# Strengthening Smallholder Farmers' Capacity to Adapt to Climate Change: Roles of Community Seedbanks

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## Contents



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**Abstract**

Community seed banks are repositories of local genetic diversity that is often adapted to prevailing climate conditions including biotic stresses. They may be useful to contribute to community-based strategies for adaptation to climate change. This chapter provides evidence about actual and potential roles of community seed banks in climate change adaptation based on a series of studies being carried out in various smallholder farmer regions of the world (Bangladesh, Guatemala, Nepal, South Africa, Uganda, and Zimbabwe). These studies illustrate two important ways in which more effective management of plant genetic resources can strengthen farmers' capacity to adapt to climate change. The ways are (1) securing improved access to and availability of diverse, locally adapted crops and varieties through the use of multiple germplasm sources and (2) enhancement of related local knowledge and skills in plant management including seed selection, treatment, storage, multiplication, and distribution. As such, community seed banks can enhance or revive traditional social seed networks that have existed for decades or centuries based on combinations of seed-saving, seed exchanges, seed-giving, seed-bartering, and seed purchase. What is needed now are growing recognition among and support from policy-makers that community seed banks can be a very effective form of farmer organization toward more climate-smart agriculture.

**Keywords**

Access · Agrobiodiversity · Availability · Community seed bank · Conservation · Farmers' rights · Food sovereignty · Resilient seed system · Seed sovereignty

## Introduction: Brief Overview of Community Seed Banking

A community seed bank (also known as seed house, seed hut, seed library, seed reserve, and seed wealth center) is defined as a locally governed and managed institution whose core function is to maintain seeds for local use (Development Fund 2011). Community seed banks have been around for about 35 years (Vernooy et al. 2015). Most of them are managed by a small group of dedicated farmers, but they usually serve a large number of farmers at the community or district level. Women are very active in most, if not all, community seed banks, often as the principal seed selectors and guardians and, in some cases, as community seed bank leaders. The Gumbu community seed bank in Limpopo Province of South Africa is an all-women-managed community seed bank (Vernooy et al. 2019a). However,

women's roles are not always recognized, let alone supported, in development policies, programs, and projects.

Over time, the functions of community seed bank roles have evolved beyond the original one of safeguarding seeds (the conservation function) to a broader range of additional ones. These can be grouped under (a) providing access and availability of diverse seeds and planting materials according to farmers' needs and interests and (b) promoting seed and food sovereignty and community empowerment (Vernooy et al. 2014). Some community seed banks continue to focus on conservation of agricultural biodiversity, including reviving or rescuing lost local varieties, while others are giving priority to both conservation and access and availability of diverse types of seeds and planting materials, including (farmer or participatory plant breeding) improved varieties, suitable to local agroecological conditions. Farmers in different regions of the world will have different needs and interests when it comes to identifying the crops and crop varieties to be included in their own community seed bank. Factors that influence their reasoning and decision-making include local agroecological and weather conditions, farming history, status of and trends in agrobiodiversity (e.g., the recent disappearance from an area of a certain crop), available resources, type and frequency of disasters, and household preferences and needs.

Some community seed banks explicitly present their efforts as promoting seed and food sovereignty, e.g., in Bangladesh, Brazil, and India, and the seed libraries in North America, emphasizing farmers' rights (citizen's rights) and capacity to keep control over their own seeds. Building on the description of farmers' rights in the International Treaty on Plant Genetic Resources for Food and Agriculture, farmers' rights are the rights of farmers to (1) save, use, exchange, and sell farm-saved seed and propagating material, (2) receive recognition and protection for their knowledge related to genetic resources, (3) receive rewards and support for their contribution to the conservation and sustainable use of the global pool of genetic resources, and (4) participate in the decision-making on issues related to crop genetic resources. Without these rights, the promotors of seed and food sovereignty argue, there will be no effective conservation and sustainable use. The approach known as community biodiversity management builds on this right (de Boef et al. 2013) and encourages the search for, use of, and control over portfolios of locally adapted germplasm. Such germplasm is usually first sourced from the locality, but in the context of climate change adaptation, it makes good sense to complement local germplasm with seed sourced from other locations, locally, nationally, or internationally. Some community seed banks have made a start doing the latter (e.g., the case from Uganda described in this chapter).

Across the globe, community seed banks vary significantly in size (membership), governance and management models, infrastructure (building, storage, and other equipment), and technical aspects. There is also considerable variability in terms of technical and operational capacities. In recent years, the number of newly established community seed banks has been on the rise, partly due to the growing support of national and state/provincial governments. Examples of government-supported efforts include Bhutan, Brazil, Ethiopia, India, Mexico, Nepal, South

Africa, Timor-Leste, and Uganda. In China, new community seed banks are established with the support of the China Farmers' Seed Network, a coalition of nongovernment and government organizations interested in supporting smallholder farmers. In several countries, e.g., Kenya, Nepal, South Africa, and Uganda, members of community seed banks are creating national networks to scale their activities and influence national policies and laws. Several books and handbooks have been published, documenting, guiding, and supporting their establishment and effective management (Shrestha et al. 2013; Joshi et al. 2018; Vernooy et al. 2019b, 2020a, b, c). Two recent master's degree theses addressed the roles of community seed banks in climate change adaptation and resilience, based on examples from Guatemala (Gómez César 2017) and Guatemala (Porcuna Ferrer 2018). It seems that these publications and studies are having an awareness-raising and encouragement effect.

