Resources **2014**, *3*, 636-656; doi:10.3390/resources3040636

OPEN ACCESS

resources

ISSN 2079-9276

www.mdpi.com/journal/resources

Article

The Multiple Functions and Services of Community Seedbanks

Ronnie Vernooy [1,*], Bhuwon Sthapit [2], Gea Galluzzi [3] and Pitambar Shrestha [4]

[1] Bioversity International, Via dei Tre Denari 472/a, Maccarese 00057, Italy

[2] Bioversity International, 93.4 Dharahara Marg, Fulbari, Ward #11Pokhara, Nepal; E-Mail: b.sthapit@cgiar.org

[3] c/o Bioversity International, c/o CIAT, km 17 Recta Cali-Palmira, Cali, Colombia; E-Mail: geagalluzzi@gmail.com

[4] LI-BIRD, P.O. Box 324, Pokhara, Kaski, Nepal; E-Mail: pitambar@libird.org

* Author to whom correspondence should be addressed; E-Mail: r.vernooy@cgiar.org; Tel.: +39-066118280.

External Editor: Takayuki Hiraki

Received: 16 June 2014; in revised form: 20 October 2014 / Accepted: 13 November 2014 / Published: 25 November 2014

Abstract: Although community-level seed-saving initiatives have existed in many countries around the world for about 30 years, they have rarely been the subject of systematic scientific enquiry. Based on a combination of a literature review and field research, we present a novel comprehensive conceptual framework that focuses on the multiple functions and services provided by community-based seed-saving efforts, in particular community seed banks. This framework is output oriented and complements an input oriented typology of community seed banks presented in 1997. The framework identifies three core functions: conserving genetic resources; enhancing access to and availability of diverse local crops; and ensuring seed and food sovereignty. The framework can be used for analysis of existing seed-saving initiatives and serve as a guide for the establishment of new community seed banks. In addition, it can inform the development or revision of national policies or strategies to support community seed banks. The framework's utility is illustrated by three case studies of community seed banks in Bangladesh, Guatemala and Nepal.

Keywords: agricultural biodiversity; conservation of biodiversity; plant genetic resources; community seed banks; farmers' rights; food sovereignty; seed sovereignty; Bangladesh; Guatemala; Nepal

---

1. Introduction

Community-level seed-saving initiatives have been around for about 30 years. These efforts have taken various forms and labels, including community gene bank, farmer seed house, seed hut, seed wealth center, seed-savers group, association or network, community seed reserve, seed library and community seed bank. We use the latter as an umbrella term. Broadly speaking, community seed banks are local, mostly informal institutions whose core function is that of collectively maintaining seeds for local use [1–3]. As such, they are usually part of farmers' informal seed systems, in which the various stages of seed management—selection, conservation, exchange and improvement—take place without involvement of or control by research, development or government agencies.

Beyond this core conservation function, community seed banks have a broad range of additional purposes and vary significantly in scope, size, governance and management models, infrastructure and technical aspects (e.g., seed storage facilities and conservation techniques, documentation and administration) [4]. Community seed banks are examples of on-farm management of local crop diversity that allows the processes of both natural and human selection to continue to act in the agricultural production system [5,6]. Through a combination of effectively and efficiently managed community seed banks responsive to local needs, the continuous flow of seeds and information between community seed banks and other stakeholders and an enabling policy/legal environment, community seed banks can make important contributions to local seed security in terms of seed access and availability.

The drivers underlying their establishment, evolution and sustainability vary considerably. Some were set up following a famine, drought or flood and the accompanying loss of local seed supplies. Others were initiated following participatory crop improvement efforts that resulted in the availability of new cultivars and new skills to maintain healthy and genetically pure seed locally. Still others were established because farmers were far removed from a reliable source of quality seed. In developed countries, community seed banks often arose when hobby farmers and gardeners began to conserve and exchange their seeds [7].

Depending on management capabilities, governance modalities and type, level and duration of external support, community seed banks have withered rapidly or endured. Although most initiatives were born thanks to the financial and technical support of nongovernmental organizations (NGOs) and farming communities themselves, in recent years, a number of national governments have developed plans and mobilized financial and technical resources for the establishment of community seed banks. In search of self-support mechanisms, some of the more recently established banks in developing countries have expanded their seed-multiplication services (e.g., maize seed banks in Guatemala [8] and in the Philippines [9]). In some cases, they have become local contractors for commercial seed enterprises or government seed agencies and, thus, have moved away from the community seed bank framework described in this review.

Perhaps surprisingly, community seed banks have rarely been the subject of systematic scientific enquiry. Based on a literature review and field research, we propose a framework for filling this knowledge gap that allows a comprehensive analysis of the multiple facets, functions and activities of local seed-saving experiences that can be united under the common definition of community seed bank. We present an overview of the literature and an account of the history and evolution of community seed banks around the world. We then describe our framework illustrated by three descriptive case

studies of community seed banks. We conclude by highlighting a number of sustainability challenges and opportunities.

2. Results

2.1. Filling the Knowledge Gap: A Review of the Literature

Most of the writing about community seed banks has been empirical and can be found in grey literature or in reports or briefs by NGOs that assist farmers in conservation and sustainable use of local crops and landraces [4]. A few references to community seed banks can be found in the literature on seed systems and the management of agricultural biodiversity (e.g., [10–16]). In this literature, community seed banks are treated as examples of local-level institutions that contribute to seed conservation, especially of farmer varieties, countering erosion of crop diversity or its loss following natural disasters. Surprisingly, a major international publication, the Food and Agriculture Organization's *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* [17], does not make reference to community seed banks.

The 1997 working paper "A typology of community seed banks" [18] is, to our knowledge, the first and only attempt to characterize community seed banks globally. Its authors focused on the following distinguishing features: type of seed stored, storage method and seed-exchange and seed-multiplication mechanisms. Based on these features, the authors identified five types of community seed banks: *de facto* seed banks, community seed exchanges, organized seed banks, seed-saver networks and ceremonial seed banks. Because of its focus on the type and management of seeds, this characterization could be described as input centered, and it is a useful early attempt to categorize the wide variation among community seed-saving efforts. However, it fails to address fully the diversity of functions and services provided by community seed banks.

Jarvis *et al.* [19] developed a framework to identify multiple ways of supporting the conservation and use of traditional crop varieties (key components of agricultural biodiversity) within agricultural production systems. They list grassroots seed-saver networks, community seed banks, community-based seed production groups and seed cooperatives as effective participatory seed exchange mechanisms to improve the availability of plant genetic materials. This more recent framework integrates community seed banks into a broader perspective of conservation and use of plant genetic resources. However, it does not elaborate what they actually do, what functions they perform, what services they deliver and what factors influence their sustainability.

