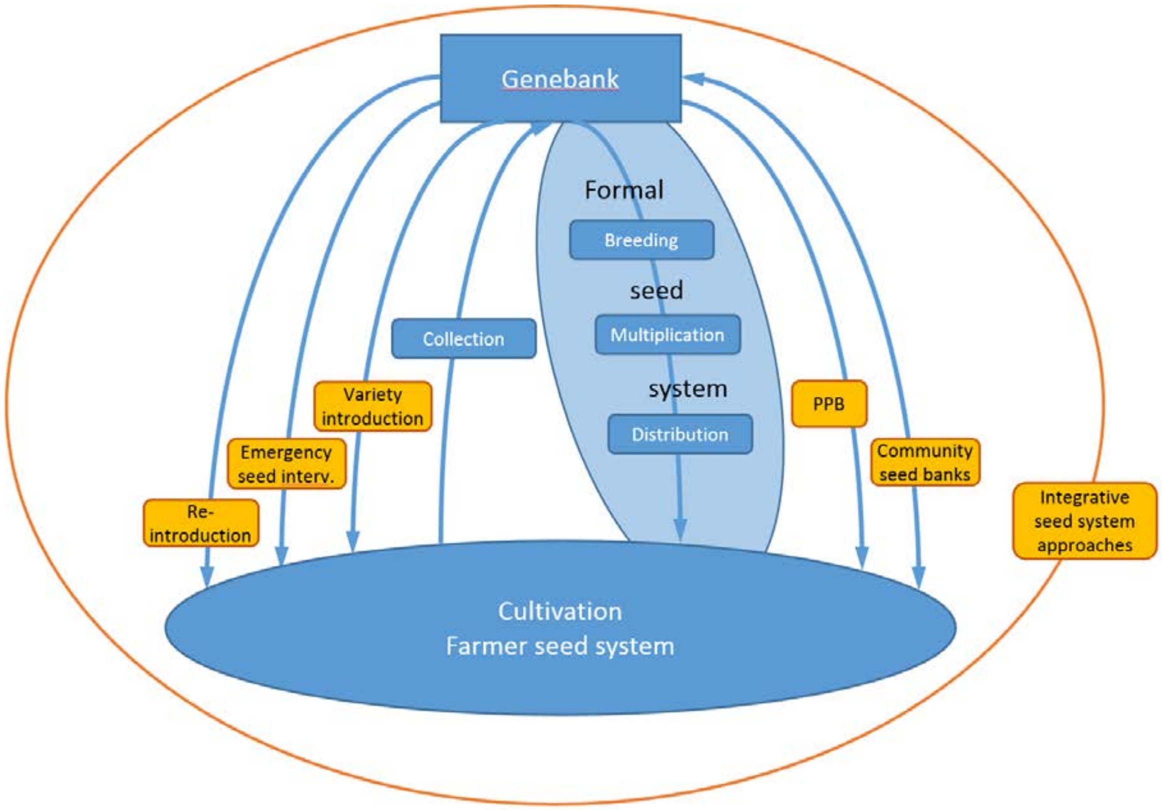

Figure 1. Conceptual frame of approaches to introduce *ex situ* conserved genetic resources in farmer seed systems. Institutions and activities in the shaded blue circuit represents a conventional formal seed system. Other approaches facilitating farmers' access to genebank material reviewed in this report are shown as arrows with orange boxes.

Table 1. Summary of features of different approaches to introduce *ex situ* conserved genetic resources in farmers' seed systems.

Approach	**Duration of intervention**	**Scale**	**Documentation/merits**	**Pros**	**Cons**
Reintroduction	Short term	Local-national	Limited documentation.	Strengthens knowledge and local ownership (build trust and facilitate access/sharing PGRFA) as well as strengthening linkage between formal and informal systems	Small scale. Often more conservation oriented than seed security oriented.
Community Seed Banks	Long-term	Local	Well documented. Few neutral assessments.	Links conservation and use.---platform for integration of the formal and informal systems	Work intensive. Small scale. -challenge in economic and institutional sustainability -limited recognition/policy &institutional support
Participatory Plant Breeding	Long-term	Local-national	Well documented. Few neutral assessments	Integrative at practice level. Effective adoption. -Empowerment	Work intensive. Scaling and sustainability challenges(limited formal recognition/ policy &institutional support)
Emergency Seed Interventions	Short term	Local-national	Well documented. Highly context dependent.	Immediate development outcomes -an opportunity for sustainable	Focus on short term impact -supply driven

				seed system development	
Variety Introduction	Short term	National	Limited documentation.	Larger scale. Focus on long term impact	Institutional sustainability challenge
Integrated Seed System Approaches	Long-term	National	Limited documentation. Conceptually well developed.	Integrative at policy and institutional level	Challenge to move from concept to operationalization

Key considerations

Organizations involved with facilitating linkages between genebanks and farmers will have to define their objectives in terms one or several of the following outcome dimensions: (1) *development*; (2) *scale*; (3) *policy*.

(1) The ultimate objective of most efforts of this sort is enhanced food security and resilience in the face of environmental change. These higher order outcomes are difficult to measure and projects will often resort to reporting number of varieties developed and distributed as indicators of development impact. Adoption and uptake of the varieties is of course a better indicator, but still not very informative in terms of livelihood outcomes.
A suitable level for measuring development impacts for farmer seed system is captured in the notion of *Seed Security*. Conceptual frameworks for seed security have generally recognized three components, which draw from food security frameworks: seed *availability* (sufficient quantity of seed within reasonable proximity to people and in time for critical sowing periods); seed *access* (people can produce own seed or have the means to acquire through purchase, gift loan), and seed *quality* (including both physical quality and varietal suitability, e.g., meets farmer needs/preferences). Recently, FAO added two additional components to the seed security framework and assessment tools (FAO 2015; FAO 2016): *varietal suitability* (previously considered as part of seed quality); and *resilience* (stability of seed system in the context of shocks and stresses).

(2) Reaching scale – in terms of number of varieties released and farmers reached – is a challenge for all categories of approaches identified and described in this report. Genebanks are only able to distribute small quantities of seeds and in all approaches the seed multiplication step is to a lesser (PPB) and larger (emergency interventions) degree critical. There is a need for exploring ways to scale up in terms of numbers of households reached, but approaches like PPB and CSBs are so intensive that the number of farmers directly involved in each initiative will remain limited. A way to overcome this challenge is to incorporate elements of the approaches in more mainstream BDAs. Examples of this is the use of on farm evaluation trials in otherwise conventional maize breeding pipelines. However, when considering scale it is also important to acknowledge that there are no silver bullets and that projects must be crop and context specific (both in terms of agroecological and social context). The areas that have been "bypassed" by Green Revolution style modernization of the agricultural sector are in reality often areas where this strategy has failed. Thus, the solution in these areas is not likely to be another type of technology package dissemination.

Related to the challenge of scale is the challenge of institutional sustainability. Most interventions in the six categories identified are project-based and involve external funding (often foreign development assistance). Projects generally have a limited time-span and although donors normally want to have a "disengagement strategy" in place, the reality is often that the public and private sector involvement is too limited to ensure long term economic and institutional sustainability. Targeting the public institutions already mandated within the sector and grounding effort in local institutions (e.g. farmer organizations) is necessary for long term sustainability.

(3) In terms of policy and laws there are both challenges and opportunities. The challenges are connected to the nature of many of these projects: bottom up, participatory, reliant on local, often informal institutions, context specific and situated. These features are not always easily compatible with seed policies and laws developed to serve and regulate commercial and formal seed systems. There are exemptions for use of genebank material for research, but when it comes to distribution, national seed laws often prohibit distribution of unregistered varieties as well as sale of uncertified seeds. Integrated seed system approaches articulate ways to tackle this challenge head on by promoting a pluralistic approach that allow for the coexistence of various seed systems with appropriate associated policies, regulations and institutions.

On the other hand, many of the approaches represents great opportunities for realizing international and national policy objectives for farmers' rights and sustainable use. Strengthened collaboration between genebanks and organisations working with seed system development is potentially beneficial for both sides: Farmers benefit from access to genetic diversity they otherwise would not have ready access to and genebanks are integrated with seed systems they would not reach through the conventional BDA channel. Working through alternative channels, genebanks can increase their actual and perceived relevance among groups that otherwise consider genebanks far removed from the production system. Involvement of farmers in the development, evaluation and distribution of varieties is a way to realize farmers' rights as they are recognized in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The approaches and projects discussed here represent avenues that bridge the *ex situ* conservation and farmers' rights agenda to reach the common goal of enhanced seed security.

1. Introduction

The role of genebanks in the formal seed systems is to provide access to genetic resources for breeders. In such systems, the route germplasm travels from *ex situ* collections to farmers' fields goes through the process of breeding, delivery and adoption (BDA) of improved varieties. This has been their traditional role since the establishment of the first genebank by the Russian plant breeder Nicolai Vavilov in the early 20th century and this is their main role also in contemporary agricultural research systems. With the rise of the environmental agenda in the 1970s and increasing concerns over the loss of genetic diversity, the role of genebanks expanded to encompass conservation in a wider sense than for purely instrumental purposes (Pistorius 1997). In the same period, the Green Revolution model of agricultural development faced increasing criticism for being top-down and overtly prescriptive and new participatory approaches for knowledge and technology dissemination and sharing became increasingly popular among development NGOs (Sumberg et al. 2013). Partly as a result of this trend, the user group for genebanks over time expanded from plant breeders to a broader group ranging from basic scientists to farmers and hobby growers interested in testing old varieties.

Approaches to deploy the resources conserved in genebanks to farmers through other routes than conventional BDA are important for farmers' access to well adapted seeds– and thereby contributing to enhanced food security and resilience in the face of environmental change. One argument for the importance of alternative routes from genebanks to farmers is that research on farmers' seeds systems over the last 20-30 years shows that the formal seed systems continue to play a relatively minor role in supplying farmers in developing countries with seeds (Coomes et al. 2015). Another argument, which is explored here, is the merits of the alternative approaches in contributing to enhanced seed security. Our objective here is to assess the approaches to introduce *ex situ* conserved genetic resources in farmer seed system and assess their merits in terms of development outcomes.

The use of genebanks has received limited attention in the scholarly literature, and the few publications that exist on the topic mainly address the geographic distribution of users (Dulloo et al. 2013; Fowler et al. 2001; Rubenstein et al. 2006; Smale and Day-Rubenstein 2002). These works have shown that genebanks are important for non-profit science organizations in developing countries and have thus challenged the view that genetic resources conserved *ex situ* primarily are useful for commercial interests in the Global North. However, these studies have not focused on identifying farmers' use of genebanks as they have either categorized users in more general groups like commercial vs nonprofit or they have only focused on germplasm use reported in peer reviewed articles (Dulloo et al. 2013) which most likely excludes direct use of farmers. Through its focus on direct use of genebank accessions by farmers, this report thus redresses a literature gap.

The conceptual frame we use for this study draws on a body of literature on seed systems in developing countries. We define seed systems as the institutional arrangements involved in seed supply and seed sourcing, from plant variety development to their use on the farm, including the bureaucratic, scientific and social institutions that develop varieties and mediate exchange of and access to seeds. The seed system framing is useful to show the linkages between the different activities and approaches farmers and organizations working with farmers employ from seed selection to cultivation and back again (Figure 1). This framing foregrounds that it is farmers' *use* of seeds that it the primary concern, not merely *conservation* of seeds. This is an important feature that distinguishes the seed system literature from a body of literature focusing on *in situ* conservation and on farm management as a goal in itself. The seed system literature represents a turn towards focusing on the function of crop diversity in production systems, rather than how production systems can be harnessed to manage crop diversity. A related concept is *seed security* defined by FAO as "ready access by rural households, particularly farmers and farming communities, to adequate quantities of quality seed and planting materials of crop varieties, adapted to their agro-ecological conditions and socioeconomic needs, at planting time, under normal and abnormal weather conditions" (FAO 1998). In these terms, the objective of this review is to assess approaches that use genebank accessions in *seed system interventions* aiming to *increase seed security*.

The methods we have used to solicit information about approaches and projects include (1) a literature review (scholarly literature as well as grey literature), (2) a survey among genebank managers and organisations and development actors involved with seed system work, (3) primary data collection from the international genebanks of the CGIAR and (4) interviews with key seed system practitioners and policy makers. The questions included in the survey are listed in Annex 1. Respondents were taken to different questions according to their role as either an *ex situ* plant genetic resource collection *holder* or an institution involved in facilitating on farm *use* of *ex situ* conserved plant genetic resources. We received a total of 77 responses, with the majority (75%) from collection holders. Many respondents had not responded to all questions, precluding meaningful statistical analyses. Rather we used the input to obtain a better overview of relevant projects and activities. The interviews were done with key informants identified during the survey and literature review process.

This report proceeds as follows: First we provide a brief assessment of the current magnitude of direct distributions from gene banks to farmers. Second we present the six main categories of approaches identified: Reintroduction, Community Seed Banking, Participatory Plant Breeding, Emergency Seed Interventions, Variety Introduction, and Integrated Seed System Approaches. We describe each category according to purpose and activities, historical roots, merit and current status. In the conclusion, we discuss challenges with the approaches and point at opportunities to overcome some of these challenges, realize synergies and find common ground for the *ex situ* conservation agenda and the farmers' rights agenda. Finally, in the annexes, we provide an overview of major projects, actors and donors.

1.1. The magnitude

The first question of relevance to our objective in this study is what the relative magnitude of distribution from genebanks to farmers is. The survey we undertook for this study showed that there is large variation in the availability and type of distribution data. Not all genebanks distinguish between user groups in such a way that the number of accessions distributed directly to on farm research or use can be singled out. However, the Multilateral System (MLS) of the ITPGRFA does provide some guidance on this aspect. The on-line information tool for the generation, use and reporting of SMTAs (the EasySMTA) has separate user categories for *Farmers* and *Non-Governmental Organizations* and when this information eventually is published as part of the Information Sharing Mechanism it will be possible to analyze to what extent farmers and organizations working with farmers are an important recipient group from all the genebanks in the MLS[1]. In the meantime we have access to distribution data from the CGIAR genebanks. These genebanks are among the most important in terms of number of international germplasm distributions. In 2015 more than 40,000 samples were distributed[2].