## Climate Change Adaption Activities: A Framework

Gaining in importance in recent years are community seed banking activities that are particularly relevant with regard to climate change adaptation at farm, community, and landscape levels (Vernooy et al. 2017). These activities highlight the central roles that plant genetic resources play in dealing with climate change, seed, and food security (Jarvis et al. 2015). Table 1 gives an overview of these activities with regard to the two major roles of conservation, and access and availability. We do not know of community seed banks that explicitly state that seed and food sovereignty contributes to climate change adaptation (and resilience), but it may be a matter of time more than the lack of a solid argument before this will happen. Community seed banks that control and maintain a large and diverse portfolio of locally adapted crops undoubtedly give farmers an advantage when it comes to strengthening adaptive

**Table 1** Key climate change adaptation activities of community seed banks located in countries around the world

| Conservation | Access and availability |
|---|---|
| Conservation of a portfolio of diverse seeds of crops and crop varieties (e.g., Burkina Faso, China, Ethiopia, Mexico, Nicaragua, Sri Lanka, South Africa (*this chapter*)) | Platform of multiple channels of access and availability of seeds at the community level (e.g., Ethiopia, Guatemala, Honduras, India, Mali, Nepal, Uganda (*this chapter*)) |
| Conservation of seeds from plants that have high capacity to survive under extreme weather conditions (e.g., Bangladesh (*this chapter*), Nepal) | Accessing novel diversity not conserved locally (Nepal (*this chapter*), South Africa) |
| Restoration of "lost" varieties in particular with good adaption potential (Bhutan, Guatemala (*this chapter*), Zimbabwe (*this chapter*)) | Accessing seeds from areas where plants have adapted to extreme weather conditions (Uganda, *this chapter*) |
| | Provision of adapted seeds to marginal communities not served by commercial seed dissemination efforts (Zimbabwe, *this chapter*) |

Sources: Vernooy et al. (2015), country studies in this chapter

capacity over those farmers who cannot count on such resources. Locally adapted crops may not always have very high yields when compared to modern cultivars grown under optimal conditions, but they usually do have the advantage of producing reasonable yields over periods of time, even under difficult conditions – hence, their (more) resilient nature. Farmers who opt for locally adapted varieties usually are aware of these trade-offs.

Using agrobiodiversity for climate change adaptation is an example of an incremental adaptation strategy – selecting better performing crops and/or crop varieties is a stepwise process and cannot be achieved through a one-off action. As such, it is a knowledge-intensive process and different from other interventions, in particular those that are more transformational in nature, e.g., through the introduction of technologies such as irrigation facilities in drought-prone areas or drainage management infrastructure in flood-prone areas.

All these activities can contribute to more resilient seed systems (Subedi and Vernooy 2019) that reduce farmers' exposure to vulnerability by:

- Ensuring access to seeds in terms of preference, affordable price, and availability when needed
- Ensuring availability in terms of production and distribution
- Guaranteeing seed quality in terms of adaptability, safety, and longevity
- Guaranteeing seed choice and diversity
- Producing crops which underpin a healthy diet
- Recognizing and respecting seed as social and spiritual capital

## Climate Change Adaption Activities: Conservation Examples from the Field

### South Africa: Cherishing Diversity

Since 2013, the Department of Agriculture, Forestry and Fisheries (DAFF) (now: Department of Agriculture, Land Reform and Rural Development) and Bioversity International have been working together to establish and support community seed banks as a means of strengthening farmers' seed systems, supporting conservation and sustainable use of traditional farmer varieties, maintaining seed security at district and community levels, and strengthening famers' capacity to respond to climate change (Tjikana et al. 2016, Vernooy et al. 2019a). The community seed banks established so far support the Department's National Plan on Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture, both in situ and ex situ. To date, the main results include:

- Training of the National Plant Genetic Resources Centre (NPGRC) staff (responsible for implementation of the initiative) in technical and organizational aspects of community seed banking

- The establishment of two pilot community seed banks in Gumbu, Limpopo Province and Sterkspruit, Eastern Cape Province, and recently the newly formed community seed bank in Jericho, North West Province (this community seed bank was established based on the experiences of and lessons learned from the two pilot community seed banks)
- Increased access to and availability of diverse, good quality seed with knowledge and seed exchanges among community seed banks and between the NPGRC and community seed banks

## Evolution of Activities

The efforts started in 2013 with an assessment of the local seed diversity situation followed in 2014 by a number of research and training activities related to community seed bank governance, leadership, participation, seed management, bookkeeping, and documentation. One of the findings of the situational assessment was farmers' increasing uncertainty with regard to weather events and the negative impact of this on crop production. They also speculated that changing weather conditions (more unpredictable and later rainfalls, higher temperatures, and longer drought spells) contributed to the disappearance of some species/varieties.