Sthapit [3] considers community seed banks as platforms of community-based management of agricultural biodiversity that can ensure effective implementation of farmers' rights through the recognition of local knowledge of agricultural biodiversity, participation in decision-making concerning its conservation, benefit sharing and the existence of a supportive policy and seed regulatory framework. He argues that community seed banks can also provide an opportunity for interaction and integration of informal and formal seed systems for the promotion of *in situ* and *ex situ* linkages to back up genetic resources locally and as building blocks of crop improvement, food security and sustainable community development. Sthapit's careful attention to the political, institutional, socio-economic and agro-ecological

dimensions of community seed banks allows for the development of a coherent holistic framework. In this paper, we build on his analysis.

2.2. Origins and Evolution of Community Seed Banks

The number, diversity and degree of development of community seed banks vary greatly among countries. Because of the paucity of formal literature, exact numbers are hard to determine, but in some countries, e.g., Brazil, India, Mexico, Nepal and Nicaragua, mention is made of a total ranging from 40 to more than 100. In other countries, e.g., Bhutan, Bolivia, China, Rwanda, South Africa and Uganda, only a few seed banks exist and they are often at the early stages. Some countries, e.g., Australia, Canada, Nepal and Spain, have a formal national network of community seed banks or local seed-saver groups.

Although there may be a variety of starting points for establishing community seed banks and of actors involved in the initiatives, there is no doubt that NGOs have played an instrumental role and continue to do so in many countries. In the early 1980s, ideas emerged within civil society organizations to set up community seed banks in the South, not only to address local conservation needs, but also to demonstrate that smallholder farmers are able to back up conventional gene banks and ensure local seed supply and, in turn, food sovereignty [20].

Among the pioneering NGOs in community seed bank work is the Rural Advancement Foundation International (RAFI, now known as the ETC Group). In 1986, RAFI produced a "community seed bank kit", the first hands-on guide to establishing a local gene or seed bank [21]. Inspired and assisted by RAFI were other NGOs, such the Philippine-based SEARICE (Southeast Asia Regional Initiatives for Community Empowerment) operating in a number of Southeast Asian countries [22]. The Unitarian Service Committee (USC Canada), based in Ottawa with partner NGOs around the world, established the Seeds of Survival program in the late 1980s and early 1990s, which is still providing support to community seed banks in ten countries [23]. Bioversity International has pioneered and supported the establishment of community seed banks in a number of countries (e.g., Bolivia, Burkina Faso, China, Malaysia, Nepal, Rwanda, South Africa and Uganda) as part of its research on the conservation and sustainable use of agricultural biodiversity and, more recently, on adaptation to climate change.

In the early days, community seed banks were mainly established to conserve local varieties, including rare ones, in response to the loss of local crop genetic diversity and the corresponding threats to productivity and local food security. In some cases, they were a response to a natural disaster, most notably droughts and floods, which affected the seed supply of farming communities. Examples include Unnayan Bikalper Nitinirdharoni Gobeshona (UBINIG; Policy Research for Development Alternatives) in Bangladesh [24,25], the Relief Society of Tigray and Ethio-Organic Seed Action in Ethiopia and the Community Technology Development Trust in Zimbabwe, where a first community seed bank was set up in 1992 following severe drought [26]. In India, several NGOs took the lead including the GREEN Foundation, the Academy of Development Sciences [27], the Deccan Development Society [28], the M.S. Swaminathan Research Foundation and Gene Campaign, and, in Nepal, USC-Asia and LI-BIRD (Local Initiatives for Biodiversity, Research and Development) [29]. In Nicaragua, NGOs, such as Centro Intereclesial de Estudios Teológicos y Sociales (CIEETS) and the Programa Campesino a Campesino (PCaC) [30] took the lead; in Guatemala, Asocuch, and, in Honduras, the Fundación para la

Investigación Participativa con Agricultores (FIPAH) were the prime actors [31]. In South America, Centro de Educación y Tecnología (CET) based in Chile and the Fundación Proinpa in Bolivia [32] played lead roles; in Brazil, various NGOs support community seed banks at the state level. Several of the national NGOs mentioned above receive financial and technical support from the Norwegian Development Fund, one of the few long-term supporters of community seed banks globally [1].

Exceptions to strong NGO involvement exist. For example, in Ethiopia, the Plant Genetic Resource Center, a government agency, supported a number of community seed banks, thus building direct links between the national and local levels [33,34]. Another example comes from Mexico where a national network known as SINAREFI (Red de Centros de Conservación del Sistema Nacional de Recursos Fitogenéticos para la Alimentación y la Agricultura) has been set up to systematize all formal conservation and sustainable use activities concerning plant genetic resources. SINAREFI is coordinated by the Servicio Nacional de Inspección y Certificación de Semillas and is part of the country's overall strategy for conserving agricultural biodiversity [35]. SINAREFI's interest in and support of community seed banks are recent. As in Mexico, other governments around the world are also developing plans to support community seed banks.

Preceding and partly in parallel with these initiatives in the South, so-called seed-saver groups, associations and networks in the North have taken up the cause. These are made up largely of farmers and gardeners who share a common interest in keeping traditional and local crop diversity alive. The designation "heirloom seed" is often used in these efforts, reflecting the desire to reconnect with long-standing agricultural traditions. For instance, in the North American context, heirloom seeds are those originally carried and adapted by settlers from Europe. Seed savers form a sort of community of practice that connects like-minded people, often living thousands of miles apart, and are thus quite different from the place-bound social groups that operate in the South. The USA-based Seed Savers Exchange, a not-for-profit, member-supported organization, was established in 1975 by Diane Ott Whealy and Kent Whealy. Its aim is to preserve heirloom seeds by building a network of committed people who collect, save and share seeds and plants [36]. The organization is anchored by an 890-acre heritage farm in Decorah, Iowa, where seeds of over 600 varieties are reproduced, catalogued and disseminated and where educational activities also take place. Most seeds are donated by long-time members. In 1986, inspired by this example, Australian Seed Savers was set up by Michel and Jude Fanton. First established nation-wide without government support, it has since developed a network of local networks across the country [37,38]. Since 1995, the Australian network has supported the establishment or strengthening of such groups in almost 40 countries.

Seed-saver networks not only keep seed diversity flows going over time and in space, but in a number of countries are also actively engaged in policy debates and advocacy efforts to gain recognition and support for the activities of *in situ* conservation and sustainable use of crop and tree diversity. These networks effectively function as alternative sources to access types of seeds that are not made available by most commercial seed companies or government breeding programs.