In Figure 2 we report distribution of germplasm samples (includes seeds and vegetative propagation material) to the major user groups by CGIAR center and crop in the period 2012-2014. The share of distribution to farmers' organizations varies from zero (e.g. wheat from CIMMYT) to being the largest user group (forage trees from ICRAF). Obviously the crop type is important to interpret these numbers; while a tree accession might be immediately useful in a production system an accession of wheat can hardly be used before it has been multiplied several times. At the same time we see fairly large distribution numbers for other crops that requires multiplication such as rice accessions from IRRI and bean accessions from CIAT.

Figure 3 shows distribution data from 2015 for all crops aggregated. From this graph we see that farmers, farmer organizations and NGOs indeed comprise a substantial user group of the CGIAR genebanks, receiving some seven percent of the samples, on par with the distribution to commercial sector requestors. In this report we bring forth examples of use of both CGIAR genebank material and national/sub-national genebanks.

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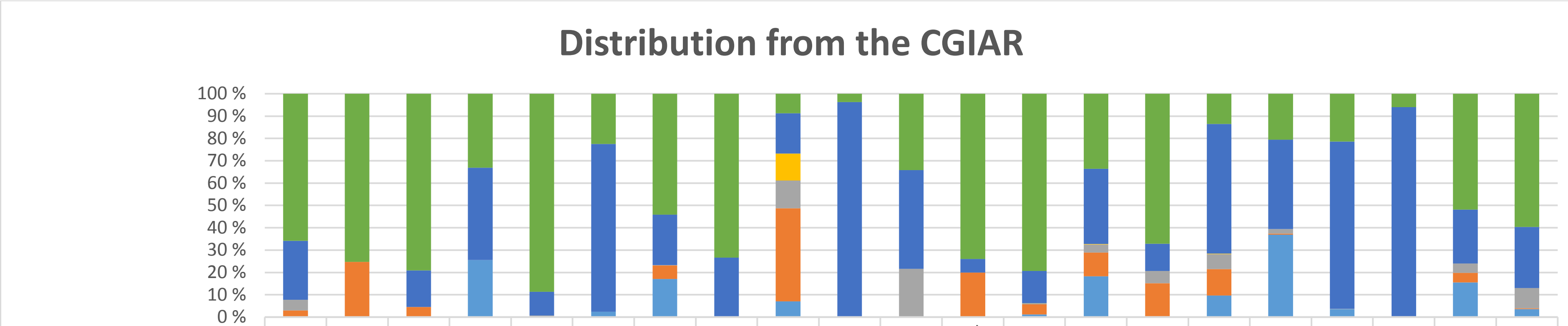
[1] Report from the Friends of the Co-chairs Group on User and Crop Categories http://www.fao.org/3/a-bp084e.pdf

[2] Data obtained from the Crop Trust based on Annual Reports from the CGIAR genebanks in the CGIAR Research Program for Managing and Sustaining Crop Collections use managed by the Crop Trust.



	Cowpea (IITA)	Maize (IITA)	Groundnut (ICRISAT)	Pearl Millet (ICRISAT)	Pigeon pea (ICRISAT)	Small millets (ICRISAT)	Sorghum (ICRISAT)	Chickpea (ICRISAT)	Trees (ICRAF)	Barley (ICARDA)	Wheat (ICARDA)	Andean roots & tubers (CIP)	Potato (CIP)	Beans (CIAT)	Cassava (CIAT)	Forages (CIAT)	Maize (CIMMYT)	Wheat (CIMMYT)	Rice (Africa Rice)	Rice (IRRI)	Banana (Bioversity)
Universities	577	73	976	627	2 435	451	2 598	12 019	204	100	1 015	536	3 082	2 186	377	288	2 316	4 581	1 337	21 511	1 242
NARS	232	0	201	784	295	1 513	1 083	4 341	422	2 612	1 311	44	559	2 189	68	1 232	4 487	16 052	20 719	9 966	569
International genebanks	0	0	0	0	0	0	0	0	280	4	0	0	4	14	0	4	0	0	0	0	0
Individuals	42	0	0	0	10	0	3	0	292	0	643	0	17	233	31	142	233	6	0	1 745	190
Farmers' orgs	26	24	56	0	1	0	290	13	972	0	0	145	177	697	83	252	57	0	64	1 815	6
Commercial sector	0	0	0	484	7	47	821	0	165	0	0	0	44	1 187	2	204	4 146	778	27	6 414	75

Figure 2. Distribution of germplasm samples from selected crops from CGIAR genebanks 2012-2014. Source: Annual reports of the CGIAR genebanks to the Global Crop Diversity Trust.

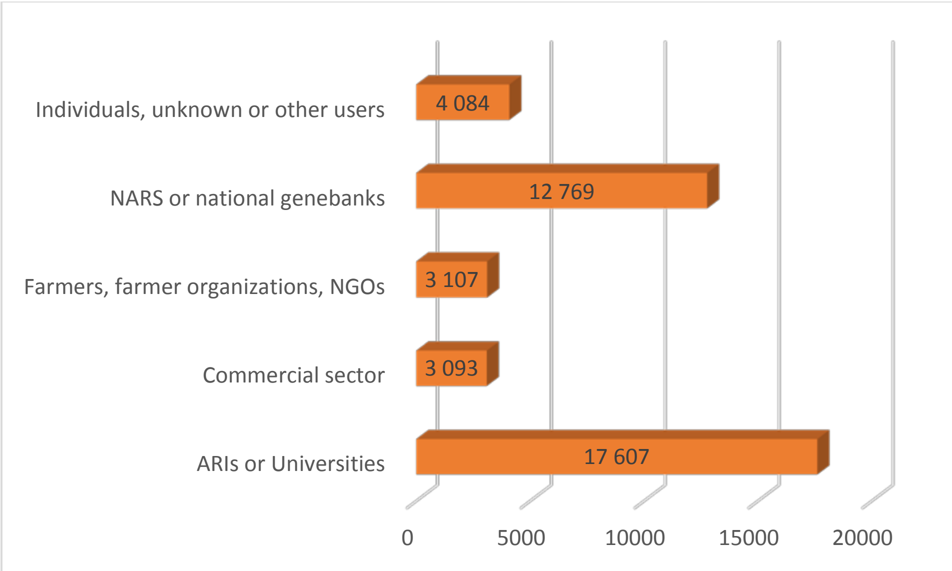


Figure 3. Distribution of germplasm samples from CGIAR genebanks in 2015. Centres and crops included: AfricaRice, Bioversity, CIMMYT, CIAT, CIP, ICARDA, ICRAF, ICRISAT, IITA, ILRI, IRRI; Rice, Banana, Beans, Cassava, Forages, Maize, Wheat, Andean roots & tubers, Potato, Sweet potato, Barley, Chickpea, Faba Bean, Forages, Grasspea, Lentil, Pea, Wheat, Fruit trees, Multipurpose trees, Chickpea, Groundnut, Pearl Millet, Pigeon pea, Small millets, Sorghum, Cassava, Cocoyam, Cowpea, Misc. legumes, Yam, Forages & fodder. Data source: Annual reports of the CGIAR genebanks to the Global Crop Diversity Trust.

2. Approaches

In these next sections we turn to look at different approaches used to introduce genebank accessions in on farm work. Based on a literature review, a survey and interviews we identify six categories of approaches, with one category classified as integrative approaches.

2.1. Reintroduction

In this report, re-introduction involves direct transfers of landrace seeds from genebank collections to farmers and gardeners, as individuals or groups, in order to restore lost or diminished crop varieties/species, originally collected from the same area or similar agroecological zones. The same approach is also called restoration when the aim is to re-establish lost plant species (FAO nd) or repatriation (Potato Park et al. 2004). One type of reintroduction is when seeds samples are multiplied and introduced in rural areas struck by crises and disasters. We will elaborate further on this under "Emergency Seed Interventions" below. Another type is reintroduction motivated by on farm conservation concerns, or farmers or gardeners' wishes to access planting material that gradually has disappeared, and no longer is available through existing seed sourcing channels. The present section will focus on this latter type of reintroduction.

Reintroduction of landrace seed can take place as an integral part of projects with a broader scope, such as the establishment of community seed banks or participatory plant breeding. It can also form a main activity in itself. Reintroduced seed can be distributed on the request of individuals (typically non-project based), or it can be distributed to farmer/gardener groups, who then further multiply and distribute seed amongst themselves (more often project-based). As shown below, NGOs often mediate the interactions between genebanks and farmers.

The genebank system was not set up with reintroduction directly to farmers in mind, but rather organized to provide samples to present and future breeders and researchers. Still, reintroduction events took place in various genebanks from the 1990s, and, probably in rare cases, also before. For instance, Ngoc De (2000) reports that Can Tho University in Vietnam reintroduced landraces from their genebank collections as part of the initiation of participatory breeding efforts already in 1975. Reintroduction of landraces from the national genebank collections has also been part of the *in situ* conservation work taking place in Ethiopia since the late 1980s (Worede et al. 2000).

In several cases, representatives from indigenous groups have put forth requests of access to lost landraces to genebanks. In Brazil, a series of reintroductions from genebanks in the Brazilian Agricultural Research Corporation (Embrapa) national *ex situ* conservation system was initiated in the mid-1990s, after a request from Krahô indigenous farmers (Borges Días et al. 2013). The Krahô community had lost a particular maize type of ritual importance, pohypey, and its leaders went to ask for seed to the Embrapa genebank in Brasilia, upon learning from an extension worker of its existence in the genebank's collections. Six relevant varieties, actually collected from another indigenous group, were identified, and small amounts of seed provided. When farmers the following year returned seed from their new harvests to the genebank, they gained trust among its conservation professionals, something which would form the initiation of a long-term community conservation collaboration. Subsequently several other indigenous groups having heard of the Krahô example also contacted Embrapa for recovering formerly cultivated varieties, and seeds of maize, squash and sponge gourds have since been identified, multiplied, and distributed.

The reintroduction project having received most international attention is probably the 2004 repatriation agreement between the International Potato Center (CIP) and the six indigenous communities comprising the Potato Park in Cuzco, Peru (Potato Park et al. 2004). Brokered by the regional NGO, Association for Nature and Sustainable Development (ANDES), the agreement to transfer 410 potato accessions from the CIP genebank in Lima to the Potato Park communities was unique not only because of the substantial amount of diversity involved, but also because of the legal contract regulating it. This contract emphasized the rights of the farming communities who originally contributed to the development and maintenance of agricultural biodiversity to have access to collected seed and associated technology and knowledge. The Potato Park was established as an indigenous biocultural heritage area, linking on farm conservation to the revitalization of local cuisine, traditional medicine and customary laws, and development of ecotourism activities (Argumedo 2008). A community potato seed bank (see section below) curates both repatriated varieties and material collected locally. In fact, local material by far outnumbers the reintroduced, amounting to some 900 native varieties, of which 200 have been collected and deposited in the CIP genebank. Since 2004, CIP, the Potato Park and ANDES have developed a strong relationship, and recently, a new 5-year contract for continued collaboration in conservation, research and development work was signed (CIP 2016). In later years, climate change adaptation has become another focal point of the collaboration; by managing diversity, farmers cope with altered growing conditions (IIED 2014).

CIP, however, has been involved in reintroduction efforts both before and after the Potato Park. Between 1998 and 2008 a total of 3608 samples of some 1250 native varieties were distributed to 41 communities (Tay 2009). This figure has since increased to at least 4600 samples (CIP nd). CIP is presently working to scale-up the Potato Park experiences to a pan-Andean project, establishing on farm conservation sites and community seed banks to introduce previously collected native varieties in a series of former collection hot spots from Jujuy in Argentina to Merida in Venezuela (CIP nd; Meza et al. 2012). In 2016, the Peruvian national agricultural research institute (INIA) together with CIP received government funding for developing phytosanitary diagnostic tools "in order to increase the distribution, repatriation and use of virus-free seed of" other native Andean root and tuber crops (INIA 2016). The reintroduction work is thus expanding to new crops in the Peruvian context.

Phytosanitary cleaning is an important aspect of genebanks' provision of seeds of clonally propagated crops such as the potato. Viruses and other pathogens typically accumulate over time, reducing yields. Contemporary processes such as increased long-distance trade and climate change may accelerate this process. When farmers seek to regenerate their seed stocks with cleaner seed, it is key for the maintenance of diversity that not only improved varieties, but also landrace material is available (Iriarte et al. 2000). In order to address this situation, the PROINPA genebank in Bolivia has engaged in projects to clean up landrace seed in a participatory process involving farmers as selectors and propagators (Iriarte et al. 2000).

In Ecuador, the genebank of the national agricultural research institute, INIAP, has supported on farm conservation activities for at least 15 years, including reintroductions from its collections, along with diversity fairs, initiation of community seed banks, and awareness raising (this survey). For instance, INIAP has collaborated with a county-level civil society organization, UNORCAC, to promote on farm conservation since the early 2000s. In a project running from 2002-2008, supported by the United States Department of Agriculture, UCODEP (an Italian NGO) and Bioversity International, they employed various strategies and activities, including the reintroduction of accessions formerly collected in the project area (Tapia Bastidas and Carrera Rueda 2013). An initial 480 accessions of seven crops were planted in diversity blocks[3], and a sub-selection based on farmers' evaluations was multiplied up on communal land and distributed to interested farmers. New accessions were also collected and deposited in the genebank, and the collaboration has continued; INIAP and UNORCAC are currently involved in a larger-scale project funded by the Global Environmental Facility and supported by FAO, focused on both *ex situ* and *in situ* conservation across sites in three Ecuadorian highland provinces (GEF 2016).

In Chile, the national agricultural research institute (INIA) is presently involved in four projects that have a reintroduction component (this survey). These include one international effort with participants from Argentina, Uruguay and Paraguay, one national project, and two regional initiatives. The larger projects cover several crops, while the regional initiatives are focused on specific local, landrace types of maize and tomatoes. In addition to providing access to material from *ex situ* collections, the projects encompass activities such as multiplication, initiation of community seed banks and farmer networks, characterization, protection through achieving geographical indications, commercialization, and participatory breeding. Two of the projects are farmer initiated.