Seed collection activities to safeguard local crop diversity started in 2015, and by December 2018, the Gumbu community seed bank had registered more than 240 seed contributions of 15 different crops and 1 tree species (Fig. 1), and the Sterkspruit community seed bank had registered almost 80 contributions of 10 different crops. The Jericho community seed bank kicked off activities in June 2019 by storing 80 contributions of 11 crops and 1 tree species (see lists below):

**Fig. 1** Harvesting beans on the land of the Gumbu community seed bank, South Africa. (Credit: Bioversity International/R. Vernooy)

- Crops conserved in Gumbu: Bambara nut, calabash, coriander, cowpea, finger millet, groundnut, maize, melon, mung bean, pearl millet, pumpkin, sorghum, tepary bean, watermelon, wheat. Tree species conserved: *Moringa*
- Crops conserved in Sterkspruit: bean, calabash, cowpea, maize, melon, pea, pumpkin, sorghum, watermelon, wheat
- Crops conserved in Jericho: bean, calabash, cowpea, groundnut, jugo bean, maize, melon, mung bean, pumpkin, sorghum, watermelon. Tree species conserved: *Moringa*

As a direct result of these conservation efforts at community level, the amount of diversity now accessible to farmers has increased significantly compared to before a community seed bank was established. A challenge that remains to be addressed is availability of this diversity, given that it takes time, effort, and favorable growing conditions to multiply the varieties donated to the community seed banks.

In Sterkspruit, farmers use a temporary facility to store seed, established on the terrain of the district farmers' association. In Gumbu, farmers use a solid and spacious new physical structure built on a piece of land donated by the village tribal office, which was officially inaugurated in March 2016. Gumbu farmers are very pleased with this new facility, which is equipped with a convenient meeting area that they can use when working together. In Jericho, an existing structure donated by the tribal authority was renovated and inaugurated in June 2019.

## From Conservation to Seed Multiplication

In 2017, the Gumbu farmers managed to harvest some quantities of seeds from the first regeneration plots set up on the land of the community seed bank. Farmers managed the whole process collectively and this brought some good results. A challenge was the irregular supply of water, which affected some crops and resulted in lower than expected harvests. In the 2017–2018 growing season, they planted ten different priority crops for seed multiplication: Bambara nut, black-eyed bean, cowpea, mung bean, red maize, white maize, pearl millet, and watermelon. Unfortunately, there was almost no harvest due to water shortage and low soil moisture content. Gumbu experienced late rains, which did not sufficiently replenish soil moisture in time for seedling emergence.

In 2017, farmers in the Eastern Cape were unable to harvest enough seeds from the first regeneration plots due to the lack of rains and due to irregular monitoring given the distance from their respective villages to Sterkspruit where the community seed bank is located. Based on the experience, the farmers decided to adopt a new strategy whereby they multiply priority crop varieties stored in the community seed bank on their own farms and in their backyard gardens. This makes regular monitoring for the farmers much easier. After the harvest, the farmers brought new quantities of seeds to the community seed bank for storage and, possibly, exchange. Selected crops included Bambara nut, cowpea, maize, pumpkin, sorghum, watermelon, and wheat. In addition to the existing inventory of 2016, the farmers brought 17 more accessions to the community seed bank. The Sterkspruit community seed bank has a large number of maize varieties (more than any other crop), which

underscores its high importance. The 2017–2018 season was also affected by drought, but farmers managed to produce some small amounts of seed, maize in particular (Vernooy et al. 2019a).

In order to strengthen the work with the community seed banks in the coming years, the team will carry out participatory crop improvement of selected crops of interest to local farmers with a focus on adaptation to climate change. This will be done in collaboration with the Agricultural Research Council (ARC) for vegetable and ornamental plants stationed at Roodeplaat and the provincial/district Agricultural Extension Advisory Services.

Based on the initial interactions with farmers from Gumbu and Sterkspruit, a number of crops could possibly be included in the breeding activities: cowpea, finger millet, maize, okra, pearl millet, red sorghum, and spinach. A final selection of crops will be put together after a second round of consultations with the farmers. Farmers will then be trained in basic participatory plant breeding techniques, and the first field experiments will start in 2021.

## Bangladesh: Community Seed Wealth Centers and Stress-Tolerant Crop Varieties

In the late 1980s, small-scale farmers practicing monoculture and chemical-based agriculture experienced loss of biodiversity and environmental degradation. The costs of production were rising beyond their capacity. In search for alternatives to chemical fertilizers and pesticides, farmers in the Tangail area of the country started Nayakrishi Andolon, a movement to support biodiversity-based ecological farming. The Tangail area was severely affected by the flood of 1988 causing severe loss of standing *Aman* crops (monsoon rice crops). The situation was similar in other parts of Bangladesh. Nayakrishi, initiated by the nongovernment organization UBINIG (Policy Research for Development Alternative), investigated the causes of the severe damage and loss.