2.3. Toward a New Framework to Assess the Functioning of Community Seed Banks

Based on the review of the literature and our own experience and insight gained from direct involvement with community seed banks in a number of countries around the world, we propose a novel analytic framework that describes community seed banks from the point of view of their functions and services. This framework is not only useful for supporting more systematic and comprehensive analyses of existing initiatives, but can also guide the establishment of new community seed banks and inform the development or revision of national policies or strategies to support community seed banks. The framework identifies three core functions of community seed banks (Table 1): conserving plant genetic resources; enhancing access to and availability of local crop diversity; and ensuring seed and food sovereignty. For each function, we identified a number of services and benefits, not all of which are necessarily present at the same time in every community seed bank.

Table 1. Multiple functions and services of community seed banks.

Function	Services
Conservation	- Short-term conservation of mostly local varieties - Longer-term conservation of heirloom and rare varieties - Restoration of "lost" varieties - Development of protocols for conservation of healthy seed and training of local communities
Access and availability	- Platform offering multiple channels of access and availability of seeds at the community level - Maintenance of locally adapted seed at a low cost - Fostering of seed exchanges at local and supra-local levels - Access to novel diversity not conserved locally - Provision of adapted seed to marginal communities not served by commercial seed dissemination efforts - When quantities suffice, capacity to respond to local crises/disasters/ acute shortages of seeds - Seed multiplication including varieties bred through participatory activities
Seed and food sovereignty	- Maintenance of local control over seed conservation, exchange and production activities (community-based biodiversity management) - Income generation through the sales of seeds - Sharing of agricultural biodiversity knowledge and expertise - Links between *in situ* and *ex situ* conservation - Support of traditional and ethnic food culture and cultural use - Contribution to ecological agriculture and food sovereignty movements

Conceptually, the three core functions are intertwined, complementary and not mutually exclusive. In practice, one function tends to dominate, although some community seed banks have multiple functionality [39,40]. The contribution of a community seed bank to seed security depends on its functions and the degree to which it has achieved them. The case studies that we present below demonstrate the

differences that exist; they were selected from a diverse, global compilation of 35 in-depth cases studies commissioned by Bioversity International. They are meant to illustrate the three major types of community seed banks. They differ not only in terms of main function, but also with regard to trajectory, types of seeds handled, scope of operations and policy and legal environment. In the following sections, we describe each of the functions in more detail and present an example of each approach.

2.4. Conservation of Crop Genetic Diversity

Two complementary methods for conserving plant genetic resources exist: *ex situ* and *in situ* conservation. *Ex situ* conservation consists of storing samples of crop species outside their natural habitat or growing conditions (e.g., in gene banks and botanical gardens); *in situ* conservation takes place on farm (for crops) and in the wild (for wild relatives of crop species), *i.e.*, in natural habitats or protected areas. Community seed banks occupy an intermediate position between these two forms of conservation. They generally store seeds of local varieties under *ex situ* conditions in a physical structure. (The exception is community seed banks that deal primarily with roots and tubers, which are continuously propagated in the field.) Seed banks conserve, but usually with the aim of making seed available to the local community from one planting season to the next through mechanisms that usually require users to replenish the seed stocks each cycle. In this way, they are providing on-farm conservation services more directly and more locally than institutional gene banks, which store seeds for longer periods and usually serve the needs of breeders and researchers rather than those of small-scale farmers.

In addition to short-term conservation of material in regular use by local farmers, a number of community seed banks store materials that have limited use or are not currently grown in the field, giving rise to a longer-term conservation service. For these materials (such as heirloom, rare and wild semi-domesticated species), the community seed bank functions more as a conventional gene bank, *i.e.*, purely conservation oriented.

Women are very active in most, if not all, community seed banks, often as the principal seed selectors and guardians and, in some cases, such as in Nicaragua [30], managing all aspects of community seed banks from selection to distribution of seeds. However, the role of women is not always recognized by formal-sector agencies.

In some cases, mostly following technical advice from supporting organizations, community seed banks have been instrumental in recovering seeds of "lost" varieties. This has been done by identifying, collecting and carefully multiplying seeds held by only one or a few farmers in the community or by acquiring and multiplying varieties held in the national gene bank that had disappeared from the community where they were originally collected.

There is no single way to run the technical side of a community seed bank. The bank's management committee decides how to record seed-sample information (*i.e.*, the "passport data" as it is called in formal *ex situ* institutions), which descriptors to use to distinguish accessions, what storage infrastructure to set up (keeping seeds genetically pure and healthy is an essential task) and how to manage seed distribution, evaluation and regeneration activities. Handbooks on how to save seeds written by seed-saver pioneers are available online [37,41], but may not be accessible to farmers in the South. Several NGOs involved in community seed banking in small-scale farming communities in the South have developed technical booklets to assist farming communities manage a community seed bank. Our review of

experiences in developing countries revealed that inadequacies in the technical aspects of seed storage persist, often due to financial and infrastructural limitations, and still represent a major challenge. We now describe a successful, mainly conservation-oriented seed bank in Nepal.

Case study 1: Conserving crop diversity richness in Nepal [42]

On the main road halfway between Kathmandu and Pokhara, in the village of Jogimara, a small, two-story building can be found. The ground floor consists of a single room about 4 m by 3 m; it houses the Jogimara community seed bank. Seed banking was initiated in this mountainous, dry area by LI-BIRD, an NGO specializing in agricultural and natural resource management research, including the conservation and sustainable use of agricultural biodiversity; its headquarters are in Pokhara. In 2009, LI-BIRD staff, as part of its programming related to fair access and benefit sharing of plant genetic resources [2], offered training in farmers' rights, breeders' rights and intellectual property in relation to conservation of agricultural biodiversity. This encouraged local smallholder farmers to set up small biodiversity focal groups in nine wards (the ward being the lowest administrative unit of the country) and to start by making an inventory of all plant genetic resources available there. Varietal richness still existed in the area, but most farmers did not value the contribution of local varieties. They tended to favor modern varieties and hybrids, especially for marketing. However, some farmers valued local varieties for their taste and nutritive value (e.g., finger millets) or because they are drought tolerant and good forage for animals.

To improve the performance (and thus the acceptance) of local varieties, LI-BIRD also introduced new agricultural management practices, such as integrated pest management and the use of home-made pesticides. After the groups were set up in each ward, the members decided to form a committee to manage a community seed bank. Together with LI-BIRD, the committee organized a series of events to raise awareness among farmers about conservation of agricultural biodiversity, such as a diversity fair, a festival and rural street drama. Gradually farmers became aware of the importance of local varieties and more natural forms of agriculture that are less harmful to the environment. They also realized that important local crop diversity was being lost. LI-BIRD supported the setup of the community seed bank with a one-time financial contribution. Additional funds and in-kind contributions were mobilized in each ward and allowed the construction of the seed bank building. In 2012, the community seed bank began to operate on its own with no external financial support. Serving hundreds of local farmers, it has acquired the status of local NGO, which, in Nepal, confers legitimacy as a local farmer organization. NGO status could also aid in the search for funding, but so far the community seed bank management committee has not taken action in this regard.