Also in the Global North, farmers and gardeners demonstrate a growing interest in accessing *ex situ* conserved planting material from genebanks. In many countries, seed saver networks have emerged, to which genebanks may provide small amounts of seed that later are multiplied and shared within the membership. All of these networks promote the exchange of seed between members, e.g. through issuing catalogues with overviews of who can provide seed of different varieties, and some, such as the Seed Savers Exchange in the US (www.seedsavers.org) and Arche Noah in Austria (www.arche-noah.at), have established their own *ex situ* collections, from which seed may be ordered online. Members typically

[3] Diversity block is an experimental block of farmers' varieties managed by local institution for measuring and analyzing agro-morphological characteristics as well as for validating farmers' descriptors. Development actors use this for raising public awareness, exchange of germplasm, seed production of rare cultivars.

include farmers and hobby gardeners with a particular interest in diversity, spread out across the country in question (Arndorfer et al. 2009; Kendall and Gras 2013).

For instance, the Maison de la Semence Paysanne in France was formed in 2001 by a group of farmers in search of non-hybrid and non-GMO maize seed for organic production. They initially obtained seed both from the INRA genebank and from other farmers, and have since grown to a national network comprising 250 farmers in different parts of the country (Kendall and Gras 2013).

There are not many reported projects where genebanks have actively intervened to reintroduce collected accessions to farming communities in the Global North, but they exist. The Hiroshima Agricultural Gene Bank has worked closely with farming communities in the province of Hiroshima since the 1990s, in order to reintroduce rare vegetable varieties, and support their cultivation and commercialization (Nishikawa and Winge 2013). The genebank has since 2001 offered a "seed loan" system, where farmers receiving seed commit to return seed after harvest. They have also run a project on "treasure vegetables" – locally collected landraces with particularly good agronomic and culinary characteristics – with selection, multiplication, seed distribution and promotion among growers and consumers.

Some genebanks routinely send seed samples to farmers and gardeners requesting seed for their own cultivation. The Suceava national genebank in Romania began such shipments in 2009, through the initiation of a yearly shipment campaign carried out by committed staff (Ana 2015). The INIA genebank in Chile reports to have begun such shipments in 2014, and have sent some 100 samples each year to farmers since then (this survey).

The Nordic Genetic Resource Center (NordGen), collectively conserving plant genetic resources for Finland, Sweden, Norway, Denmark and Iceland, reports to have experienced a great increase in orders from private gardeners and farmers during the last years. Unable to fulfill all the requests, they have proceeded to limit the annual time period through which online orders can be made (NordGen 2016). In 2010, NordGen handled 186 request of in total 1552 accessions from private gardeners and farmers. In 2015 and 2016 each seed requester could only order maximum 10 samples and NordGen had also made a cap on 6000 samples. These were distributed within a few days (pers comm Jette Nydam Hansen). NordGen are currently working with national seed saver networks to overcome challenges related to catering to requesters through the development of a new model for participatory plant conservation and breeding, in the form of a "user genebank" taking on the tasks of seed multiplication and distribution as well as gathering data on seed performance and characteristics (this survey). An example of such a user genebank, on a more limited scale, was established by the Norwegian farmer Johan Swärd for cereals. Native Norwegian cereal diversity was all but extinct, but Sward obtained seed from NordGen and multiplied them (Asdal 2012). With the institutional support of a regional extension agency and the Norwegian Genetic Resource Center, he offers 1 kg packets of a selection of some 50 varieties to all interested farmers (Ystad 2016).

2.2. Merits and Prospects

While many related projects have been conservation oriented, the above experiences indicate that reintroduction of collected seed from genebank *ex situ* repositories is an approach that also carries potential to increase farmers' seed security by enhancing resilience. . It may replenish diversity in sites where it due to various reasons has dwindled. It may restore people's access to seeds of particular, lost but remembered varieties, as in the case of Krahô's pohypey maize. Where a more wholesale loss of diversity has taken place, it may serve as a source to a broader set of landraces, even of whole crop complexes, as in the case of Norwegian cereal diversity.

Beyond the seed itself, reintroductions can fuel processes of cultural revitalization and awareness building, again leading to fertile ground for *in situ* conservation and further agricultural development (Nazarea and Rhoades 2013; Nishikawa and Winge 2013). Thus, looking back at the reintroductions involving Embrapa genebanks in Brazil, its staff noted:

> "This exemplifies the importance of interactions between *ex situ* and on-farm management, because it led not only to the recovery of local varieties but also to the revitalization of indigenous people's rituals and myths, which is important for maintaining their culture and for maintaining plant genetic resources within communities" (Borges Dias et al. 2013: 93).

Reintroducing material from *ex situ* collections carries symbolic weight, especially when it is brought back to indigenous farming communities that historically have contributed to collectors without receiving much in return, and can thus be a form of realizing Farmers' rights, as instituted in the International Treaty on Plant Genetic Resources for Food and Agriculture (Andersen and Winge 2013).

Reintroduction can form a focal point for development of mutually beneficial collaborative relationships between farming communities and genebanks, encompassing knowledge and technology transfer and participatory research. This is equally relevant in developing as well as developed countries, as exemplified by the work of CIP and NordGen above. As the examples above show, the scopes and aims of such research and development can range from efforts to increase the use of diversity by building high-value niche products through activities such as characterization, geographical indications, and agrotourism, to breeding and crop adaptation to climate change.

As noted above, the genebank system is designed for provision of accessions to breeders, researchers, and other genebanks, and transferred samples are therefore small. Gardeners and in particular farmers, on the other hand, need larger seed quantities. Genebanks generally do not have the infrastructure or capacity to regenerate and distribute large quantities of each accession, and the number of samples they are able to prepare may also be limited. If reintroduction is going to take place on a larger scale beyond occasional requests, there is therefore a need to establish new mechanisms for seed multiplication and distribution. Several options exist here. As seen above, local organizations such as farmers' associations and seed saver networks often play a key role in mediating the relationship between growers and genebanks, and they may contribute toward multiplication as well as distribution. Community seed banks and seed banks run by seed saver networks have successfully been established in many settings, facilitating access to many users (see next chapter). One challenge related to the exchange of seed between members in these kinds of groups concerns phytosanitary aspects, particularly critical for clonally propagated crops. In Norway, this issue has been addressed by establishing a national genebank for potatoes which offers small amounts of disease-free mini-tubers of selected landraces, funded and coordinated by the Norwegian Genetic Resource Center (Rasmussen 2016).

Another challenge is to identify proper material suiting users' needs. The type of information needed by gardeners and farmers is typically different than what is needed by researchers, and may include agronomic performance in marginal settings, appropriate management practices, culinary qualities, storage properties, and cultural information regarding the histories of the varieties, all aspects that are dearly lacking in most passport data (Asdal 2011; Bramel-Cox 2000). Enhancing passport data may be done by expanding data collection for future collection expeditions, by recollecting *in situ* data for formerly collected accessions, and by growing out, testing and characterizing such accessions. Nazarea (1998), in the context of work at CIP's UPWARD programme, developed "memory banking", a detailed protocol for how to collect cultural information that can be linked up to genebanks' passport databases. Bramel-Cox (2000), from the perspective of work at ICRISAT, suggested documenting farmers' knowledge during germplasm collections, including farmers' names and environmental descriptions, farmers' descriptions of variety characteristics, end uses and specific properties, cultural practices, and the history of the variety with the farmer in question. Farmers' knowledge can also be sought by returning to sites of former collections, and interviewing farmers, employing a memory banking protocol (Nazarea 1998, 2005). Finally, it is possible to create new, relevant knowledge by planting and evaluating genebank accessions according to criteria determined by farmer user groups, either on research stations or in a participatory manner involving growers as citizen scientists, as is proposed in the NordGen user genebank model.

3. Community Seed Banks

The practice of saving, preserving, and exchanging seed within a farming community is as old as agriculture itself. Community seed banks are institutions for collective action where organized groups of farmers manage and govern different "stages of seed management – selection, conservation, multiplication, exchange and improvement"' (Vernooy et al. 2014), sometimes in collaboration with national genebanks (Feyissa et al. 2013; Jarvis et al. 2011; Melaku et al. 2000) and agricultural research institutions including universities (Global Alliance for the Future of Food 2016; Jarvis et al. 2011). Community seed banks are local institutions and mostly part of informal or farmers' seed systems. "It is the key component of the community seed network, representing a low-cost and low-technology demanding system for seed management that may be owned and managed by local communities as part of existing community services including cooperatives" (Melaku 2011).

The main function of community seed banks is to maintain seeds for local use. But different community seed banks serve various functions. These include: 1) conserving and reintroducing germplasm – short and long-term preservation of small seed samples of crop varieties for direct use or for breeding material in participatory variety improvement; 2) providing access to seeds for members of the community – timely availability of locally adapted good quality planting materials; 3) enhancing seed and food sovereignty – by recovering, maintaining and increasing the control of farmers and local communities over seeds. Depending on how they are organized, community seed banks serve one or a combination of these functions (The Development Fund 2011; Vernooy et al. 2015; Vernooy et al. 2014). Experiences documented from all around the world demonstrate that most community seed banks focus mainly on traditional varieties, but some incorporate farmers preferred improved varieties that are released and certified through the formal seed regulatory framework (Vernooy et al. 2015), demonstrating their potential role in integrating formal and informal seed systems (Sthapit 2012).

In a recent book about community seed banks (Vernooy et al. 2015), the editors established that the founder of community seed banks was the Rural Advancement Foundation International (RAFI), now known as Action Group on Erosion, Technology and Concentration (ETC group), a non-governmental organization working on policies related to conservation and sustainable use of plant genetic resources at the global political level. The earliest program known to have promoted community level seed management is that of USC Canada's Seeds of Survival Program in 1989 following the drought that affected millions of people in Ethiopia (Dalle and Walsh 2015; Melaku et al. 2000). Later, this program led to the establishment of a community seed bank practice that spread in South and West Africa, South and Southeast Asia and Latin America in the 1990s. Some countries such as Brazil, India and Nepal now have a large number of community seed banks. Other countries such as Bhutan, Bolivia, China, Ethiopia, Guatemala, Mexico, Rwanda, South Africa, and Uganda have a lower number of community seed banks (Vernooy et al. 2015). In most of these countries community seed banks have been supported externally by non-governmental organizations. The rest have been run either by volunteer members who work together using local resources and facilities or through local financing and governance by an elected committee or by the public sector (*ibid*).

Community seed banks are advocated both by civil society groups (Correa 2015; GFAR et al. 2015; Teshome and Ortiz 2015; The Development Fund 2011; The Right to Food and Nutrition Watch Consortium 2016) and academics (Andersen et al. 2013; Andersen and Winge 2011; Sthapit 2012; Vernooy et al. 2016) as an appropriate platform to effectively implement farmers' rights as set out in the ITPGRFA. On the other hand, implementing Farmers' Rights to save, use, exchange and sell farm-saved seeds in national seed legislations is recommended as crucial policy steps to create the necessary legal space for CSBs (Sthapit

2012; Teshome and Ortiz 2015; Vernooy et al. 2016). Thus, CSBs are a way to operationalize Farmers' Rights and Farmers' Rights are a prerequisite for CSBs to be able to operate.

Farmers holding biodiversity fair including genebank samples multiplied by CSB group in Dremetse Geog in Eastern Bhutan - Photo T. Hunduma

3.1. Merits and Prospects

Until recently, the information on the history and features of community seed banks was mostly confined to gray literature produced by its promoters such as non-governmental organizations, donors and some governments. In recent years, a number of new publications have shaped the scientific understanding of community seed banks and helped in guiding their management to become more science based and rigorous (Chaudhary et al. 2001; de Boef et al. 2013; Jarvis et al. 2011; Maluleke et al. 2015; Shrestha et al. 2006; Shrestha et al. 2012; Vernooy et al. 2016; Vernooy et al. 2015; Vernooy et al. 2014), thus increasing their potential for scalability in developing countries and for contributing to national seed security in a significant way. A manual on how to establish a functioning community seed bank published by Bioversity International (Gupta et al. 2015) is based on these publications and aiming to guide practitioners to effectively integrate seed technology and community biodiversity registers. A community biodiversity register refers to a participatory process whereby community members "record and keep information in a register, of the genetic resources in a community, including information on their custodians, passport data, agro-ecology, cultural and use values" (See also Andersen et al. 2013; Rijal et al. 2003, p. 233). By so doing, Bioversity aims to help practitioners in solving the technical challenges they face in seed management to contribute to easy expansion of community seed banks based on a robust documentation system. Newly established community seed banks in Uganda and South Africa have already benefited from lessons learned from other countries and Bioversity's capacity building program (Maluleke et al. 2015; Vernooy et al. 2015).

Although there seems to be renewed interest among different actors in community seed banks, they face a number of challenges. These include financial limitations, technical and organizational capacity and policy and legal frameworks (Vernooy et al. 2015; Vernooy et al. 2014). For example, Vernooy et al. (2015) mention that only a few community seed banks (in Ethiopia, Costa Rica, Nepal and Zimbabwe) have evolved into economically sustainable local seed businesses. In terms of policy and legal environment, both seed regulations and provisions on intellectual property rights to seeds are cited as impediments to the implementation of community seed banks in many countries (Vernooy et al. 2016). Currently the implementation of these instruments is very different among countries varying from essentially no control to strict laws about the labeling of seeds, terms of use and their distribution (Vernooy et al. 2016; Vernooy et al. 2015).

Many of the respondents to our survey reported that community seed banks facilitate better use of *ex situ* collections by farmers and their communities. Both our literature review and the current survey revealed that multiplication of germplasm conserved *ex situ* is important for distribution to farmers. Genebank accessions are generally small and distribution lots are too small to be used directly by farmers and CSBs can play the role as intermediary. The two countries where CSBs are most widespread and involve the largest number of farmers are Ethiopia and Nepal. In Nepal there are more than 100 self-described CSBs "with functions ranging from pure conservation to commercial seed production" (Vernooy et al. 2015). In 2016, there are 21 functioning community seed banks in Ethiopia (this survey). Countries such as Bhutan, Brazil, Ethiopia, Guatemala, India, Nepal, Mexico, South Africa, and Uganda have either approved or are considering the approval of policy measures and legislation in recognition and support of community seed banks (Vernooy et al. 2016), thus showing a positive trend among governments to integrate community seed banks into their seed sector development.