Flood is a common natural disaster in the country, but the damage caused by flood is different for crops grown from modern seed (mostly HYVs and hybrids) and crops grown from local varieties (farmer-saved indigenous varieties). Indigenous varieties, developed by farmers over time, have developed certain characteristics that make them usually more adaptive to particular local ecological conditions. For example, modern rice varieties cannot survive in high-standing water and will be damaged entirely. The indigenous varieties may have the straw damaged, but if the roots remain connected to the soil, the grains can be harvested from the fallen plants. In Bangladesh, flooding has been a determining factor in selecting and improving flood-resistant varieties. Chamara is a flood-resistant variety, but particularly suitable for low-lying flood plain areas of Tangail. In other flood plain areas, farmers likely select another flood-resistant variety, such as Hijoldigha. The government policy that promotes modern varieties and the rise of the commercial seed market contributed to severe erosion of the capacity of farmers to cope with climatic disaster related to flood, drought, and salinity.

**Fig. 2** Part of the seed collection of the Tangail Community Seed Wealth Center, Bangladesh. (Credit: Bioversity International/R. Vernooy)

The Nayakrishi Seed Network (NSN), composed of Community Seed Wealth Centers (CSWCs) at district level and Seed Huts (community seed banks) at village level, plays a key role in the Nayakrishi movement (UBINIG 2018). CSWCs are the institutional setup for seed collection, storage, conservation, distribution, exchange, and regeneration (Fig. 2). The tasks of the CSWCs also include documentation and maintenance of general information of the area. Farmer representatives of NSN participate in the decisions of the CSWCs. Any member of the Nayakrishi Andolon can obtain seed from a CSWC with the promise that they will return some seed after the harvest, at least double the quantity received. Another way to return seed is by donating a variety that is not yet part of the CSWC collection. Farmers can then ask for seed of the variety or varieties they have returned at any time. Community Seed Wealth Centers have been established by UBINIG in three different agroecological zones: flood plain, drought-prone, and coastal areas.

Nayakrishi's effort in local seed conservation and regeneration has been dictated, among others, by the rationality of traditional knowledge practices (Akhter et al. 2019). The community seed banking, established to support Nayakrishi farming, has had to deal with various climatic disasters that require different solutions for diverse biogeographical landscapes. One important strategy of the NSN has been to maintain collections of local seeds capable to perform in different ecosystems facing various forms of biotic stress. In this way, the NSN strengthens community practices that integrate disaster preparedness in day-to-day farming practices. The household members of the NSN are the focal point for both in situ and ex situ conservation. Women farmers are the key actors and leaders in the NSN, based on their traditionally assigned roles of seed conservers and regenerators.

## Conservation, Crop Improvement, and Capacity Development

Climate change is felt by farmers through the effects on the cropping patterns; the planting time is delayed, or the seedlings are damaged because of no rain or unexpected heavy showers. The winters are shorter, warmer, or becoming too foggy and too cold. Modern varieties are not surviving in such conditions. In the

drought-prone area of the country, the *Aus* paddy (rice sown in April) was reintroduced as it is suitable in dry soils with natural moisture. Nayakrishi farmers are using their adaptation knowledge to deal with the new situation, but they could benefit from additional (crop) research.

CSWCs maintain a collection of endangered varieties and most commonly used varieties by the farmers. Farmers conserve stress-tolerant seeds needed in the stress-prone areas, particularly in flood- and drought-prone zones and in saline-prone coastal areas. For example, there are 38 flood-tolerant varieties, 35 drought-resistant varieties, 22 salinity-tolerant varieties, and 19 cold-tolerant varieties preserved in the CSWCs of Tangail, Pabna, and Cox's Bazar districts. Some of these have not been cultivated for some years due to a shift to HYV rice. However, in recent times, crop damage has occurred due to unpredictable weather conditions, particularly in the form of less rainfall, drought, and even cold spells. These conditions encouraged Nayakrishi farmers who had safeguarded the stress-tolerant varieties to share and exchange them among members of the Seed Huts and the CSWCs. Farmers conduct field schools in the stress-prone areas, observe changing weather conditions, and select the most appropriate varieties for cultivation. They also prepare a second basket of emergency seeds in case "delayed cultivation" is required to overcome seed losses and ensure food security.

### An Example: Rajendrapur Seed Hut

In 2018, 24 farmers in 4 villages of Natore belonging to the Rajendrapur Seed Hut cultivated 4 drought and flood-tolerant varieties of rice together as a mixed crop (Kalobakri, Pakri, Kartikshail, and Hidi in medium and high lands). Many farmers in the area had stopped cultivating these varieties, so it was a challenge to obtain seed to start the experiment. In an uncertainty of drought or flood situation, farmers tried both Aus and Aman varieties together in order to minimize the damage by drought or flood. Aus season starts in the dry month of April while Aman season during monsoon (when the floods occur). Due to climate change, the drought condition can also extend to the Aman season, and there can be pre-monsoon rain in the Aus season.