The community seed bank maintains varieties of the major crops in the area, rice (11 irrigated varieties and five traditional upland varieties) and maize (two traditional varieties). In addition, it maintains a large collection of neglected and minor crops, including several types of millets, beans, gourds, oilseed crops, cowpeas and pumpkins. Seeds are kept in three types of containers: traditional clay pots, traditional straw baskets and modern plastic containers. According to the farmers, plastic storage containers are very effective and their transparency

allows easy and immediate visual inspection. However, plastic containers also have disadvantages, such as risk of mold and reduced growth and viability of oil- or high-moisture-content seeds in low-lying humid subtropical environments. Thus, careful seed drying and handling is required.

At the beginning of each growing season, the leaders of the community seed bank organize a meeting with villagers to determine which seeds they would like to borrow. The seed bank has established a small biodiversity fund to support conservation and use of local varieties; anyone who borrows from the fund must grow at least one traditional crop variety. Another rule is that each village takes care of the regeneration and seed multiplication of all varieties of one crop. For example, ward 3 propagates rice. For each kilogram borrowed, 1.5 kg are repaid; this encourages farmers to make use of the community seed bank, as no cash is required. Practice indicates that farmers appreciate these regulations. In 2011, the second year of operations, the community seed bank distributed about 250 kg of seeds. To date, 155 farmers, mostly resource poor, have benefited and the number is growing.

The community seed bank's committee faces a number of challenges related to management and operations, such as lack of time and resources, still-limited technical skills required to control seed quality and the absence of interactions with other community seed banks to exchange seeds and learn from each other. Management committee members wish to enlarge the bank's genetic resource base, involve more farmers and, thus, acquire more diverse seeds in terms of both crops and varieties.

2.5. Enhancement of Access and Availability

The second function of community seed banks focuses on providing access and guaranteeing availability of diverse seeds and related knowledge. Community seed banks can serve as key local sources of germplasm allowing farming communities to exchange seeds in a decentralized manner through social networks and organized events, such as diversity fairs and participatory seed exchanges. As such, community seed banks can operate as a central node in the local seed system and as a bridge to the supra-local level and the formal seed system, e.g., through links with other community seed banks, the national gene bank or other plant genetic resource institutions. Farmers' abilities to search for new forms of diversity, select new traits, cultivate and exchange selected materials with friends, relatives and community members are the basis for the processes that allow genetic materials to evolve and adapt [43]. In the broader perspective, it could be argued that this function could contribute to socio-ecological resilience which, for rural communities, means a capacity to withstand changes and manage risk in their agro-ecosystems [44,45]. This process is very knowledge intensive and continued local and national institutional support is required to drive it.

Because they are based on forms of farmer–farmer cooperation (in particular, pooling of land, labor and knowledge), principles of reciprocity and fairness, community seed banks can provide access to seeds for marginalized households or groups in the community. Another important feature is that seed exchanges usually do not involve monetary transactions (seeds borrowed are paid back with seeds); thus, they allow greater participation, even of cash-poor households. When community seed banks are able to build up consistent stocks of seed for at least some major crops, they can function as a back-up seed source in times of sudden, higher than expected need, such as after a natural disaster.

A number of community seed banks are engaged in participatory plant breeding and variety selection, which can strengthen access to and availability of improved seeds and increase diversity. Usually started on a small scale, some of these crop improvement practices have evolved into seed production and sales of new varieties, for example, of maize in China, beans in Honduras and rice in Nepal. Usually, such local seed production focuses on crops and varieties that the commercial seed sector does not offer. This kind of activity can contribute to financing day-to-day operations of community seed banks and, thus, enhance their viability in the longer term.

Case study 2: Communities revitalizing maize diversity in Guatemala [46]

The Huehuetenango region in the Cuchumatanes highlands of western Guatemala is an important center of maize diversity. Although farmers there have developed a wealth of open-pollinated local varieties, changing environmental and socio-economic conditions are beginning to have a negative impact on the continued maintenance of local genetic resources on farm. Over the past ten years, climate variations and a series of natural disasters have considerably affected maize-based production systems. The increasing fragmentation of land holdings has led to weakening of traditional forms of seed exchange and related knowledge. Declining productivity has begun to affect families' food security, as current production levels sustain home consumption for only half the year. This has led to a tendency among farmers to devalue and abandon their local varieties and to buy seeds of commercial varieties and hybrids on the market. However, these seeds are expensive and often do not perform well in the low-input, harsh growing conditions of the area or they may not suit the cultural preferences of traditional communities.

Based on the conviction that the maintenance and continued evolution of locally adapted genetic resources through collective, community-based innovations, including community seed banks, are key elements for achieving resilience of local communities and agro-ecosystems, Asocuch, a Guatemalan association of agricultural cooperatives, initiated efforts to halt the loss of agricultural biodiversity. Asocuch joined forced with the Fundación para la Innovación Tecnológica, Agropecuaria y Forestal and the governmental Instituto de Ciencia y Tecnología Agrícola to establish a Guatemalan component of the Collaborative Programme on Participatory Plant Breeding in Mesoamerica.

Starting in the Quilinco community, maize landraces conserved by farmers were collected and characterized, resulting in a base collection representative of the on-farm diversity in the area. This initial collection formed the basis of a participatory breeding process, in which farmers were trained in selection techniques (mostly mass selection), whose application gradually improved the performance of local varieties according to farmers' preferences. In parallel, community efforts were made to conserve the initial collection in a rudimentary seed bank. Over the years, the collection has grown thanks to the inclusion of the gradually improved materials from the breeding program. The Quilinco seed bank now holds about 660 maize accessions and another seven community seed banks have been established in other communities in the area. Up to 1000 farmers have been trained in mass selection and seed conservation, and significant increases in local landrace yields have been achieved.

These efforts have not only contributed to strengthening the seed and food security of more than 5000 people in the region, but have also enabled the conservation of locally adapted maize varieties. Recently, community members have begun selecting best-performing adapted landraces for larger-scale multiplication leading to the production of seed packets for sale. They plan to expand their operations and search for markets farther away.

However, challenges remain in terms of dissemination and wider adoption of these seeds. No policy mechanism currently allows registration or certification of improved landrace seeds produced by farmers and agricultural co-operatives, and this limits wider commercial distribution. Benefit-sharing and intellectual property issues around this type of community-based innovation and rules and regulations concerning access and availability are also unclear. Asocuch is currently participating in technical and policy discussions around the drafting of a national seed law and advocating the inclusion of a seed category and related regulations appropriate for registering, sharing and commercializing the improved landraces produced by the farmers of the Cuchumatanes.