CSBs are not stand alone projects, to be meaningful they must link with other seed system approaches. The following account from our interviews illustrates this. Melaku Worede, the former Director of the Ethiopian Plant Genetic Resources Centre, now known as Ethiopian Biodiversity Institute (EBI) told the story of how the current network of CSBs in the country started as a post-emergency intervention:

"The drought and famine that struck Ethiopia during the mid-1980s was a disaster, especially in the north-eastern (Welo) and northern (Tigray) parts of the country. Very few farmers did dig and hide their seeds under the ground before they migrated to the central, southern and western parts of the country. Many of the farmers were forced to either consume or sell their seeds in exchange for other food commodities. When enough rain came after two years and the people moved back to their homestead, they had nothing to plant. They had to depend on the grain and seed aid. That was another crisis as the seeds planted did not fit the local agro-ecological conditions and resulted in crop loss. We had thousands of accessions that were collected from the area and similar agro-ecological zones in Ethiopia in the genebank. But we had only small samples. (…) Thanks to the generosity of the Consortium of Canadian NGOs, we managed to launch Seeds of Survival (SoS) Ethiopia programme in 1989 with the support channeled to us through USC Canada, a Canadian NGO. I would also like to thank people like Pat Mooney of ETC group and the then Executive Director John Martin of USC Canada who were very understanding and supportive of what we wanted to achieve. We used the financial resources channeled to us from USC Canada to train farmers and our staff and to multiply germplasm we hold in the genebanks. Hundreds of farmers were involved and we managed to inject a great diversity of sorghum and maize into farmers' seed system in Welo and Tigray. We also did similar work with durum wheat and chick pea in the east central part of the country (east Shoa). The project "A Dynamic Farmer-Based Approach to the Conservation of African Plant Genetic Resources" funded by the Global Environmental Facility (GEF) was based on what we had achieved in seed multiplication of traditional varieties through networks of farmers in the late 1980s and early 1990s. The project was implemented from 1992-1997, and the genebank established 12 community seed banks in six different agro-ecological zones and trained dozens of Ethiopians. However, the project was conservation based and it had less attention on farmers' livelihood. There were also some CSB that were established in areas where tree and tuber crops are dominant. These were not particularly successful. But many of the community seed banks are still functional. We learnt a lot of lessons and the community seed bank approach has now greatly empowered farmers in those areas where cereal crops are dominant and NGOs, especially the Ethio-Organic Seed Action, for which I am still board member, are supporting the work." (Melaku 2016)

4. Participatory Plant Breeding

Plant breeding is the process of developing new crop varieties. Conventional plant breeding is based on rather simple principles: parents (varieties) with specific traits or characteristics of interest are crossed and offspring with desired trait combinations are selected for further refinement or crossing (McCouch 2004). The plant breeding programs during the so-called Green Revolution (GR) were characterized by high intensity breeding pipelines in which the initial germplasm was developed by International Agricultural Research Centers (IARCs) and adapted to local conditions in national public breeding programs (Conway 2012; Evenson and Gollin 2003). This centralized plant breeding was typical of the "state intervention" era in agricultural development (Sumberg et al. 2013). Participatory plant breeding (PPB) represents a countermovement to the top-down approach in GR style breeding programs. It is an operationalization in plant breeding of the participation agenda of the "farmers first movement" (Chambers and Ghildyal 1985; Chambers and Thrupp 1994) that swept in the 1980s and 1990s and significantly changed the agricultural development agenda (Sumberg and Thompson 2012; Sumberg et al. 2013).

PPB can be defined as a breeding process in which farmers and breeders jointly select cultivars from crosses under specific target environments (Jarvis et al. 2016). The commonly cited rationale behind PPB is that it enables development of varieties that are better adapted to local environmental and management conditions, especially for smallholders in developing countries, compared to conventional breeding programs. Thus, in addition to farmer participation, a central element of PPB approaches is that they are decentralized (Ceccarelli and Grando 2007; Desclaux et al. 2012; Sperling et al. 2001). While the PPB approach first and foremost has been used in the context of development oriented agronomic research in the Global South, it has more recently become an important approach in crop development for organic and other forms of low external input agriculture in the Global North (Chable et al. 2014; Desclaux et al. 2012). Consequently, PPBs today spans a wide spectrum of agro-ecologies and farming systems, from marginal to favorable, and from subsistence systems to commercial farming (Almekinders and Hardon 2006; Sperling et al. 2001).

The degree of farmer participation in PPB varies from participatory varietal selection (PVS) to taking active part in all stages from selection of source germplasm, to trait development, cultivar development and evaluation (Morris and Bellon 2004). Sperling et al. (2001) developed a typology of PPB based on some key variables, including the kind of participation achieved. In projects with the highest degree of participation, farmers are involved as researchers in all the development stages as well as in the seed multiplication and distribution process (Dawson et al. 2008; Sperling et al. 2001). Sperling et al. (2001) make a broad distinction between "formal-led PPB" and "farmer-led PPB" based on the role of the professional plant breeders vs that of the farmers involved. Formal-led PPB programs are "researcher controlled" and plugged into a formal seed system while farmer-led programs typically are initiated by NGOs or CBOs and the breeders are expected to facilitate a process in which farmers establish the breeding objectives. The best known formal-led PPB programs are probably those led by Salvatore Ceccarelli at the International Centre for Agricultural Research in the Dry Areas (ICARDA). The programs started in Syria in the 1990s and has since expanded to several countries in West Asia and North Africa (Ceccarelli 2015; Ceccarelli and Grando 2007; Ceccarelli et al. 2001). A number of international centres such as ICRISAT, IITA, CIAT and CIMMYT have since followed ICARDA's example and engaged in PPB as a way to reach groups of farmers and areas that were bypassed by the GR. Many farmer-led PPB programs are small-scale, but there are examples of large scale programs such as the Biodiversity Use and Conservation Asia Programme (BUCAP) which started in 1996. This project grew out of the Biodiversity Development and Conservation Programme network. This is also the roots of the on-going Sowing Diversity, Harvesting Security

(SD=HS), a larger crop diversity and food security centered program encompassing PPB, implemented in several countries in South East Asia, Africa and Latin America. SD=HS is coordinated by Oxfam-Novib and implemented by a number of national and regional NGOs together with local farmer groups and national agricultural research institutions. SD=HS builds on CBDC-BUCAP co-funded by SwedBio of Sweden, Development Fund of Norway and Oxfam-Novib.

Participatory plant breeding in the Mekong Delta, Vietnam. Photo: H.K. Tin.

4.1. Merits and Prospects

The literature on the merits of PPB is for the most part written by researchers involved in PPB work, including some reviews of the state of the field (e.g. (Almekinders and Hardon 2006; Dawson et al. 2008; Morris and Bellon 2004; Sperling et al. 2001; Weltzien et al. 2003). Some examples of more recently released PPB developed varieties described in the peer reviewed literature include sweet potato in South Africa (Laurie and Magoro 2008), sweet potato in Uganda (Gibson et al. 2011), rice in Nepal (Gyawali et al. 2010), barley in Ethiopia (Abay et al. 2008), and common beans in Ethiopia (Asfaw et al. 2012). However, many PPB projects do not necessarily aim for official release of the varieties developed, but rather disseminate the varieties developed in the informal seed systems and consequently the documentation of the outcomes are often less rigid than in conventional breeding programs which often report their achievements in terms of number of varieties released (Almekinders and Hardon 2006; Ceccarelli 2015). Some of the relatively few studies that document outcomes of PPBs include Trouche et al.'s (2011) account of how "Farmer on Farm" selection of sorghum in Nicaragua was more effective than both "Breeder on Station" and "Breeder on Farm" measured both by agronomic performance and farmer appraisal of the new varieties. Likewise, Ceccarelli et al. (2001) reported that farmers are more effective than breeders at selecting superior barley genotypes in their own fields. Ceccarelli (2015) furthermore cites economic Cost-Benefit analyses from Mexico and Syria which show that PPB programs have significantly higher return on investment compared to conventional programs. Sperling et al. (1993) showed that farmers' selection of breeding lines outcompeted that of breeders measured in terms of yield and adoption over time (Sperling et al. 1993).

Assessments of the socioeconomic suitability of PPB have identified both strengths and challenges with PPB compared to conventional centralized approaches (Jones et al. 2014; Mendum and Glenna 2009). Assessing sorghum and pearl millet PPB in West Africa, Jones et al. (2014) concluded that the program led to a range of positive "instrumental and empowerment outcomes" for the farmers involved, including increased access to suitable seeds. In a Northern American context researchers identified several important obstacles for PPBs, ranging from the declining number of traditional breeders working outside the private seed industry, intellectual property policies as well as funding policies (Mendum and Glenna 2009). A commonly reported successful outcome is the faster adoption of PPB developed material ensured by the involvement of the farmers in the process (Ceccarelli 2015; Sperling et al. 2001).

Turning to the question about the extent to which genebank material is used in PPB we identify an information gap in the literature. Peer reviewed papers and other reports typically do not specify if the parental lines used originally were sourced from a genebank and/or if they are stored in a genebank currently. The review by Sperling et al. (2001) mentions genebanks only when discussing potential capacity building outcomes and Dawson et al. (2008) do not mention genebanks at all. Almekinders et al. (2006) place genebank material alongside other potential breeding material: "Suitable varieties or breeding populations may be collected from neighbouring communities, farmers in other districts, from research stations or national and international genebanks".

In the survey undertaken for this study we explicitly asked for information about the use of genebank material and we learned that many of the ongoing PPB programs, both formal and the farmer-led, do indeed use genebank accessions. The role of the genebanks span from being an input provider (e.g. the IRRI genebank supplies various organisations with material for PVS and PPB alongside some technical advice) to active involvement in the design and implementation of the PPB programs (e.g. the CATIE genebank has a program on PVS in chili and tomato in Central America). Before genebank accessions can be used in PPB they will normally have to undergo a pre-breeding process to transfer traits to parents that are feasible to work with. Accordingly, the material used in the PPB in the SD=HS program coordinated by Oxfam Novib is pre-bred; the maize populations used in Zimbabwe are F3 and F4 segregating populations from CIMMYT and their pearl millet and sorghum PPB in West Africa and their potato PPB in Peru uses breeding populations from ICRISAT and CIP (Visser, pers. comm.). This material is based on landrace accessions held in these CGIAR centres, but usefulness in the breeding programs thus relies on several steps of pre-breeding, both at the international centers and at the local research breeding stations operated by these centers. In other cases the genebank in question is more of an active collection and not necessarily linked with a long-term storage facility. The SD=HS operation in Vietnam is operated by the Mekong Delta Research Institute and they report using genebank material in their PPB developed varieties: The rice landrace Nang Nhuan was collected in the 1980s and was used as a parent to develop the HD1 early segregating populations (F3) used in many of the farmers' crosses (Tin, pers. comm. October 2016).

One respondent to our survey question about benefits of using genebank material in PPB says: "Farmers get access to more diverse materials for their breeding work while plant breeding institutions are assured that materials they developed together with farmers will be used by farmers." The same respondent notes the following challenge among others: "Most government policies and programs do not support this kind of initiatives hence buy-ins and cooperation from relevant stakeholders are difficult to achieve."

The latter statement speaks to the current trend in agricultural development. With the return of the Green Revolution agenda (AGRA 2013; WB 2007) there is a concern among many proponents of participatory agricultural research in general and PPB in particular that these approaches receive proportionately much less funding and policy support than conventional and private sector development focused interventions. A recent report from the Global Alliance for the Future of Food entitled "Seeds of Resilience. A compendium of perspectives on agricultural biodiversity from around the world" summarizes this concern as follows: "Government support of proprietary commercial seed research over farmer centered, participatory plant breeding approaches undermines the capacity of farmers to improve their own plant varieties" (2016, p. 10).

5. Emergency Seed Interventions

Seed distributions during and after emergencies is another approach where the use of material conserved *ex situ* may be relevant. The great majority of such distributions have taken place without the involvement of genebanks, but there are examples of their involvement.

Seed distributions to farmers in emergency and post-emergency recovery situations have formed part of humanitarian relief efforts since the 1980s (Sperling and Longley 2002). It is the most common agricultural aid intervention, and from the 1990s it has been implemented as a routine activity complementing food aid by many NGOs, governments, and agencies, particularly in Sub-Saharan Africa and parts of Asia (Sperling et al. 2008; Sperling and

McGuire 2010). Seed aid is widely considered an empowering method to enable rural households to produce their own food, recover livelihoods and reduce dependency on food aid, however, as shown in the next paragraph, the approach, and in particular, the way it has commonly been implemented, has also been critiqued.

Research in various settings has shown that seed systems prove remarkably resilient to emergency stress (Buruchara et al. 2002; Haugen 2001; McGuire and Sperling 2013b). These studies indicate that even households with severe harvest losses may be able to set aside a share of the harvest for sowing, or source seed from social networks and local informal markets that continue to function also in disaster struck situations. They further show that often, seed availability is less of a problem than access; the key constraints farmers face are rather economic in the form of lack of cash to purchase seed. When seeds are distributed in a bulk fashion, without sufficient attention to and knowledge of seed systems and local needs and dynamics, negative effects such as the use of mal-adapted seed resulting in poor harvests and displacement of local, adapted seed ensue. If carried out repetitively, such seed aid can potentially undermine existing local market actors and lead to aid dependencies (Sperling and McGuire 2010). Indeed, the seed aid apparatus, often distributing seed in a repetitive fashion under the banner of permanent emergencies, has been critiqued for providing profits and benefits to a number of involved actors, including seed companies, agencies, NGOs and government agencies, whereas the benefits for farmer communities remain elusive (Scoones and Thompson 2011). While aid agencies typically prefer improved seed and formal seed channels, seeds of farmer varieties derived from the informal systems may be of equally high quality and prove superior both in terms of agro-ecological adaptation and use and market related characteristics (Haugen 2001; Sperling and McGuire 2010). An alternative to the direct distribution of seed is the provision of vouchers or cash for seed to be used in existing local markets or specially arranged seed fairs (Remington et al. 2002). This approach aims at reducing some of the above mentioned negative side effects, by instead stimulating local seed systems, expanding the diversity of crops and varieties encompassed by the aid, and improving farmers' access to locally available seed.

In recent years, there seems to be a growing awareness among key actors and agencies such as the FAO of the need to shift emphasis from standard, repeat emergency seed distributions, toward interventions tailored strengthen seed security and the resilience of seed systems in affected regions also in the longer-term (FAO 2016a, b; SeedSystem 2016b). Tools for evaluating needs prior to interventions, notably the "Seed System Security Assessment", have been developed (FAO 2016c; Sperling 2008) and put to use (McGuire and Sperling 2016; SeedSystem 2016a), and there is focus on training and capacity building in order to improve the efficacy of seed related relief efforts (FAO 2010).