The local varieties are chosen to adapt to these fluctuating conditions.

Kalobakri (an *Aus* variety) performed well under drought conditions as a mixed crop with Kartikshail (an *Aus* and *Aman* variety). Kalobakri is harvested earlier (September), while Kartikshail is harvested in October–November. The other drought-tolerant *Aman* varieties (Pakri and Hidi) performed well. Farmers cultivated drought-tolerant varieties of *Aus* and *Aman* in about 8 acres with four varieties. They harvested over 11 t of paddy and obtained Tk. 91,920 worth of straw. Some cultivated flood-tolerant *Aman* varieties on 2.65 acres of land and harvested 4 tons of paddy and Tk. 26,300 worth of straw. Some of these farmers (ten) had their own collection of seeds, while others who received the seeds from the Seed Hut in Rajendrapur have deposited back to the Seed Hut. The district CSWC also received a small amount to add to its collection.

## Guatemala: Community Seed Banks Coming to the Rescue

Community seed banking in Guatemala has its roots in the Central American participatory plant breeding program (*Programa Colaborativo de Fitomejoramiento Participativo en Mesoamérica*, set up in 1999), which encouraged farmers to safeguard traditional maize varieties as inputs for improving local crops. In 2008, a network of community seed banks (locally known as seed reserves) was established with the active participation of farmer groups connected to the NGO known as ASOCUCH (*Asociación de Organizaciones de los Cuchumatanes*). The community seed banks received technical support of FUNDIT (*Fundit Guatemala/ Fundación para Desarrollo Integral de El Tejar*) and ICTA (*Instituto de Ciencia y Tecnología Agrícolas*) and financial support of the Development Fund of Norway.

Activities of the community seed banks in the Sierra de los Cuchumatanes include awareness-raising, education and training, documentation of traditional seed knowledge and practices, seed production, conservation and exchange, seed and knowledge exchange, promotion of ecological agriculture, participatory plant breeding, income generation, community enterprise development, advocacy, and policy analysis (Fig. 3). The community seed banks have empowered farmers individually and collectively (Porcuna Ferrer 2018).

More recently, ASOCUCH and the network of community seed banks in the Sierra de los Cuchumatanes collaborated with Bioversity International to safeguard (rescue) local varieties of particular interest that were at the risk of disappearing from the region. Through a novel participatory process (Drucker et al. 2019), community seed banks identified a total of 72 of such varieties, which were classified according to their important features including food and nutritional values, sociocultural values, adaptability to climate change, stress tolerance (biotic and abiotic stresses),

**Fig. 3** A newly constructed seed reserve supported by ASOCUCH, Guatemala. (Credit: Bioversity International/R. Vernooy)

and commercial potential. Of the 72, 8 maize and 6 bean varieties were prioritized for immediate action. Several of these varieties were characterized as having good capacity to withstand weather vagaries such as drought and cold spells. Examples are a drought-tolerant black maize variety that matures within 4 months and a small-sized drought- and cold-tolerant red bean variety that can be grown at altitudes above 2,500 masl.

ASOCUCH then carried out a seed search operation for the 14 varieties. The campaign was called "[Seeds] Wanted." ASOCUCH mobilized the members of the community seed bank network and farmers from other communities through a special call made during the 9th Agrobiodiversity Fair in the region (2017), to obtain enough seed for reproduction of the 14 varieties. Seed production was then organized through a special competitive seed service delivery call (based on similar calls piloted in the Andean region), which created strong interest in the region leading to the involvement of 150 farmers. By the end of 2018, more than 3,000 kg of seed was produced through this effort, which were divided among farmers for consumption and seed supply (own household and other farmers) and community seed banks for saving. As a result, the total planting area of varieties at the verge of disappearing increased by almost 800%. ASOCUCH envisions to solidify the rescue effort by donating about 1 k of seed of the rescued varieties to the national gene bank held by the ICTA. This would guarantee a longer-term backup in case of emergency.

## Climate Change Adaption Activities: Access and Availability Examples from the Field

### Zimbabwe: Championing Adaptive Plant Genetic Resource Conservation

Community seed banks in Zimbabwe supported by the Community Technology Development Organisation (CTDO) provide a collective framework and institutional platform for communities to make decisions pertaining to the crops they want to cultivate, enhance on-farm seed production of preferred crop varieties, and support the conservation of local but climate adaptive germplasm. It is imperative for communities to store different varieties of local crops, which can be used as reserve in years of stresses and shocks caused by floods and droughts.

The community seed bank allows individual households to conserve their seeds to protect them from household-based disasters, such as fire and pests. Farmers deposit their seeds in a designated room of the community seed bank and retain ownership of them. They can only be used, exchanged, and multiplied with the family members' consent. In the family collections, participating members bring seeds from their households for storage in small quantities (200 to 500 gram). Seed brought undergoes a thorough cleaning process at the farmer's homestead. All seeds are inspected by the community seed bank management committee to ensure that they are free from pests and diseases. The management committee continuously

**Fig. 4** Part of the collection of one of the community seed banks supported by the CTDO, Zimbabwe. (Credit: Bioversity International/R. Vernooy)

assesses the quality of the seed to ensure that only good quality seed is maintained in the seed bank (Fig. 4).