2.6. Seed and Food Sovereignty

The third function of community seed banks is much broader than the previous two. It focuses on the sustenance of rural livelihoods, local cultural and ethnic food traditions (some authors use the term peasant autonomy [47]) through seed and food sovereignty, the practical implementation of farmers' rights and community empowerment. Food sovereignty is an evolving concept, first launched by the international NGO La Vía Campesina (literally, the peasant road) in 1996 as a critique or counter-frame [48] to the concept of food security as well as to the globalization and industrialization of agriculture. The defenders of the concept argue that this is primarily a political issue and a prerequisite for achieving food security. The core element is that people should have the right to choose their own food. To achieve this goal, it is argued, people should have or regain democratic control over the food system, rely more on local food markets, recognize the key role of women farmers, tie international trade to social goals and promote sustainable agriculture and the protection of the natural resource base as the pillars of food production [49]. Seed sovereignty is considered an integral part of food sovereignty [50].

Seed sovereignty is expressed through the locally controlled practices of using, conserving and exchanging locally adapted seeds (and other planting materials), related knowledge and, where appropriate, marketing through forms of collective action. By definition, these activities are at the heart of community seed banks and seed networks at local and even national levels; examples of the latter are the national seed-saver networks that exist in many countries. From a sovereignty point of view, the challenges related to the operation of collectively managed seed initiatives are defined in terms of access and control [48] rather than in terms of conservation and sustainable use. One particular method inspired by the food and seed sovereignty concept is known as community-based biodiversity management by which local groups aim to take control of all their biodiversity-based assets and improve them through collective efforts, such as a biodiversity fund [16].

Andersen and Winge [51] have pointed out that community seed banks contribute to the realization of farmers' rights as defined by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Under ITPGRFA, contracting parties have made a range of high-level

commitments to *in situ* and *ex situ* conservation and sustainable use of plant genetic resources, to pooling and sharing those resources for agricultural research and breeding and to promoting farmers' rights. Community seed banks ensure a diversified supply of seeds adapted to local conditions, protection of knowledge related to local varieties, reduction of dependence on seed sources from outside the community, sharing and multiplication of seeds, crop improvement activities, and access to seed reserves in time of stress. Through the use of the ITPGRFA's multilateral system, better links between farmers and community seed banks, on one hand, and between community seed banks and national and international gene banks and breeding programs, on the other, have the potential to improve the flow of diversity and information in both directions. This will increase the diversity available to farmers from *ex situ* collections and plant breeding programs and, conversely, allow more materials from farmers to be available for *ex situ* collections and breeders [52]. At the same time, the Benefit-sharing Fund set up under the ITPGRFA could serve as a funding mechanism for community seed banks, a window that has been opened by the last round of funding announced in 2014 [53].

In Europe, numerous examples of seed-saver networks have the clearly stated intention of promoting the concept of food and seed sovereignty, e.g., in France, Germany, Italy, Spain [54,55]. These networks are involved in the organization of regional and local seed fairs, training workshops, participatory plant breeding activities and transmission of farmers' knowledge about the selection and conservation of local varieties, the organization of food festivals and the promotion of ecological or organic agriculture. In the South, a relevant example of a sovereignty-oriented seed-saving experience comes from Bangladesh.

Case study 3: The new agricultural movement of Bangladesh [56]

The Mamudpur Nayakrishi Seed Hut (NSH) in Bangladesh was set up in 2001 with the support of the policy research NGO UBINIG. In a seed hut, which is the equivalent of a community seed bank, a group of farming households jointly takes responsibility for looking after their seeds, which are collected and regenerated on behalf of a wider community of farmers. Women play key roles in management. The NSH is linked to the Community Seed Wealth Center of the UBINIG Tangail Center. The NSH and center are both affiliated with Nayakrishi Andolon, a nation-wide farmers' initiative for biodiversity-based and organic farming. Its members have identified ten principles of farming, one of them being "keep seeds in farmers' hands" [57]. Nayakrishi Andolon now encompasses more than 300,000 farming households in 19 districts of the country. The NSH also serves as a common meeting place for the Nayakrishi farmers to discuss their crops, access to seeds and other related issues, such as food safety and food and seed security.

The main species in the Mamudpur NSH are rice (17 local varieties), wheat (1), barley (1), pulses (5), oilseeds (6), vegetables (40), spices (11) and fiber crops (2). Currently, about 1500 kg of seeds are stored. Smallholder farmers are interested in cultivating indigenous varieties of crops and vegetables following Nayakrishi principles, as they prefer local seeds for their resistance to common pests and pathogens. Moreover, modern varieties are costly and require the application of chemical fertilizers, pesticides and irrigation. In addition to the species and varieties in greatest demand by local farmers, specially identified custodian farmers take care of regenerating and maintaining seed of a number of neglected and underused species. In 2010,

12 of the lesser used materials identified and regenerated by the NSH included safflower (oilseed), satpotal (a rare variety of ridged gourd), elephant foot yam, a bean variety, local red radish, aniseed, tossa jute, finger millet and a number of rare rice landraces. This effort is already bear fruit in the case of some previously neglected species, e.g., barley, foxtail millet, sesame and chili, which have been reintroduced into organic cultivation and are showing good adaptation to changing environmental conditions. The Mamudpur NSH has also engaged in germplasm exchange with other NSHs in the area.

Two committees are responsible for the management and coordination of the NSH: the Natural Resource Auditing Committee with seven members and the 11-member Specialized Women Seed Network (SWSN). The latter is engaged in collecting, drying and storing seeds, drying containers and cleaning the seed hut. The SWSN meets every week to approve the seasonal cropping plan, seed distribution and seed exchanges. The use of local varieties has increased along with the use of on-farm resources (cow dung and compost) and practices (crop diversification, mixed cropping, reduced use of chemical fertilizer and no use of pesticides). More and more farmers are growing local varieties of seeds and the number of member farmers is gradually increasing.

Mamudpur NSH holds 89 varieties of crops (and the associated knowledge), all of which are suited to flood plain agro-ecological conditions. Of these, 15 varieties have been identified as adapted to changing climatic conditions. Recently, rainfall patterns and soil moisture conditions have become variable: drought may be followed by heavy rain and flooding in the same season. Farmers are now selecting rice varieties that can survive dry conditions and adapt if flooding occurs. The NSH is planning to expand its operations to the production and marketing of seeds. The seeds not used by members will be sold and the money used to run the NSH.