In most of the above described work on emergency seed interventions, genebank *ex situ* collections have played a peripheral role, mainly as a provider of material for breeding new varieties that may be distributed in post-emergency settings (Sperling 2008). Still, a few examples of more direct involvement exist.

An early instance of reintroduction from genebanks in a post-emergency situation was the transfer of potato seed to local communities by CIP in Peru after people had fled their homes because of the "Shining Path" guerilla in the 1980s (Huamán and Schmiediche 1999). After a forced absence of four years, farmers returned without seed, and obtained formerly cultivated landraces from CIP's *ex situ* collection. In a few other cases during the 1980s and 1990s CIP also reintroduced tubers to Andean communities because of loss due to diseases or natural disasters (Huamán and Schmiediche 1999).

After the war and genocide in Rwanda in 1994, a coalition of international and national agricultural research institutions joined forces in the "Seeds of Hope" project, in order to help rebuild the country (Buruchara et al. 2002). They prepared to repatriate formerly cultivated varieties from *ex situ* collections in neighboring countries, however, later found that much of this material continued to be available within Rwanda's seed system. Landraces and improved varieties previously employed in Rwanda of four main crops were sourced in the *ex situ* collections of neighbouring countries. Much of these material had earlier been supplied by Rwanda through regional research networks. Seeds were multiplied in a number of sites, and programmed for distribution by NGOs. Assessments then showed that most varieties were still available locally; those that had become scarce were mainly those formerly sourced through the formal seed sector having collapsed during the conflict, including some improved bean varieties and potato seed. Thus, the repatriation proved most useful to national research institutions whose collections had been destroyed. The project proved important in rebuilding Rwandan research programmes and institutions, which had been severely affected by the brutal conflict.

In Cambodia, 766 rice landraces formerly collected and stored at IRRI, were returned to the country's farms via the national agricultural research programme during the 1980s, after a war that had disrupted the country's agricultural research and development, and led to the loss of many varieties from both farms and national *ex situ* storage (Nesbitt 1997). The Cambodia-IRRI-Australia Project (CIAP) running from 1989 to 1997 carried out further collections as well as breeding and reintroduction efforts, and IRRI continues to collaborate with the Cambodian Agricultural Research and Development Institute (CARDI) on conservation and agricultural development (IRRI 2016).

Another example comes from Burkina Faso, where a network of smaller genebanks focused on the conservation of local germplasm is being established as part of the National Plant Genetic Resources System. Apart from their role in conservation, they are meant to be used as a source for reintroducing local plant genetic resources in the case of natural disasters such as extreme droughts (Bragdon et al. 2009).

After a devastating earthquake that hit Nepal in 2015, the "Seed Rescue Project" was initiated by Local Initiatives for Biodiversity, Research and Development (LI-BIRD), an NGO based in Pokhara. At a seed handover event, 444 accessions of 46 crops were delivered from farmers in three districts to the national genebank together with passport data. The project was supported financially by Bioversity International and technically by the National Agriculture

Genetic Resource Center, and the further plan is to multiply the accessions and make them accessible to farmers through the establishment of community seed banks (LI-BIRD 2016).

5.1. Merits and Prospects

Calls for a greater involvement of genebanks in post-emergency situations date at least some 20 years back (Richards and Ruivenkamp 1997). Nevertheless, genebanks remain on the margins of most emergency seed interventions. Examples of successful genebanks involvement from the past few decades show how they can contribute to make such interventions more sustainable, and truly help recuperate and increase seed security in disaster-struck areas, in line with the recent refocusing of seed aid approaches. Genebanks can still play a potentially much greater role in efforts to restore agricultural production after natural and human caused emergencies, both by providing expertise and training on seed systems, varietal diversity, and local and regional agricultural conditions, thus aiding efficacy and good targeting of resources, and when necessary, provide seeds for multiplication and distribution to affected research institutions and farmers.

A scaling up of such efforts is not without challenges, indeed, most of the obstacles discussed in the context of reintroduction interventions above remain. In emergency situations, there is an added dimension of time stress, indicating a need for the establishment of guidelines and procedures for rapid but accurate assessments of needs, and selection, multiplication and distribution of seeds in the cases where it is found relevant. The incorporation of genebanks into national emergency plans and the establishment of collaboration with aid and development agencies would be a helpful foundation from which to work.

6. Variety Introduction

While reintroduction and Emergency Seed Interventions typically have focused on bringing back lost or rare varieties there is now increasing focus on the need for introduction of crop varieties that are adapted to novel climates (Burke et al. 2009; van Etten 2011). Thus, it is not necessarily the crop diversity of the past that is needed when the climate is changing, but rather landraces from other areas or new varieties from breeding programs. This has inspired another type of "from genebanks to farmers" projects that we categorize as Variety Introduction. Recently, two leading voices in the field propose somewhat complementary ideas for facilitating an Scaling-up of the use of exotic genebank material by farmers (Global Alliance for the Future of Food 2016). Cary Fowler, the former director of the Crop Trust, proposes a massive distribution program for seed packages with a mix of landraces and improved varieties for farmers to experiment and select from. His model is the US seed introductions in the 19th century. Today, the selection of varieties to include could be guided by spatial climate suitability modelling. Pat Mooney from the Canada based think-tank ETC Group proposes establishment of an *Office for Farmer Seed Exchanges* to be hosted by the ITPGRFA secretariat. The purpose of this office would be to facilitate germplasm requests from farmer organizations to genebanks. Thus, both of these authors propose international level consolidated efforts to increase the deployment of genebank material to farmers' fields.

There is however, already a project on the ground in several countries that does introduce crop varieties from genebanks to farmers' fields. The initiative is called Seeds for Needs[4], started up in 2009 and is led by Bioversity International. The Seeds4Needs initiative is a collection of projects with a shared framework for identifying and testing varieties conserved in genebanks on farm. The initiative uses "crowdsourcing" to evaluate both landraces and improved varieties across agroecologies. The initiative's coordinator Jacob van Etten explains that the root of the initiative is the work on farmer innovation in seed systems by the anthropologist Paul Richards and collaborators (van Etten 2011). The initiative now has project sites in 13 countries in Africa, Asia and Latin America and works through partnership with public sector institutions, NGOs and farmer cooperatives. There are also linkages between the Seeds4Needs project and the Benefit Sharing Fund of the ITGRFA through the so-called Collaborative Programme for Participatory Plant Breeding (van Etten pers comm).

An example of how the Seeds4Needs initiative operates is provided in a series of factsheets reporting on a project on durum wheat in Ethiopia (Bioversity 2016). The project involved farmers in the evaluation of 400 durum wheat landraces selected through a climate modelling exercise from the Ethiopian genebank. The farmers' qualitative assessments were linked with quantitative agronomic and morphological data collection. This resulted in the identification of 11 landraces that performed better than 12 commercial control varieties specifically improved for drought resistance (Bioversity 2016). In order to test the selected varieties on farm under different agroecological conditions packages of three varieties were distributed to farmers in 12 villages over a large area (350 km^2). The preferred varieties were subsequently included in a CSB approach to multiply and make the varieties available. The project does not stop at just identifying suitable landraces – it also includes efforts to further improve the landraces through breeding efforts done at a public breeding institute. With regard to our focus in this report the project factsheet is explicit: "The initiative shows that existing landraces have the potential to provide immediate options for managing climate-related risks. This calls for a broader use of traditional material conserved in genebanks."

In addition to the global scope Seeds4Needs initiative, some CGIAR genebanks are also directly engaged in this kind of crop distribution projects at the national or regional scale. We have already described CIP's distribution of both "lost" and new potato material in the Andes. Other good examples are reported from Mexico and Guatemala by CIMMYT (Denise Costich, pers. comm. October 2016). CIMMYT has over several years distributed genebank accessions of improved varieties that are not available locally. One important point

[4] http://www.bioversityinternational.org/seeds-for-needs/

illustrated by these projects is that genebanks not only conserve and make available landraces, but also modern varieties.

6.1. Merits and Prospects

These recent ideas and experiences on larger scale direct distribution of packages of varieties of diverse origins to farmers present a new and promising approach that carries potential to strengthen seed security, in particular in the face of environmental change altering local growing conditions in ways that might undermine the adaptation of presently employed seeds. Linked to the young age of this approach, there is as of yet little assessment of its impacts. Only further development and practical implementation of projects, combined with monitoring and evaluation, will teach us more about its actual merits.

7. Integrated Seed System Approaches

The Convention on Biodiversity (CBD) established three objectives that have run through all subsequent UN policies on biodiversity: conservation, sustainable use and fair and equitable benefit sharing. The focus on the social development dimensions of natural resource management spurred a lot of research and development projects seeking to integrate conservation of biodiversity with empowering local communities. This agenda created the momentum for an integrated approach to promote conservation and sustainable use of genetic resources called Community Biodiversity Management (CBM) (de Boef et al. 2013). In a book on the CBM approach it is described as "a methodology with its own set of practices, which aims, through a participatory process, to build community institutions and strengthen their capabilities to achieve the conservation and sustainable use of PGR" (de Boef et al. 2013). This set of practices encompasses most of the categories of approaches to link *ex situ* conservation with on farm work described above and the most direct route – reintroduction – is part of seven of the ten CBM projects assessed in the book: two in Brazil, one in Ethiopia, one in France, two in Ecuador, one in Bhutan/Thailand/Vietnam, and one in Central America.

In the perspective provided by the framework in Figure 1, CBM encompasses the whole circle from conservation to cultivation as well as the linkages between "formal" *ex situ* conservation and on-farm management and use. And while the early CBM work largely focused on *in situ* conservation and on farm management as goals in themselves, the CBM approach evolved: "development and conservation organizations now approach PGR in the context of sustainable and livelihood development, rather than as a means to achieve conservation." (de Boef et al. 2013) (p. 4). Arguably, the CBM thereby was the harbinger for the current generation of integrative approaches known as integrated seed system approaches.

The term *integrated seed systems* has been used by different scholars and practitioners conceptualizing ways to make seed interventions and policies more coherent with the seed systems reality most smallholders in developing countries actually use (Louwaars and de Boef 2012; McGuire and Sperling 2013a; Walsh et al. 2013). A fundamental principle in the development oriented integrated seed system literature is that farmers should be presented to a variety of options in terms of varieties and sources. For example, instead of using concepts such as *improved* varieties, connoting that quality and formal breeding is intrinsically linked, one project within this approach speaks about farmer preferred varieties[5] – communicating that quality depends on socio-economic and agro-ecological context. This approach recognizes the importance of both informal and formal seed systems and represents a departure from the conventional linear development model whereby seeds systems develop from informal to formal. Such linear transitions have some inherent risks: Commercial formal systems focus on crops for which there is a market revenue such as hybrid maize and exotic vegetables (Hassena et al. 2012; Pingali 2012), while crops that are locally important for food security are often excluded. However, the integrated seed systems concept is also not based on romantic notions of informal systems as inherently well-functioning: farmers' seed systems often have problems with regards to providing access to seeds to all members of the community as well as with processing and storage capacity (Coomes et al. 2015; Hassena et al. 2012; Lipper et al. 2010). Thus, integrated seed systems approaches are based on the notions that there are strengths and weaknesses both with the formal and the informal system. Being an integrative approach, integrated seed system projects can make use of all the preceding categories of approaches introducing genebank material to farmers.

The integrated seed system concept has developed from theory to practice. Various organizations use variants of the term to describe and contextualize their projects aimed at enhancing farmers' seed security. Most notably in this regard is the Integrated Seed Sector Development in Africa (ISSD) project led by the Centre for Development Innovation (CDI) at Wageningen UR in the Netherlands. The ISSD has now been on the ground in various African countries for some years. The operationalization is probably most advanced in Ethiopia where the ISSD has been instrumental in the formulation of the national Seed System Development Strategy (2013-2017) involving a number of national partners comprising universities, regional seed enterprises, and the Ethiopian Seed Growers and Processors Association (ESGPA)[6]. The Ethiopian implementation of the ISSD is framed as an inclusive approach that recognizes the relevance of informal, formal and intermediary seed systems, as well as the complementary roles of the private and public sectors. The project is said to promote the development of a "vibrant and pluralistic seed sector"[7]. In the words of some of the architects, "The ISSD concept promotes that the different seed systems within a country should be supported with a policy framework and specific actions, building on their strengths, and the type of crops and varieties and seed they address." (Hassena et al. 2012, p. 333).

ISSD has considerable focus on creating an enabling environment for entrepreneurship and establishment of a dynamic commercial formal seed sector. This focus on promoting

[5] http://www.issdethiopia.org/
[6] http://www.issdethiopia.org/
[7] http://www.wur.nl/en/show/CDIcourse_ISSD_2017.htm

entrepreneurship and market-orientation is characteristic of the ISSD operationalization of the integrated seed system concept. This is seen in the project on ISSD undertaken from 2009 to 2013 in cooperation with the African Unions' African Seed and Biotechnology Programme (ASBP) in which the objective was to stimulate cooperation and innovation in policies and programmes in the African seed sector[8]. The current processes of regional harmonization of seed laws promoted by the Common Market for Eastern and Southern Africa (COMESA) aimed at facilitating international seed trade (AU 2011) is apparently not regarded as conflicting with the pluralistic seed sector agenda.

7.1. Merit and Prospects

There is so far limited empirical work on the implementation and effects of the efforts to promote integrated seed systems. One of the common rationales cited for integrated seed system approaches is that it is sustainable and more amenable to be implemented at scale than many community based interventions. It is thus of great interest to see how the different components play out in practice. Are the informal interventions benefitting from being integrated with formal interventions or are they marginalized? One factor that might pull in both directions is the availability of funding for different types of interventions. If funding is mainly available for commercial formal sector interventions this pathway is likely to become dominant potentially precluding alternatives.

Perhaps the most characteristic intervention under the integrated seed system label is facilitation of the establishment of local seed businesses, variably referred to as community seed production, smallholder seed enterprises, informal seed supply, and local seed system development programs (Walsh et al. 2013). The rationale for the need for such local scale community seed enterprises is that outside of hybrid maize and vegetable seeds, it is difficult to make a business case for pure private sector investment (David 2004; Walsh et al. 2013). The objectives of community seed production are to increase farmer access to varieties and to increase seed quality through variety maintenance, selection, handling, and storage (Walsh et al. 2013).