In terms of access to new germplasm, farmers within the catchment area of the community seed bank organize and participate in annual seed and food fairs to facilitate the exchange of valuable seeds and information and local knowledge on agricultural biodiversity. In this case, the community seed banks serve as a center of excellence for community members with the support of the National Gene Bank (NGB), the National Crop Breeding Institute (NCBI), the National Extension Service (AGRITEX), and two CGIAR centers (ICRISAT and CIMMYT). The gene bank and breeding centers provide advanced and segregating lines to the farmers to facilitate farmer-driven action research designed to identify climate adaptive crops and varieties in the respective district. The community seed bank management committee regularly receives information about these promising materials available in gene banks and breeding centers.

The climate adaptation strategy used has four steps:

1. Farmers make genetic diversity choices of climate adaptive materials from the accessed pool of genetic materials based on current productivity, genotype X environment interaction, agronomic traits, pest and disease resistance, yield potential, and food and nutrition value.
2. On-farm seed production of selected and ecologically adaptive crop varieties is undertaken by specifically identified farmers within the community.
3. Each of these farmers deposits 50 kg of the seed to the bulk seed storage room of the community seed bank to enhance the community strategic seed reserves that are used for distribution before the onset of the rain season.
4. The seed is used for replanting purposes if a drought occurs, and this practice is critical to ensure easy accessibility to and cost-effectiveness of planting materials.
5. These collaborative interactions have become mechanisms to access novel crop diversity, make seed systems "accountable" to their environment, identify useful materials, and retire old materials, which are no longer climate-suitable.

### An Example: Chimukoko

Smallholder farmers of Chimukoko, where one of the community seed banks is located, mostly maintain their planting materials on farm as a key input for their adaptive farming systems. The crops they grow have characteristics that are important for their food and nutrition security. Among the practices and measures, they implement the following:

- Preventing genetic erosion by depositing subsections of the germplasm accessions to the national and Southern African Development Community (SADC) regional gene banks as security against any future calamities
- Storing collected germplasm from other areas with good climate adaptive traits
- Using the community seed bank as a seed distribution and exchange center, e.g., for seed fairs, as seed selling/marketing point, and as farmer training venue
- Utilizing the community seed bank as a center of knowledge management where there is intragenerational knowledge transfer between the young and older generations, in particular of indigenous knowledge
- Using the community seed bank as a meeting point to interface between policymakers, local leadership, traditional leaders, extension, researchers, civil society (NGOs), development partners, farmers' organizations, and women's self-help aid groups
- Using the community seed bank as a center of agricultural excellence linking research, education, and extension to provide quality services to the smallholder farmers triangulated by indigenous knowledge
- Providing information and knowledge on crop germplasm value addition and product development that is linked to food and nutrition security
- Undertaking participatory variety selection, enhancement, and identification of climate-resilient crop cultivars through the farmer field school (FFS) approach

## Nepal: Community Seed Banks Are More than (About) Seeds

Nepal is known as one of the highly vulnerable countries to climate change in the world. Agriculture is largely characterized as subsistence-oriented. Smallholder farming predominates with no or little access to year-round irrigation, inputs, and extension services. Poor access to basic agricultural inputs is making smallholder farmers very vulnerable. In addition, farmers in Nepal have to struggle with heavy rainfall, floods, and landslides during the monsoon, with a long dry season from October to May, and with cold spells, snowfall, and hailstorms in between. In recent years, farmers have been reporting changes in rainfall patterns, the drying up of water sources, delays in time of spring water coming, increased intensity of heat in the summer and cold spells in winter, and a decrease in the number of cold days. Such changes in the climate have a direct impact on agriculture – loss of traditional varieties, untimely flowering, and increase in occurrence of diseases and pests.

**Fig. 5** Seed display at a diversity fair, Nepal. (Credit: Bioversity International/R. Vernooy)

In order to cope with the changing climate, farmers prefer short-duration crop varieties. They are also changing the cropping pattern in some cases. Community seed banks and the farmer organizations managing them play an instrumental role in coping with the changing conditions. The community seed banks supply diverse types of seeds and planting materials directly on farmer's doorsteps (Vernooy 2019) (Fig. 5). In addition, they offer other services such as loans, technical advice, and bridging farmers and the extension service-providing agencies. Community seed banks in Nepal are more than about seeds alone (Shrestha et al. 2013; Joshi et al. 2018).

## An Example: The Purkot Community Seed Bank

Located in Tanahun District in Gandaki Province of Nepal, the Agricultural Biodiversity Conservation Committee (ABCC) is one of the many farmer organizations established with the support of Local Initiatives for Biodiversity, Research and Development (LI-BIRD). ABCC operates since 2011 and provides integrated services to the farming community. The main objective of ABCC is to promote community biodiversity management (CBM) activities in the village including the establishment and management of a community seed bank. The community seed bank operated by ABCC is known as the Purkot Community Seed Bank. The Purkot Community Seed Bank has been promoting conservation and use of 116 local varieties of 42 crop species but also produces and provides access to quality seeds

of improved rice varieties. Many crop varieties, both local and improved, are suitable to the local climatic condition, have short maturity duration, and are tolerant to climate stresses, such as drought.