2.7. Funding and Sustainability

A key issue of importance to all community seed banks, no matter their function, is financial sustainability. To be financially viable and not completely dependent on voluntary labor, a community seed bank should be designed in such a way that it generates economic incentives at two levels: for its members (in particular those playing key roles) and for the organization as a whole. One important reason why community seed banks become less functional when external support is withdrawn is the lack of economic activities to support the livelihoods of member families. From our global review, it was apparent that many community seed banks fail to consider economic empowerment and financial sustainability, except in terms of producing and marketing farmer-preferred varieties of local and improved seeds. In cases where this strategy is successful, it has generated economic benefits at both levels. It has also gone hand in hand with making seeds available to needy members and others, usually at a lower price than other sources. For example, community seed banks in Nepal, Zimbabwe and Costa Rica are producing and selling seeds in large volumes and doing well financially. Others are in the process of developing community seed banks as enterprises, e.g., in Uganda.

A unique approach, developed in Nepal and now disseminated elsewhere, is the establishment of a community biodiversity management fund [40]. These funds (approximately USD 5000–10,000 per

community seed bank) were created using project-related donor funding and contributions from the community (ranging from 10% to 25%). They are set up as revolving funds available to seed bank members to finance income-generating activities. This system provides easy access to small amounts of credit (without the need for collateral or complex procedures) to seed bank members, as well as generating some income for the community seed bank in the form of interest. Currently, at 12% a year, the interest is used to cover staff salaries, the cost of regenerating rare local varieties and other operational expenses.

3. Discussion: Challenges and Opportunities

The practice of community seed banking around the world has made enormous progress. In this article, we have aimed to advance the conceptual dimension of the varied experiences. Community seed banks continue to emerge in different parts of the world in response to concerns about the gradual loss of biological diversity in agricultural systems, the loss of seeds caused by natural disasters and the demands of farmers to participate in locally driven diversity management strategies. In an attempt to shift away from or complement the exclusive focus on community seed banks based on their "inputs" (what they conserve and how), we based our assessment on their "outputs" (functions and services). We suggest that community seed banks can be effective platforms for local collective action and empowerment in terms of the conservation and sustainable use of plant genetic resources for food and agriculture. Seed banking initiatives contribute not only to the conservation and continued use of major crops, but also to the preservation of a number of underused species usually not targeted by formal-sector conservation and plant-breeding initiatives. Some community seed banks fulfill one predominant function (conservation, access and use or local development and sovereignty), whereas others serve more than one function or shift among them over time, depending on the context. The framework presented here captures these three core functions and allows for their interplay.

The three diverse case studies illustrate how community seed banks are effective examples of community-based management of agricultural biodiversity. They can also be a vehicle for the practical implementation of farmers' rights, in cases where governments recognize their collective practices, provide incentives and rewards and invite community seed bank members to participate in decision-making processes concerning plant genetic resources at local, national and international levels. In addition, they have begun to foster synergies between informal and formal seed systems by involving their members in activities such as participatory plant breeding. Community seed banks can play an active role in the multilateral system of the ITPGRFA as both providers and users of diversity through links among community seed banks, exchanges with other seed networks and collaboration with formal-sector institutions. However, for a community seed bank to be effective in the long run, a number of conditions must be met: legal recognition and protection, options for financial viability, members with adequate technical knowledge and effective operational mechanisms. Careful and systematic planning right from the start is another important factor.

Recently, the potential of community seed banks to deal with the effects of climate change has come to the fore [58]. Increasing crop and varietal diversity is one strategy farmers can deploy to deal with climate changes that are affecting or expected to affect local production systems. A decentralized seed bank network with well documented collections and flows of material for conducting multi-location

trials would allow the evaluation of species' adaptive capacity and exchanges among regions. An additional benefit of such a network would be to alleviate the risk of seed losses caused by increasingly unpredictable weather and provide support in case of emergencies.

Better connections with the formal sector would provide opportunities for improving the functioning of community seed bank in areas such as management, documentation, seed storage and production, marketing, finances and incentives for new members to join. In South Africa, for example, the Department of Agriculture, Forestry and Fisheries considers community seed banks to be a means to strengthen the informal seed system, support the conservation of traditional farmer varieties and maintain seed security at district and community levels [59,60]. The Departmental Strategy on Conservation and Sustainable Use of Genetic Resources for Food and Agriculture proposes, among other things, both *ex situ* and *in situ* conservation of plant genetic resources for food and agriculture. South Africa has a well-developed *ex situ* conservation facility, the National Plant Genetic Resources Center (NPGRC), where accessions of plant material are maintained. The mandate of the NPGRC has recently been extended to include community seed banks as a strategy to promote on-farm management and conservation.

Common challenges for maintaining and upscaling community seed banks around the world include improving the mechanisms that contribute to a more secure and diversified supply of high-quality seeds adapted to local conditions and developing incentives for farmers, particularly younger generations, to continue their seed-saving efforts. The former can be achieved through the introduction of more efficient and effective systems to acquire and exchange seeds, better seed conservation and multiplication practices for a broad range of crops and training in crop improvement practices. Community seed banks would benefit from targeted technical and financial support from formal-sector agencies, possibly becoming a line item in national plant genetic resource conservation budgets.

The development of an enabling policy and legal environment is most likely the greatest challenge that most community seed banks face. However, in a few countries, an environment somewhat favorable to local seed conservation and use exists. For example, the state of Paraíba in northeast Brazil passed a law to legalize the distribution of seeds produced by community seed banks without the required formal certification by specialized agencies [61]. Recently, several governments around the world (e.g., in Central America, Bhutan, Bolivia, Rwanda and South Africa) have begun to work on creating support mechanisms and incentives. Community seed banks can provide a concrete, important testing ground for legislation and policies to protect, recognize and promote farmers' rights in the realm of agricultural biodiversity conservation. More broadly, such regulations would guarantee communities' rights to self-determination and sovereignty and provide incentives for them to continue their farming activities sustainably to the benefit of all of society.

Practical experience has come a long way. In this article, we have attempted to also move theory forward in the hope that the future development of community seed banks can be informed by our efforts to provide a solid revision and theoretical framing of the state of the art at the global level.

Acknowledgments

We thank Elsa Andrieux for her contribution to the literature review and initial inputs for the framework, Isabel Lapeña for her contribution to the Guatemala case study and colleagues at Unnayan Bikalper Nitinirdharoni Gobeshona (UBINIG; Policy Research for Development Alternatives), Dhaka,

Bangladesh, for allowing us to include a summary of their case study of the Mamudpur Nayakrishi Seed Hut. We thank Sandra Garland for her excellent text editing. We gratefully acknowledge the useful comments and suggestions to improve the article made by two reviewers. This work was supported by the Directorate-General for International Cooperation of the Ministry of Foreign Affairs of the Netherlands. The research documented in this article contributes to the Consultative Group on International Agricultural Research (CGIAR) Research Program on Policies, Institutions and Markets (http://www.pim.cgiar.org/). This program is led by the International Food Policy Research Institute, Washington, DC, USA, a member of the CGIAR.