As in the case for many of the approaches described in this report, community seed enterprises are commonly operated by NGOs and there is limited peer-reviewed empirical research on the merits. Foundation seeds are typically sourced from a public seed producer. But there are also examples of community seed enterprises that are linked with PPB programs such as the barley breeding program at Mekelle University in Ethiopia (Andersen and Winge 2013). In this case, the strengths of farmer seed networks are harnessed to spread the varieties developed in participatory plant breeding (Abay et al. 2011; Hassena et al. 2012).

[8] https://www.wur.nl/en/show/Integrated-seed-sector-development-in-Africa.htm

8. Discussion and conclusion

The literature review and the survey and interviews carried out for this study show that a shift is underway in the conceptualization and practice in the field of crop genetic resource conservation and use. While genebanks traditionally have been considered part of a formal seed system, mainly servicing plant breeders, there is today considerable demand for the genetic resources they hold also from farmers and farmer organisations. While the early research and development work on *in situ* was centered on conservation, today's activities increasingly focus on the function of diversity in production systems. We have divided the approaches into six categories: (1) Reintroduction, (2) Community Seed Banks, (3) Participatory Plant Breeding, (4) Post-emergency Seed Distribution, (5) Variety Introduction, and (6) Integrated Seed System approaches. These categories are not standalone and exclusive as the activities they employ overlaps. All six are potential entry points for organizations aiming at facilitating on farm use of genetic resources conserved *ex situ* as a means to enhance seed security (Figure 2).

Farmer in groundnut multiplication plot in Malawi. Photo: T. Hundama.

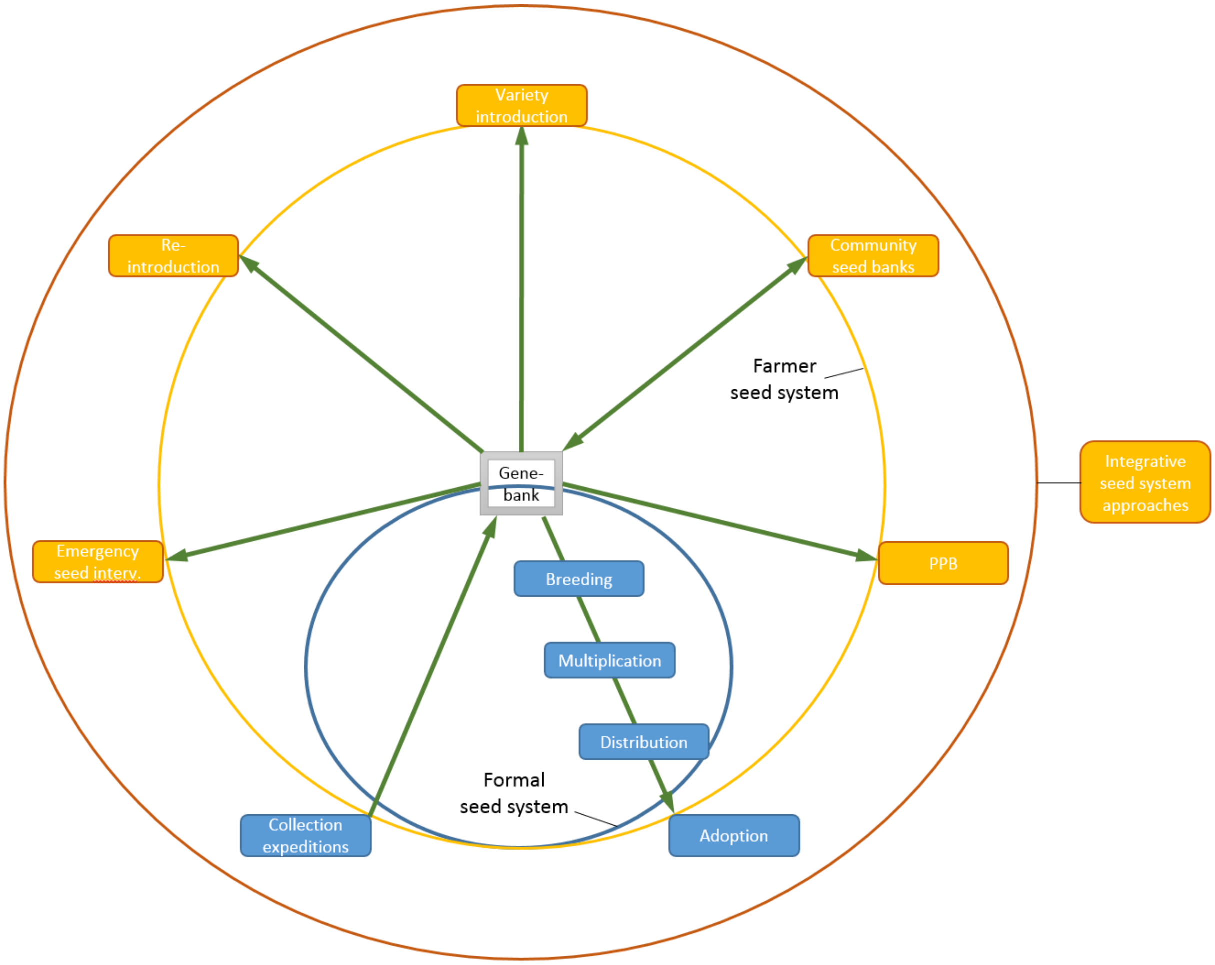


Figure 2: Entry points for facilitating farmer use of genebanks. Orange boxes indicate strategic entry points for introducing genebank material to farmers in projects aiming at enhancing seed security.

8.1. Challenges and Opportunities

Several of the approaches assessed in this report, most notably PPB, CSB and Integrative Seed System approaches, are part of a decentralization and participation agenda in the development discourse. This agenda is both about empowering farmers by giving them more control over agricultural research and about making agricultural research more effective by involving the end users. A current formulation of this agenda is called "social learning": "the process through which groups of people learn, by jointly defining problems, searching for and implementing solutions, and assessing the value of solutions for specific problems" (Koelen and Das 2002). A 2013 stocktaking study[9] of the relevance of social learning approaches in agricultural R&D in the CGIAR found many examples of 'exemplary and mature" projects with potential for upscaling. It is however worth reflecting on why

[9] https://cgspace.cgiar.org/handle/10568/33719

participatory approaches and other social learning approaches remain quite marginal in the project portfolio of large agricultural development organizations. Some common challenges for the approaches assessed in this study that are relevant in this regard are (1) reaching scale (2) achieving long term sustainability, and (3) legal aspects.

The scale challenge is both a question of seed availability and the number of beneficiaries involved. Genebanks are only able to distribute small quantities of seeds and in all approaches described here the seed multiplication step is to a lesser (e.g. PPB) or larger extent (e.g. emergency seed interventions) critical. There is furthermore a need for exploring ways to scale up in terms of numbers of farmers reached. Some of these approaches, in particular PPB and CSBs, are so resource intensive that the number of farmers directly involved in each project is likely to remain limited. On the other hand, the crowdsourcing approach to varietal evaluation promoted in the Seeds4Needs initiative coordinated by Bioversity International represents a promising strategy for large scale on farm evaluation of diverse portfolio of crops.

The sustainability challenge has to do with the institutional structure of the projects, but also with the type of technologies and approaches involved. Most interventions in the six categories identified are project-based and involve external funding (often foreign development assistance). Projects generally have a limited time span and although donors normally want to see a 'disengagement strategy' in place, the reality is often that the public and private sector involvement is too limited to ensure long term economic and institutional sustainability. However, when discussing scale it is also important to acknowledge that no silver bullets exist and that projects must be crop and context specific (in terms of agro-ecological conditions and socio-economic context). The areas that have been "bypassed" by Green Revolution style modernization of the agricultural sector are in reality often areas where this strategy has failed. Thus, the solution in these areas is not likely to be another type of technology package dissemination and modernization plan. In the words of Jean-Luis Pham of IRD, "In a sense there is no "best way" to protect and strengthen community based seed systems – there are ways which are appropriate or not depending on the situation." (Global Alliance for the Future of Food 2016, p. 15).

The best way to promote long term institutional and economic sustainability is either to integrate projects in the public R&D program or to make the distribution commercially viable – or a combination of both. A good example of the latter is the Vietnamese country project in the multi country program SD=HS. In this project, PPB is conducted using the Farmer Field School model involving both a public university and the national agricultural research organization in the crop development. The developed varieties are multiplied and distributed on a commercial basis in so-called seed clubs. The SD=HS program furthermore links national and international seed policy agendas and seeks to create space for farmer seed systems in the national seed policy regimes in the countries where it operates[10]. The most advanced conceptualization of the need to integrate also national level policy work is found in the Integrated Seed System literature. In its operationalization in Ethiopia, the

[10] http://www.oxfamnovib.nl/english/about-oxfam/themes/food-land-water/sdhs

Wageningen/IDLO led ISSD project has been instrumental in developing a policy and regulation framework that enables the coexistence of crop and context specific seed systems.

The legal challenge also has to do with the institutional and technological nature of this kind of projects. Common features of the approaches highlighted in this report are that they are bottom up, participatory, reliant on local, often informal institutions, context specific and situated. These features are not always easily compatible with seed policies and laws developed to serve commercial and formal seed systems. ICARDA has for example not continued the emphasis on PPB because they often are at odds with seed regulations (ICARDA ADG Kamel Shideed, pers. comm. October 2016). There are exemptions for use of genebank material for research, but when it comes to the distribution, national seed laws often prohibit distribution of unregistered varieties as well as sale of uncertified seeds. Still many genebanks have been frontrunners and distributed untested seeds of unreleased varieties when the demand has been obvious (e.g. in post-disaster contexts) even if such distribution is not strictly sanctioned by law (Thijssen et al. 2008). Such distribution has often been the precursor to relaxation of the seed regulations and not the other way around. Today, with the ITPGRFA in place, there is legal space for emergency distribution at the international level. Article 12.6 says that "the Contracting Parties agree to provide facilitated access to appropriate plant genetic resources for food and agriculture in the Multilateral System for the purpose of contributing to the re-establishment of agricultural systems, in cooperation with disaster relief coordinators" (FAO 2009). The national Seed System Development Strategy in Ethiopia explicitly accommodates different quality control systems. According to (Alemu et al. 2010) the Ethiopian framework now operates with one certification scheme for seed for the export market (commercial, formal), a Quality Declared Seed scheme for seed commonly grown by smallholders and an emergency seed scheme with slightly less demanding standards in terms of provenance, purity, and germination.

Recent discussions in the framework of the ITPGRFA suggests that also other development oriented use of genebank material can be exempted from rules and regulations made for formal seed systems. Article 13.2 about the monetary contribution to the MLS says "it may also decide on the need to exempt from such payments small farmers in developing countries and in countries with economies in transition." (FAO 2009) This was further elaborated in a recent report paper from the "Friends of the Co-Chairs (FoCC) Group on User and Crop Categories" of the "ad-hoc open-ended working group to enhance the functioning of the multilateral system"[11]. The report says that both the "Ad Hoc Advisory Technical Committee on the Standard Material Transfer Agreement and The Multilateral System" and the Friends of the Co-Chairs (FoCC) Group on User and Crop Categories agrees that "farmers should be exempt from use of the SMTA for direct cultivation. Its complexity, limited availability in many languages and lack of relevance to farmer-based use render it an unnecessary and undesirable instrument in the case of distribution of MLS material to farmers." and conclude "Small-scale farmers in developing countries could be granted an exemption from the use of the SMTA or from payment." Interviews conducted for this study revealed that already today genebanks avoid using the SMTA for some of the distributions to on farm projects.

[11] http://www.fao.org/plant-treaty/meetings/meetings-detail/en/c/414961/

8.2. Common Ground

Strengthened collaboration between genebanks and organisations working with farmers is potentially beneficial for both parties. Seed system projects benefit from access to a broad portfolio of diversity and genebanks benefit from increased use and relevance of their collections. Projects linking genebanks with famers should thus consider the relationship as a two-way street. Farmers benefit from access to genetic diversity they otherwise would not have ready access to and genebanks become integrated with seed systems they would not reach through the conventional BDA channel. Sometimes there is also a gene flow from the on farm projects to the genebanks (e.g. when CSB projects collect and share local varieties with a national genebank). Working through alternative channels, genebanks can increase their actual and perceived relevance among groups that otherwise consider genebanks far removed from the production system. The importance of increasing relevance for smallholders through approaches such as PPB has long been recognized:

"*This limited use of germplasm collections may in the long run pose a serious threat to the genetic heritage kept in genebanks. Who will keep paying for the maintenance of enormous numbers of seed samples that are hardly requested by anybody?*
Localized evolutionary breeding, however, will need the landraces with their specific adaptation and could, potentially, increase the demand on the genebanks tremendously. (…) Genebanks are organized to serve scientific plant breeding. In recent years, genebanks are also being used to supply seeds for re-establishment of landraces that have been lost from disaster areas. This is done or planned for areas in Cambodia, Eritrea, Ethiopia, Somalia and Rwanda.
But otherwise, local communities are not yet established as bona fide users of genebank materials. If farmers are organized and linked up to scientific institutions, it would be possible to establish a channel for return of relevant germplasm from genebanks to farm communities. (…) To some degree the direct return of landraces to areas from where they were originally collected and to other areas with similar agroenvironmental conditions may be warranted." (Berg 1997).

Empirical research on the seed systems farmers in developing countries de facto rely on show that dichotomous *ex situ* vs. *in situ* and formal vs. informal seed system framings fail to capture the complexity in terms of seed technologies and institutions involved (see Coomes et al. 2015). This insight is to an increasing extent taken on board by development actors in the frontline of seed security work. The Seeds of Resilience report from the Global Alliance for the Future of Food commissioned as an "opportunities report" advances concrete advice on how funding and policy can support seed system resilience and puts it this way: "There is a great potential in farmers and the more formal seed establishment coming together to co-create solutions where they have a common agenda". The approaches reviewed here show that traditionally disparate agendas like the farmers' rights agenda and the *ex situ* conservation agenda can indeed find common ground in seed system interventions aiming at enhanced seed security.