The traditional varieties promoted by the community seed bank that are tolerant to drought include black gram, horse gram, finger millet, taro, elephant foot yam, soybean, proso millet, pumpkin, cucumber, and sponge gourd. The improved rice varieties that mature early and have the ability to tolerate drought include *Sukkha* 2, *Sukkha* 3, and *Sukkha* 6. Literally, *sukkha* in Nepali means drought, thus the variety suitable in drought conditions. The community seed bank produces around 15 tons of improved rice varieties; 50% are drought-tolerant varieties. The community seed bank also maintains local and improved crop varieties that can cope with excessive precipitation (which is occurring more frequently). These include finger millet, *Anadi* and *Masino* rice, horse gram, cowpea and soybean, and improved rice varieties, namely, *Makawanpur* 1, *Raamdhan*, and *Sabitri*. Annually, more than 500 farmers are accessing seed of improved rice varieties, and more than 100 farmers borrow seed of local varieties from the community seed bank.

In order to sustain the community seed bank and run the organization in a sustainable manner (without outside financial support), the ABCC has employed a number of strategies. One such strategy is through a community biodiversity management fund (set up with the financial and technical support of LI-BIRD), which is mobilized as a collateral-free soft loan among the members. The members who borrow money from the fund utilize the loan for farm and off-farm income-generating activities, while the organization earns some income in the form of interest. The interest is used to pay for staff time and cover other operational costs of the organization, including seed production of local and improved varieties. Currently, the organization has approximately 20 thousand USD as CBM fund. In addition to the CBM fund, the organization is also operating a seed fund (about 10,000 USD), which is used for procurement of improved seed produced by its seed producers. The seed business of the community seed bank guarantees easy access to quality seed of farmer's preferred varieties in the locality. Besides, it contributes to increase the income of seed producer farmers and ABCC at the same time.

The ABCC has also developed a good working relationship with the local government and agriculture extension offices. The local government gives small funding support to ABCC for maintaining a diversity block of local varieties conserved by the community seed bank and for procuring improved seed from the community seed bank. The extension agency known as Agriculture Knowledge Center (AKC) provides source seed of improved varieties received from the research institute to the community seed bank. The AKC supports physical infrastructure development, such as the building of a seed store, a tractor, and other machineries necessary for operating the community seed bank. The strong support combined with the activities deployed by ABCC contributes to build the capacity of the community seed bank to produce quality seed of locally adapted varieties and planting material and provide access to the local community to reliable and affordably priced seed.

## Uganda: Testing New Crop Diversity to Adapt to Climate Change

Climate change has recently become a major threat to food security in Uganda. Most farmers in the country face shifting and shortened growing seasons coupled with prolonged drought, erratic rainfall, and a range of new pests and diseases. Farmers are also grappling with genetic losses as a result of climate change (Otieno et al. 2018). Increasing and maintaining genetic diversity is one way of combating the effects of climate change. In Uganda, community seed banks have become an increasingly important element of seed systems, in particular at the local level, because they are used by farmers to easily access a wide range of genetic diversity for climate change adaptation (Otieno 2018). They have five main roles:

1) As repositories for genetic diversity that would have otherwise been lost, they contribute to in situ conservation.
2) More recently, they have proved very useful in participatory varietal testing and evaluation as members experiment with new diversity for climate change adaptation and pest and disease control.
3) Community seed bank members have been engaged in various capacity development activities about policies and laws affecting community seed banks, e.g., about farmers' rights and about access and benefit-sharing issues, such as included in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and concerning quality seed production; alternative quality assurance schemes, such as (production of) Quality Declared Seeds (QDS); and seed business management.
4) Community seed bank members have formed seed cooperatives which are engaged in multiplication and sale of Quality Declared Seed.
5) As avenues for financial inclusion, especially as members have set up saving and credit schemes to help them improve their seed and farming businesses.

### Kiziba Community Seed Bank: From Conservation to Seed Production

The Kiziba community seed bank was established in 2010 in Mbarara-Sheema District of Western Uganda with the support of the National Agricultural Research Organisation (NARO) of Uganda and Bioversity International (now: the Alliance of Bioversity International and CIAT). Evolving from a small group of 30 farmers from 2 villages, the community seed bank now serves more than 2000 farmers in more than 20 villages. The seed bank also serves other farmers and visitors from other areas of Uganda. The seed collection grew from about 25 local varieties of beans to a collection of about 70 in 2015. In 2018, the seed bank diversified to include local varieties of finger millet, groundnut, and maize. Because of its stellar performance, Kiziba now serves a new function: a learning platform for the creation of other community seed banks. New community seed banks have been established in Hoima, Nakaseke, Nakasongola, and Sheema. In 2018/2019, the Kiziba community seed bank engaged farmers in capacity development, notably to produce QDS seed of seven bean varieties for sale. In the last two seasons, farmers have produced about 1.4 t of seed, which has been packaged, labeled, and sold as QDS.