Author Contributions

All authors contributed substantially to the design of this study, interpretation of the results and preparation of the manuscript. All authors approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. The Development Fund. *Banking for the Future: Savings, Security and Seeds*; The Development Fund: Oslo, Norway, 2011.
2. Shrestha, P.; Sthapit, S.; Devkota, R.; Vernooy, R. *Workshop Summary Report. National Workshop on Community Seed Banks, 14–15 June 2012, Pokhara, Nepal*; Local Initiatives for Biodiversity, Research and Development: Pokhara, Nepal, 2012. Available online: http://www.nuscommunity.org/uploads/tx_news/Community_seed_bank_national_workshop_summary_report_final.pdf (accessed on 13 October 2014).
3. Sthapit, B. Emerging theory and practice: Community seed banks, seed system resilience and food security. In Proceedings of the a National Workshop Community Seed Banks in Nepal: Past, Present, Future, Pokhara, Nepal, 14–15 June 2012; Shrestha, P., Vernooy, R., Chaudhary, P., Eds.; Local Initiatives for Biodiversity, Research and Development: Pokhara, Nepal; Bioversity International: Rome, Italy, 2013; pp. 16–40.
4. Vernooy, R. In the hands of many: A review of community gene/seed banks around the world. In *Community Seed Banks in Nepal: Past, Present, Future*; Proceedings of the a National Workshop, Pokhara, Nepal, 14–15 June 2012; Shrestha, P., Vernooy, R., Chaudhary, P., Eds.; Local Initiatives for Biodiversity, Research and Development: Pokhara, Nepal; Bioversity International: Rome, Italy, 2013; pp. 3–15.
5. Frankel, O.H.; Brown, A.H.D.; Burdon, J.J. *The Conservation of Plant Biodiversity*; Cambridge University Press: Cambridge, UK, 1995.
6. Brush, S.B., Ed. *Genes in the Field: On-farm Conservation of Crop Diversity*; Lewis Publishers: Boca Raton, FL, USA; International Development Research Centre: Ottawa, Canada; International Plant Genetic Resources Institute: Rome, Italy, 2000.

7. Nabhan, G.P. Seeds on Seeds on Seeds: Why More Biodiversity Means More Food Security. Grist, 2 November 2013. Available online: http://grist.org/food/seeds-on-seeds-on-seeds-why-more-biodiversity-means-more-food-security/ (accessed on 16 June 2014).
8. Food and Agriculture Organization. *Agricultores Mejoradores de su Propia Semilla: Fortalecimiento de la Producción de Maíz a Través del Fitomejoramiento Participativo en Comunidades de Sololá*; Food and Agriculture Organization: Guatemala City, Guatemala, 2011.
9. Reyes, L.C. Farmers have more access to good quality seeds through community seedbanks. *Rice Today* **2012**, *11*, 16–19.
10. Almekinders, C., de Boef, W., Eds. *Encouraging Diversity: Conservation and Development of Plant Genetic Resources*; Intermediate Technology Publications: London, UK, 2000.
11. Centro Internacional de la Papa–Users' Perspectives With Agricultural Research and Development (CIP-UPWARD). *Conservation and Sustainable Use of Agricultural Biodiversity: A Sourcebook*; CIP-UPWARD: Laguna, Philippines, 2003.
12. Shrestha, P.; Sthapit, B.R.; Subedi, A.; Poudel, D.; Shrestha, P.; Upadhyay, M.P.; Joshi, B.K. Community seed bank: Good practice for on-farm conservation of agricultural biodiversity. In *On-farm Management of Agricultural Biodiversity in Nepal: Lessons Learned*; Sthapit, B.R., Gauchan, D., Subedi, A., Jarvis, D.I., Eds.; Bioversity International: Rome, Italy, 2007; pp. 112–120.
13. Shrestha, P.; Sthapit, B.; Shrestha, P.; Upadbyay, M.; Yadav, M. Community seed banks: Experiences from Nepal. In *Farmers' Seeds and Varieties: Supporting Informal Seed Supply in Ethiopia*; Thijssen, M.H., Bishaw, Z., Beshir, A., de Boef, W.S., Eds.; Wageningen International: Wageningen, The Netherlands, 2008; pp. 103–108.
14. De Boef, W.S.; Dempewolf, H.; Byakweli, J.M.; Engels, J.M.M. Integrating genetic resource conservation and sustainable development into strategies to increase the robustness of seed systems. *J. Sustain. Agric.* **2010**, *34*, 504–531.
15. Sthapit, B., Shrestha, P., Upadhyay, M., Eds. *On-farm Management of Agricultural Biodiversity in Nepal: Good Practices*, rev. ed.; Bioversity International: Rome, Italy; Local Initiative for Biodiversity, Research and Development: Pokhara, Nepal; Nepal Agricultural Research Council: Khumaltar, Nepal, 2012.
16. de Boef, W.S., Peroni, N., Subedi, A., Thijssen, M., O'Keeffe, E., Eds. *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*; Earthscan: London, UK, 2013.
17. Food and Agriculture Organization. *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*; Food and Agriculture Organization: Rome, Italy, 2010.
18. Lewis, V.; Mulvany, P.M. *A Typology of Community Seed Banks*; Natural Resources Institute: Chatham Maritime, UK, 1997.
19. Jarvis, D.I.; Hodgkin, T.; Sthapit, B.; Fadda, C.; López-Noriega, I. An heuristic framework for identifying multiple ways of supporting the conservation and use of traditional crop varieties within the agricultural production system. *Crit. Rev. Plant Sci.* **2011**, *30*, 115–176.
20. Mooney, P.R. Toward a folk revolution. In *Growing Diversity: Genetic Resources and Local Food Security*; Cooper, D., Vellvé, R., Hobbelink, H., Eds.; Intermediate Technology Publications: London, UK, 1992; pp. 125–145.