Annex 1. Survey questions

Introduction:

Genebanks are repositories of key public goods for agricultural development. Genetic resources is the raw material for plant breeders developing new plant varieties, but genebanks can also be a direct source of varieties for farmers and organizations working with on farm management of genetic resources. This survey is part of a study on the linkages between genebanks and farmers.

In this study, we aim to compile data on the direct use of genetic resources conserved *ex situ* by farmers and organizations working with farmers. The objective of the study is to map different approaches to facilitate access to genetic resources for farmers and to draw lessons for future development initiatives to connect *ex situ* conservation with sustainable use of genetic resources on farm.

The study is undertaken by the Norwegian University of Life Sciences and supported by Norad, the Norwegian Agency for Development Cooperation.

Survey questions

1. Do you work for an institution with an *ex situ* plant genetic resource collection?

Multiple choice: National genebank, International genebank, Regional genebank, University collection, Non-Governmental Organization, Other

2. Do you work for an institution involved in on farm use of *ex situ* conserved plant genetic resources?

Multiple choice: Non-Governmental organization, community based organization, public genetic resources program, private sector institution, other

Questions for institutions involved in on farm use of ex situ conserved plant genetic resources:

1. Is your organization involved in facilitating use of ex-situ conserved germplasm for farmers?
2. If yes, can you please list the projects, partners, your role and specify the time frames for implementation?
3. What are, in your view, some positive aspects of these initiatives?
4. What are, in your view, some challenges in relation to these initiatives?
5. Do you know about other organizations facilitating farmers' access to ex-situ collections, can you list the projects and collaborating organizations?

Questions for genebank staff:

Collaboration with farmers and/or organizations working with farmers

1.a. Has your genebank been involved in or implementing projects supporting farmers' access to seed from *ex-situ* collections (f. example: projects supporting on-farm conservation, Participatory Plant Breeding/ Variety Selection, Community Seed Banks, Integrated Seed System Development programs)?

1.b. Please list the projects, partners, your role and specify the time frames for implementation?

2.a. Is your genebank involved in other types of projects aiming at strengthening genebank (ex-situ)-farmer (on-farm) linkages?

2.b. Please specify projects, partners your role and time frames for implementation?

If your answer is yes to question 1 and 2, please answer question 3 and 4:

3. What are, in your view, some positive aspects of these initiatives?

4. What are, in your view, some challenges in relation to these initiatives?

5. If your answer is no to question 1 and 2, what are the reasons?

6. Do you know about other organizations facilitating farmers' access to ex-situ collections, can you list the projects and collaborating organizations?

Distribution data

Is your distribution data broken down in user groups?

If so, do you have a category for direct distribution to farmers and/or organizations facilitating distribution to farmers?

If yes, what is the approximate number of samples distributed to farmers (or organizations that work with farmers)?

Annex 2. Survey distribution

We distributed the survey to the genebank managers of the IARC collections. We distributed the survey to the 371 participants in the 6th session of Governing Body (GB6) meeting of the ITPGRFA (delegates from contracting parties working in national genebanks, agricultural research/universities, ministry of agriculture and ministry of environment; observers from non-member countries, Civil Society, Seed Industry, Multilateral organizations and other national and international organizations) (see annex for participants in IT/GB-6/15/Report T/GB-6/15/Report)

We received 77 responses to the survey. 75% of the respondents reported to be holders of germplasm collections. We did semi-structured interviewes with Bert Visser (Oxfam Novib/Center for Genetic Resources, the Netherlands), Alvaro Toledo (ITPGRFA/Enefit-Sharing Fund), Walter de Boef (Bill and Melinda Gates Foundation), Jacob van Etten (Bioversity International), Pat Mooney (ETC Group). We also engaged in e-mail dialogues and more informal exchanges with a number of other actors.

References

Abay F, de Boef W, Bjørnstad Å (2011) Network analysis of barley seed flows in Tigray, Ethiopia: supporting the design of strategies that contribute to on-farm management of plant genetic resources. Plant Genetic Resources 9:495-505

Abay F, Waters-Bayer A, Bjørnstad Å (2008) Farmers' seed management and innovation in varietal selection: Implications for barley breeding in Tigray, northern Ethiopia. AMBIO: A Journal of the Human Environment 37:312-320

AGRA (2013) AGRA Growing Africa's Agriculture.

Alemu D, Rashid S, Tripp R (2010) Seed system potential in Ethiopia. Constraints and opportunities for enhancing the seed sector International Food Policy Research Institute, Addis Ababa/Washington, DC

Almekinders C, Hardon J (2006) Bringing Farmers Back into Breeding: Experiences with Participatory Plant Breeding and Challenges for Institutionalisation

Ana D (2015) Unfreezing the seed: State, expertise and patriotism at the Suceava Gene Bank. Department of Sociology and Social Anthropology. Central European University, Budapest, Hungary, p 59

Andersen R, Borromeo TH, Altoveros NC (2013) A community register in the Philippines. In: Andersen R, Winge T (eds) Realising Farmers' Rights to Crop Genetic Resources: Success Stories and Best Practices Routledge

Andersen R, Winge T (2011) Linking community seedbanks and farmers' rights In: Kroglund AP, Wilhelmsen A, Torheim BB, Ulsrud K, Shresta P, Ortiz R, Jorde S, Teshome HM (eds) Banking for the future: Savings, security and seeds A short study of community seed banks in Bangladesh, Costa Rica, Ethiopia, Honduras, India, Nepal, Thailand, Zambia and Zimbabwe. Grøset, The Development Fund, Oslo, Norway, pp 5-6

Andersen R, Winge T (2013) Realising Farmers' Rights to Crop Genetic Resources: Success Stories and Best Practices. Routledge

Argumedo A (2008) The Potato Park, Peru: Conserving agrobiodiversity in an Andean Indigenous Biocultural Heritage Area. In: Amend T, Brown J, Kothari A, Phillips A, Stolton S (eds) Protected landscapes and agrobiodiversity values. Kasparek Verlag, Heidelberg, Germany, pp 45-58

Arndorfer M, Kajtna B, Vorderwülbecke B (2009) Integrating *ex situ* and on-farm conservation approaches in the management of local vegetable diversity in Austria. Acta Hort (ISHS) 817:333-340

Asdal Å (2011) Bevaringssorter/tradisjonssorter - aktuelle tiltak i regi av Norsk genressurssenter (Conservation varieties/traditional varieties - relevant activities administered by the Norwegian Genetic Resource Center). Fagsamling om Gamle

Kornsorter (Workshop on Old Cereal Varieties). Norwegian Genetic Resource Center, Sigdal, Norway

Asdal Å (2012) Bruksgenbanken for gamle kornsorter In: Center NGR (ed). Norwegian Genetic Resource Center, Ås, Norway

Asfaw A, Almekinders CJ, Blair MW, Struik PC (2012) Participatory approach in common bean (Phaseolus vulgaris L.) breeding for drought tolerance for southern Ethiopia. Plant breeding 131:125-134

AU (2011) Communiqué on integrated seed sector development. Addis Ababa, Ethiopia: African Union http://www wageningenur nl/en/show/Integrated-Seed-Sector-Development-in-Africa htm Integrated Seed Sector Development in Africa

Berg T (1997) Devolution of plant breeding

Borges Días TA, da Fonseca Ferreira MAJ, Barbieri RL, França Teixeira F, de Azevedo SG (2013) Gene banks that promote on-farm management through the reintroduction of local varieties in Brazil. In: de Boef WS, Subedi A, Peroni N, Thijssen M, O'Keefe E (eds) Community biodiversity management: promoting resilience and the conservation of plant genetic resources. Routledge, Taylor & Francis Group, London, pp 91-95

Bragdon S, Jarvis DI, Gauchan D, Mar I, Hue NN, Balma D, Collado L, Latournerie L, Sthapit BR, Sadiki M, Fadda C, Ndungu-Skilton J (2009) The agricultural biodiversity policy development process: Exploring means of policy development to support the on-farm management of crop genetic diversity. International Journal of Biodiversity Science and Management 5:10-20

Bramel-Cox P (2000) Toward establishing links between farmers and the ICRISAT genebank. In: Friis-Hansen E, Sthapit B (eds) Participatory approaches to the conservation and use of plant genetic resources. International Plant Genetic Resources Institute, Rome, Italy, pp 69-74

Burke MB, Lobell DB, Guarino L (2009) Shifts in African crop climates by 2050, and the implications for crop improvement and genetic resources conservation. Global Environmental Change: Human and Policy Dimensions 19:317-325

Buruchara RA, Sperling L, Ewell P, Kirkby R (2002) The role of research institutions in seed–related disaster relief: Seeds of Hope experiences in Rwanda. Disasters 26:288-301

Ceccarelli S (2015) Efficiency of plant breeding. Crop Science 55:87-97

Ceccarelli S, Grando S (2007) Decentralized-participatory plant breeding: an example of demand driven research. Euphytica 155:349-360

Ceccarelli S, Grando S, Bailey E, Amri A, El-Felah M, Nassif F, Rezgui S, Yahyaoui A (2001) Farmer participation in barley breeding in Syria, Morocco and Tunisia. Euphytica 122:521-536

Chable V, Dawson J, Bocci R, Goldringer I (2014) Seeds for organic agriculture: Development of participatory plant breeding and farmers' networks in france. Organic Farming, Prototype for Sustainable Agricultures. Springer, pp 383-400

Chambers R, Ghildyal B (1985) Agricultural research for resource-poor farmers: the farmer-first-and-last model. Agricultural administration 20:1-30

Chambers R, Thrupp LA (1994) Farmer first: farmer innovation and agricultural research. KARTHALA Editions

Chaudhary P, Rijal DK, Rana RB, Pandey D, Khatiwada S, Gauchan D, Yadav R, Upadhyay MP, Subedi A, Jarvis DI (2001) Enhancing conservation and use of agrobiodiversity on-farm through public awareness. In: Sthapit BR, Upadhyay MP, Baniya BK, Subedi A, Joshi BK (eds) On-farm management of agricultural biodiversity in Nepal, p 209

CIP (2016) Una visita al saber tradicional para celebrar a la papa. International Potato Center, Lima, Peru

CIP (nd) La Ruta del Condor. International Potato Center, Lima, Peru

Conway G (2012) One billion hungry: Can we feed the world? Cornell University Press, Ithaca and London

Coomes OT, McGuire SJ, Garine E, Caillon S, Mckey D, Demeulenaere E, Jarvis D, Aistara G, Barnaud A, Clouvel P (2015) Farmer seed networks make a limited contribution to agriculture? Four common misconceptions. Food Policy 56:41-50

Correa CM (2015) Plant Variety Protection in Developing Countries: A Tool for Designing a Sui Generis Plant Variety Protection System: An Alternative to UPOV 1991. by: Association for Plant Breeding for the Benefit of Society (APBREBES) and its member organizations: Berne Declaration, The Development Fund, SEARICE and Third World Network

Dalle SP, Walsh S (2015) USC Canada's experiance in supporting community seed banks in Africa, Asia and the Americas. In: Vernooy R, Shrestha P, Sthapit B (eds) Community Seed Banks: Origins, Evolution and Prospects. Routledge, pp 212-230

David S (2004) Farmer seed enterprises: a sustainable approach to seed delivery? Agriculture and Human Values 21:387-397

Dawson JC, Murphy KM, Jones SS (2008) Decentralized selection and participatory approaches in plant breeding for low-input systems. Euphytica 160:143-154

de Boef WS, Subedi A, Peroni N, Thijssen M, O'Keeffe E (2013) Community Biodiversity Management: Promoting resilience and the conservation of plant genetic resources. Routledge, New York, USA

Desclaux D, Ceccarelli S, Navazio J, Coley M, Trouche G, Aguirre S, Weltzien E, Lançon J (2012) Centralized or decentralized breeding: the potentials of participatory approaches for low-input and organic agriculture. Organic crop breeding Wiley-Blackwell, Hoboken:99-123

Dulloo M, Thormann I, Fiorino E, De Felice S, Rao V, Snook L (2013) Trends in research using plant genetic resources from germplasm collections: from 1996 to 2006. Crop Science 53:1217-1227

Evenson RE, Gollin D (2003) Assessing the impact of the Green Revolution, 1960 to 2000. Science 300:758-762

FAO (1998) Developing Seed Security Strategies and Programmes for Food Security in Developing Countries. Proceedings of the International Workshop on Seed Security for Food Security 30 November– 1 December 1997. In: FAO (ed). FAO, Florence, Italy

FAO (2009) The International Treaty on Plant Genetic Resources for Food and Agriculture. p 60

FAO (2010) Seeds in emergencies: a technical handbook. Food and Agriculture Organization of the United Nations, Rome, Italy

FAO (2016a) Food security capacity building: Seeds. Food and Agriculture Organization of the United Nations

FAO (2016b) Seed security and rehabilitation. Food and Agriculture Organization of the United Nations

FAO (2016c) Seed security assessment: a practitioner's guide. Food and Agriculture Organization of the United Nations, Rome, Italy

FAO (nd) Seeds and plant genetic resources: a basis for life. Food and Agriculture Organization of the United Nations

Feyissa R, Gezu G, Tsegaye B, Desalegn T (2013) On-farm management of plant genetic resources through community seed banks in Ethiopia. In: W. Simon de Boef, Subedi A, Peroni N, Thijssen M, O'Keeffe E (eds) Community Biodiversity Management- Promoting resilience and the conservation of plant genetic resources. Routledge New York, pp 26-31

Fowler C, Smale M, Gaiji S (2001) Unequal exchange? Recent transfers of agricultural resources and their implications for developing countries. Development Policy Review 19:181-204

GEF (2016) Mainstreaming of the Use and Conservation of Agrobiodiversity in Public Policies through Integrated Strategies and *In situ* Implementation in three Provinces in the Andean Highlands. Global Environment Facility

GFAR, DF, CEPA (2015) Capacity building material for the realization of farmers' rights in Malawi: farmers' rights related to plant genetic resources for food and agriculture in Malawi. Global Forum on Agricultural Research, The Development Fund of Norway and Centre for Environmental Policy and Advocacy, Oslo, Norway

Gibson R, Mpembe I, Mwanga R (2011) Benefits of participatory plant breeding (PPB) as exemplified by the first-ever officially released PPB-bred sweet potato cultivar. The Journal of Agricultural Science 149:625-632

Global Alliance for the Future of Food (2016) The Future of Food: Seeds of Resilience, A Compendium of Perspectives on Agricultural Biodiversity from Around the World.