The Kiziba community seed bank has also set up a farmer field school with demonstration plots containing 32 popular bean varieties. The farmer field school is a learning point for farmers on various issues such as quality seed production, seed selection, and quality assurance, identifying phenotypic characteristics of various varieties and their response to climate changes, pest and disease management, and postharvest handling of bean seed. In the 2018/2019 season, over 230 farmers visited the demonstration plots at various stages of production to enable them to learn more about quality seed production.

More recently, the Kiziba community seed bank graduated into a seed cooperative with 73 members engaged directly in seed business. In 2018/2019, the cooperative produced 1.5 t of QDS seed of 7 bean varieties and 2 t farmer-saved seed of 15 local varieties. The main buyers are local institutions and the South West Regional Seed Association, which buys QDS seed for resale in other regions. In addition, the community seed bank and cooperative members are successfully engaged in a saving and credit scheme with a turnover of about USD 3,500 per annum, which guarantees farmers a source of finance to upgrade their seed production.

### Hoima Community Seed Bank: Adaptation and the Multilateral System

The Hoima community seed bank (HOCOSEB) was established in 2018 and serves over 1,000 farmers in 8 villages (Fig. 6). It was established as a result of 3 consecutive years of participatory varietal testing and evaluation to find potentially adapted varieties for climate change adaptation. Hoima has been experiencing dramatic effects of climate change in the past couple of years related to shifting and shortening of seasons, droughts, heavy erratic rainfall, and general loss of genetic diversity. In 2013, during the first baseline survey and agrobiodiversity assessments, farmers reported having lost nine bean varieties due to climate change. They now relied on two main varieties and another three that would only be grown


**Fig. 6** The Hoima community seed bank. (Credit: Bioversity International/R. Vernooy)

**Table 2** Results of testing and evaluation of bean and finger millet varieties suitable for Hoima, Uganda

| Crop | No. of accessions exchanged | No. of accessions viable after multiplication | No. of accessions distributed to farmers for crowdsourcing | No. of accessions identified by farmers as preferable | No of accessions in the community seed bank in Hoima |
|---|---|---|---|---|---|
| Bean | 99 | 50 | 34 | 23 | 19 |
| Finger millet | 147 | 70 | 44 | 20 | 14 |

during a good season (i.e., with reliable weather). Farmers observed that they had lost long season varieties, which should be replaced by shorter-season, more drought-tolerant ones. The community had also lost five finger millet varieties and now relied on two that could withstand the varying and changing climatic conditions.

Bioversity International (the Alliance of Bioversity International and CIAT) and research partners from Uganda and the region responded to this demand through activities under the project "Open Source Seed Systems for Climate Change Adaptation in Kenya Uganda and Tanzania." They looked for and identified potentially adaptable bean and finger millet varieties from sources beyond Hoima. Promising varieties were identified in the national gene banks of Kenya, Uganda, and Tanzania by means of novel climate profiling and GIS mapping technique profiling (Mittra 2019; Otieno et al. 2019). The beans and finger millet were then exchanged between the three national gene banks using the Standard Material Transfer Agreements (SMTA) of the multilateral systems of the ITPGRFA and made available for multiplication and subsequent testing by means of crowdsourcing by 250 farmers (Otieno et al. 2019). Table 2 summarizes the process.

The community seed bank now holds 23 varieties of beans, 19 of which are obtained through the international exchange, and 16 varieties of millet, of which 14 are obtained from the international exchange. The farmers are also working with breeders to select ten elite lines of each of the crops, which will be developed into new varieties through participatory plant breeding. So far, about 140 farmers have successfully borrowed seed from the community seed bank, and this number will double in the 2019/2020 season.

## Conclusion

Community seed banks are repositories of local genetic diversity that is often adapted to prevailing climate conditions including biotic stresses. They may be useful to contribute to community-based strategies for adaptation to climate change. This chapter provides evidence about actual roles of community seed banks in climate change adaptation based on a series of examples from various and diverse smallholder farmer regions of the world (Bangladesh, Guatemala, Nepal, South

Africa, Uganda, Zimbabwe). These studies illustrate two important ways in which more effective management of plant genetic resources can strengthen farmers' capacity to adapt to climate change. These ways are (1) securing improved access to and availability of diverse, locally adapted crops and varieties through the use of multiple germplasm sources and (2) enhancement of related local knowledge and skills in plant management including seed selection, treatment, storage, multiplication, and distribution. As such, community seed banks can enhance or revive traditional social seed networks that have existed for decades or centuries based on combinations of seed-saving, seed exchanges, seed-giving, seed-bartering, and seed purchase. What is needed now are a growing recognition among and support from policy-makers that community seed banks can be a very effective form of farmer organization toward more climate-smart agriculture and resilient rural livelihoods.

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