Gupta A, Dadlani M, Quek P, P.Mathur (2015) Community Seed Banks: a working manual. Bioversity International New Delhi, India

Gyawali S, Sthapit B, Bhandari B, Bajracharya J, Shrestha P, Upadhyay M, Jarvis D (2010) Participatory crop improvement and formal release of Jethobudho rice landrace in Nepal. Euphytica 176:59-78

Hassena M, van den Broek J, de Boef W, Thijssen M, Louwaars N (2012) Integrated seed sector development: experiences in Africa. The Defining Moments in Ethiopian Seed System. Ethiopian Institute of Agricultural Research, pp 327-339

Haugen JM (2001) Whatever the will of the weather: A study of seed systems in Honduras, and their importance for food security and agrobiodiversity in the aftermaths of Hurricane Mitch. Noragric. Agricultural University of Norway, Ås, Norway

Huamán Z, Schmiediche P (1999) The potato genetic resources held in trust by the International Potato Center (CIP) in Peru. Potato Research 42:413-426

IIED (2014) Return of potatoes from CIP to Andean farmers proves critical for climate adaptation. International Institute for Environment and Development

INIA (2016) Firman convenio por 8 millones para desarrollar nuevas variedades de papa. Instituto Nacional de Innovación Agraria, Lima, Peru

Iriarte V, Terrazzas Gino Aguirre F, Thiele G (2000) Local seed systems and PROINPA's genebank: working to improve seed quality of traditional Andean potatoes in Bolivia and Peru. In: Friis-Hansen E, Sthapit B (eds) Participatory approaches to the conservation and use of plant genetic resources. International Plant Genetic Resources Institute, Rome, Italy, pp 154-163

IRRI (2016) Cambodia and IRRI. International Rice Research Institute Cambodia, Phnom Penh, Cambodia

Jarvis DI, Hodgkin T, Brown AH, Tuxill J, Noriega IL, Smale M, Sthapit B (2016) Crop Genetic Diversity in the Field and on the Farm: Principles and Applications in Research Practices. Yale University Press

Jarvis DI, Hodgkin T, Sthapit BR, Fadda C, Lopez-Noriega I (2011) An heuristic framework for identifying multiple ways of supporting the conservation and use of traditional crop varieties within the agricultural production system. Critical Reviews in Plant Sciences 30:125-176

Jones K, Glenna LL, Weltzien E (2014) Assessing participatory processes and outcomes in agricultural research for development from participants' perspectives. Journal of Rural Studies 35:91-100

Kendall J, Gras E (2013) The Maison de la Semence Paysanne and diversity platform: promoting agrobiodiversity in France. In: de Boef WS, Subedi A, Peroni N, Thijssen M, O'Keefe E (eds) Community biodiversity management: promoting resilience and the conservation of plant genetic resources. Routledge, Taylor & Francis Group, London, pp 43-50

Koelen M, Das E (2002) Social learning. Wheelbarrows full of frogs: Social learning in rural resource management:437

Laurie S, Magoro M (2008) Evaluation and release of new sweet potato varieties through farmer participatory selection. African Journal of Agricultural Research 3:672-676

LI-BIRD (2016) Safeguarding seeds in the aftermath of the earthquake. Local Initiatives on Biodiversity, Research and Development, Pokhara, Nepal

Lipper L, Anderson CL, Dalton TJ (2010) Seed trade in rural markets: implications for crop diversity and agricultural development. Earthscan

Louwaars NP, de Boef WS (2012) Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs, and policies. Journal of Crop Improvement 26:39-59

Maluleke N, Moila P, Phora G, Dibiloane A, Vernooy R, Sthapit B (2015) Savouring diversity: first steps in implementing a strategy to support community seedbanks in South Africa's smallholder farming areas. Report of follow up field visits to Limpopo and Eastern Cape. Bioversity International and Department of Agriculture, Forestry and Fisheries, Rome, Italy and Pretoria, Republic of South Africa

McCouch S (2004) Diversifying selection in plant breeding. PLoS Biology 2:e347. doi:310.1371/journal.pbio.0020347

McGuire S, Sperling L (2013a) Making seed systems more resilient to stress. Global Environmental Change: Human and Policy Dimensions 23:644-653

McGuire S, Sperling L (2013b) Making seed systems more resilient to stress. Global Environmental Change 23:644-653

McGuire S, Sperling L (2016) Seed systems smallholder farmers use. Food Security 8:179-195

Melaku W (2011) Establishing community seed banks in Africa. In: Ching L, Edwards S, El-Hage S (eds) Climate change and food systems resilience in Sub-Saharan Africa. FAO, Rome, Italy, pp 361-377

Melaku W (2016) Telephone Interview with Dr Melaku Worede, Former Director of Plant Genetic Resource Center (Now called Ethiopian Biodiversity Institute) In: Teshome HM (ed)

Melaku W, Awegechew T, Tesfaye T (2000) Participatory approaches linking farmer access to genebanks: Ethiopia. In: Friis-Hansen E, Sthapit BR (eds) Participatory approaches to the con-servation and use of plant genetic resources. International Plant Genetic Resources Institute, Rome, Italy, pp 149-153

Mendum R, Glenna LL (2009) Socioeconomic obstacles to establishing a participatory plant breeding program for organic growers in the United States. Sustainability 2:73-91

Meza C, Rutti A, Gómez R, Zapata F (2012) Conservación y uso de la agrobiodiversidad: Guía para la implementación de bancos comunales de semillas. SGCAN, Instituto de Montaña, UICN-Sur, Lima, Peru

Morris ML, Bellon MR (2004) Participatory plant breeding research: opportunities and challenges for the international crop improvement system. Euphytica 136:21-35

Nazarea VD (1998) Cultural memory and biodiversity. University of Arizona Press, Tucson

Nazarea VD (2005) Heirloom seeds and their keepers : marginality and memory in the conservation of biological diversity / Virginia D. Nazarea. University of Arizona Press, Tucson

Nazarea VD, Rhoades RE (2013) Conservation beyond design: an introduction. In: Nazarea VD, Rhoades RE, Andrews-Swann J (eds) Seeds of resistance, seeds of hope : place and agency in the conservation of biodiversity. University of Arizona Press, Tucson, pp 3-16

Nesbitt HJ (1997) Rice production in Cambodia. International Rice Research Institute, Manila, Phillippines

Ngoc De N (2000) Linking the national genebank of Vietnam and farmers. In: Friis-Hansen E, Sthapit B (eds) Participatory approaches to the conservation and use of plant genetic resources. International Plant Genetic Resources Institute, Rome, Italy, pp 62-68

Nishikawa Y, Winge T (2013) The Hiroshima Agricultural Gene Bank: re-introducing local varieties, maintaining traditional knowledge. In: Andersen R, Winge T (eds) Realising farmers' rights to crop genetic resources : success stories and best practices. Earthscan from Routledge, London ; New York, pp 167-178

NordGen (2016) NordGen seed request. Sweden

Pingali PL (2012) Green Revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences 109:12302-12308

Pistorius R (1997) Scientists, plants and politics – a history of the plant genetic resources movement. IPGRI, Rome, Italy

Potato Park, ANDES, CIP (2004) Agreement on the Repatriation, Restoration and Monitoring of Agrobiodiversity of Native Potatoes and Associated Community Knowledge Systems.

Rasmussen M (2016) Norsk genressurssenter formidler miniknoller av historiske potetsorter (Norwegian Genetic Resource Center offers minitubers of historical potato varieties). Norwegian Institute of Bioeconomy Research, Ås, Norway

Remington T, Maroko J, Walsh S, Omanga P, Charles E (2002) Getting Off the Seeds–and–tools Treadmill with CRS Seed Vouchers and Fairs. Disasters 26:316-328

Richards P, Ruivenkamp G (1997) Seeds and survival: crop genetic resources in war and reconstruction in Africa. International Plant Genetic Resources Institute, Rome, Italy

Rijal DK, Subedi A, Upadhyaya MP, Rana RB, Chaudhary P, Tiwari RK, Sthapit BR (2003) Community biodiversity register: developing community based database for genetic resources and local knowledge in Nepal. In: Sthapit BR, Upadhyay MP, Baniya BK, Subedi A, Joshi BK (eds) On-farm management of agricultural biodiversity in Nepal Proceedings of a National Workshop, 24-26 April 2001. NARC, LI-BIRD and IPGRI, Lumle, Nepal, p 233

Rubenstein KD, Smale M, Widrlechner MP (2006) Demand for genetic resources and the US National Plant Germplasm System. Crop science 46:1021-1031

Scoones I, Thompson J (2011) The politics of seed in Africa's green revolution: Alternative narratives and competing pathways. IDS Bulletin 42:1-23

SeedSystem (2016a) Field assessments around the world. Catholic Relief Services, International Center for Tropical Agriculture, Pan-Africa Bean Research Alliance, School of International Development, United States Agency for International Development

SeedSystem (2016b) Seed system: strengthening smallholder farmer seed systems. Catholic Relief Services, International Center for Tropical Agriculture, Pan-Africa Bean Research Alliance, School of International Development, United States Agency for International Development

Shrestha P, Subedi A, Sthapit S, Rijal D, Gupta S, Sthapit B (2006) Community Seed Bank: reliable and effective option for agricultural biodiversity conservation. In: Sthapit BR, Shrestha PK, Upadhyay MP (eds) Good practices: On-farm management of agricultural biodiversity in Nepal. NARC, LI-BIRD, IPGRI and IDRC, Kathmandu, Nepal

Shrestha P, Vernooy R, Chaudhary P (2012) Community Seed Banks in Nepal: Past, Present, Future. Proceedings of a National Workshop, 14-15 June 2012. LI-BIRD/USC Canada Asia/Oxfam/The Development Fund/IFAD/Bioversity International Pokhara, Nepal

Smale M, Day-Rubenstein K (2002) The demand for crop genetic resources: international use of the US national plant germplasm system. World Development 30:1639-1655

Sperling L (2008) When disaster strikes: a guide to assessing seed system security. Centro Internacional de Agricultura Tropical, Cali, Colombia

Sperling L, Ashby JA, Smith ME, Weltzien E, McGuire S (2001) A framework for analyzing participatory plant breeding approaches and results. Euphytica 122:439-450

Sperling L, Cooper HD, Remington T (2008) Moving towards more effective seed aid. Journal of Development Studies 44:573-600

Sperling L, Loevinsohn ME, Ntabomvura B (1993) Rethinking the farmer's role in plant breeding: Local bean experts and on-station selection in Rwanda. Experimental Agriculture 29:509-519

Sperling L, Longley C (2002) Editorial: Beyond Seeds and Tools: Effective Support to Farmers in Emergencies. Disasters 26:283-287

Sperling L, McGuire S (2010) Persistent myths about emergency seed aid. Food Policy 35:195-201

Sthapit B (2012) Emerging theory and practice: community seed banks, seed system resilience and food security. Community Seed Banks in Nepal: Past, Present, Future Proceedings of a National Workshop, Pokhara, Nepal, 14–15 June 2012. LIBIRD and Bioversity International, Rome, Italy, pp 16-40

Sumberg J, Thompson J (2012) Contested agronomy: Agricultural research in a changing world. Routledge

Sumberg J, Thompson J, Woodhouse P (2013) Why agronomy in the developing world has become contentious. Agriculture and Human Values 30:71-83

Tapia Bastidas CG, Carrera Rueda HF (2013) Practices that contribute to promoting and appreciating Andean crops and identity in Cotacachi, Ecuador. In: de Boef WS, Subedi A, Peroni N, Thijssen M, O'Keefe E (eds) Community biodiversity management: promoting resilience and the conservation of plant genetic resources. Routledge, Taylor & Francis Group, London, pp 77-82

Tay D (2009) Model genebank concept: CIP Genebank as an example. 15th Triennial International Society for Tropical Root Crops Symposium, Lima, Peru, pp 5-11

Teshome HM, Ortiz R (2015) Norway's Development Fund: Supporting community seed bank practices. In: Vernooy R, Shrestha P, Sthapit B (eds) Community Seed Banks: Origins, Evolution and Prospects. Routledge, pp 194-205

The Development Fund (2011) Banking for the future: Savings, security and seeds. A short study of community seed banks in Bangladesh, Costa Rica, Ethiopia, Honduras, India, Nepal, Thailand, Zambia and Zimbabwe. Grøset, Oslo, Norway

The Right to Food and Nutrition Watch Consortium (2016) Keeping Seeds in Peoples' Hands. Bread for the World, FIAN International and ICCO cooperation, LokayDRUCK, Berlin, Germany

Thijssen MH, Bishaw Z, Beshir A, De Boef WS (2008) Farmers, seeds and varieties. supporting informal seed supply in Ethiopia

Trouche G, Acuna SA, Briones BC, Palacios NG, Lançon J (2011) Comparing decentralized participatory breeding with on-station conventional sorghum breeding in Nicaragua: I. Agronomic performance. Field Crops Research 121:19-28

van Etten J (2011) Crowdsourcing crop improvement in sub-saharan africa: a proposal for a scalable and inclusive approach to food security. IDS bulletin 42:102-110

Vernooy R, Shrestha P, Sthapit B (2015) Community Seed Banks: Origins, Evolution and Prospects. Routledge

Vernooy R, Sthapit B, Galluzzi G, Shrestha P (2014) The multiple functions and services of community seedbanks. Resources 3:636-656

Walsh S, Remington T, Kugbei S, Ojiewo CO (2013) Review of Community Seed Production Practices in Africa Part 1: Implementation Strategies and Models. Community Seed Produc on 9:3

WB (2007) Agriculture for Development: World Development Report 2008. World Bank

Weltzien R, Smith ME, Meitzner LS, Sperling L (2003) Technical and institutional issues in participatory plant breeding-from the perspective of formal plant breeding: A global analysis of issues, results, and current experience

Worede M, Teshome A, Tesemma T (2000) Participatory approaches linking farmer access to genebanks: Ethiopa. In: Friis-Hansen E, Sthapit B (eds) Participatory approaches to the conservation and use of plant genetic resources. International Plant Genetic Resources Institute, Rome, Italy, pp 56-61

Ystad D (2016) Utgåtte sorter er igjen tilgjengelig i bruksgenbanken for kornsorter (Disappeared varieties are again available in the user gene bank for cereal varieties). Norwegian Agricultural Extension Agency, Åmot, Norway