21. Rural Advancement Foundation International. *The Community Seed Bank Kit*; Rural Advancement Foundation International: Pittsboro, NC, USA, 1986.
22. Bertuso, A.; Ginogaling, G.; Salazar, R. Community genebanks: The experience of CONSERVE in the Philippines. In *Encouraging Diversity: Conservation and Development of Plant Genetic Resources*; Almekinders, C.J.M., de Boef, W.S., Eds.; Intermediate Technology Publications: London, UK, 2000; pp. 117–133.
23. Green, K. Community seedbanks: International experience. *Seeding* **2012**, *25*, 1–4.
24. Mazhar, F. Nayakrishi Andolon: An initiative of the Bangladesh peasants for a better living. In *Using Diversity: Enhancing and Maintaining Genetic Resources On-farm*; Sperling, L., Loevinsohn, M., Eds.; International Development Research Centre: New Delhi, India, 1996; pp. 255–267.
25. Mazhar, F. Seed conservation and management: Participatory approaches of Nayakrishi Seed Network in Bangladesh. In *Participatory Approaches to the Conservation and Use of Plant Genetic Resources*; Friis-Hansen, E., Sthapit, B., Eds.; International Plant Genetic Resources Institute: Rome, Italy, 2000; pp. 149–153.
26. Mujaju, C.; Zinhanga, F.; Rusike, E. Community seedbanks for semi-arid agriculture in Zimbabwe. In *Conservation and Sustainable Use of Agricultural Biodiversity: A Sourcebook*; Centro Internacional de la Papa–Users' Perspectives With Agricultural Research and Development (CIP-UPWARD): Laguna, Philippines, 2003; pp. 294–301.
27. Khedkar, R. The Academy of Development Sciences rice project: Need for decentralized community genebank to strengthen on-farm conservation. In *Using Diversity: Enhancing and Maintaining Genetic Resources On-farm*; Sperling, L., Loevinsohn, M., Eds.; International Development Research Centre: New Delhi, India, 1996; pp. 50–254.
28. Satheesh, P.V. Genes, gender and biodiversity: Deccan Development Society's community seedbanks. In *Using Diversity: Enhancing and Maintaining Genetic Resources On-farm*; Sperling, L., Loevinsohn, M., Eds.; International Development Research Centre: New Delhi, India, 1996; pp. 268–274.
29. Shrestha, P., Vernooy, R., Chaudhary, P., Eds. *Community Seed Banks in Nepal: Past, Present, Future*; In Proceedings of a National Workshop, Pokhara, Nepal, 14–15 June 2012; Local Initiatives for Biodiversity, Research and Development: Pokhara, Nepal; Bioversity International: Rome, Italy, 2013. Available online: http://www.bioversityinternational.org/uploads/tx_news/Community_seed_banks_in_Nepal__past__present_and_future_1642.pdf (accessed on 16 June 2014).
30. Servicio de Información sobre Agricultura Sostenible. *Bancos Comunitarios de Semillas: Siembra y Comida*; Servicio de Información sobre Agricultura Sostenible: Managua, Nicaragua, 2012.
31. Gallardo Guzman, O.O.; Avila Andino, C.A.; Gómez Cerna, M.J.; Pavon, M.; Galluzzi, G. *Bancos comunitarios establecidos en los Comités de Investigación Agrícola Local (CIALs) en Honduras, unpublished case study*; Bioversity International: Rome, Italy, 2013.
32. Rojas, W.; Pinto, M.; Flores, J.; Polar, V. The contribution of community genebanks to *in situ* conservation of quinoa and cañahua: The experience of Bolivia. In *On-farm Conservation of Neglected and Underutilized Species: Status, Trends and Novel Approaches to Cope with Climate Change*; Paudulosi, S., Bergamini, N., Lawrence, T., Eds.; Bioversity International: Rome, Italy, 2012; pp. 65–75.

33. Worede, M.; Mekbib, H. Linking genetic resource conservation to farmers in Ethiopia. In *Cultivating Knowledge: Genetic Diversity, Farmer Experimentation and Crop Research*; De Boef, W., Amanor, K., Wellard, K., Bebbington, A., Eds.; Intermediate Technology: London, UK, 1993; pp. 78–84.
34. Feyissa, R. Community seedbanks and seed exchange in Ethiopia: A farmer-led approach. In *Participatory Approaches to the Conservation and Use of Plant Genetic Resources*; Friis-Hansen, E., Sthapit, B., Eds.; International Plant Genetic Resources Institute: Rome, Italy, 2000; pp. 142–148.
35. Sánchez, K.S.V.; González Santos, R. Bancos comunitarios de semillas en México, una estrategia de conservación *in situ*, Unpublished work, 2013.
36. Seed Savers Exchange. Available online: http://www.seedsavers.org/ (accessed on 21 November 2014).
37. Fanton, M.; Fanton, J. *The Seed Savers' Handbook*; The Seed Savers' Network: Byron Bay, Australia, 1993.
38. Seed Savers' Network; Ogata, M. Grassroots seed network preserves food crops diversity in Australia. In *Conservation and Sustainable Use of Agricultural Biodiversity: A Sourcebook*; Centro Internacional de la Papa–Users' Perspectives with Agricultural Research and Development (CIP-UPWARD): Laguna, Philippines, 2003; pp. 284–288.
39. Engels, J.M.M.; Polreich, S.; Dulloo, M.E. Role of Community Gene/Seedbanks in the Conservation and Use of Crop Genetic Resources in Ethiopia. In *Farmers' Seeds and Varieties: Supporting Informal Seed Supply in Ethiopia*; Thijssen, M.H., Bishaw, Z., Beshir, A., de Boef, W.S., Eds.; Wageningen International: Wageningen, The Netherlands, 2008; pp. 149–159. Available online: http://edepot.wur.nl/18448 (accessed on 14 October 2014).
40. Shrestha, P.; Gezu, G.; Swain, S.; Lassaigne, B.; Subedi, A.; de Boef, W.S. The community seed bank: A common driver for community biodiversity management. In *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E., Eds.; Routledge: New York, NY, USA, 2013; pp. 109–117.
41. Cherfas, J.; Fanton M.; Fanton, J. *The Seed Savers' Handbook*; Grove Books: Bristol, UK, 1996.
42. Vernooy, R.; Shrestha, P. *Waking Up: The Experience of the Jogimara Community Seedbank Nepal*; Bioversity International: Rome, Italy, 2012. Available online: http://www.cbmsouthasia.net/2012/10/02/waking-up-the-experience-of-the-jogimara-community-seed-bank/
43. Doring, T.F.; Knapp, S.; Kovacs, G.; Murphy, K.; Wolfe, M.S. Evolutionary plant breeding in cereals—Into a new era. *Sustainability* **2011**, *3*, 1944–1971.
44. Berkes, F.; Colding, J.; Folke, C. *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*; Cambridge University Press: Cambridge, UK, 2003.
45. Dias da Silva, E. Community seedbanks in the semi-arid region of Paraíba, Brazil. In *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E., Eds.; Routledge: New York, NY, USA, 2013; pp. 102–108.
46. Galluzzi, G.; Lapeña, I. *Communities Saving Maize Diversity in Guatemala*; Bioversity International: Rome, Italy, 2013. Available online: http://www.bioversityinternational.org/news/detail/communities-saving-maize-diversity-in-guatemala/ (accessed on 16 June 2014).

47. Van der Ploeg, J.D. *The New Peasantries: Struggles for Autonomy and Sustainability in an Era of Empire and Globalization*; Earthscan: London, UK, 2009.
48. Fairbairn, M. Framing resistance: International food regimes and the roots of food sovereignty. In *Food Sovereignty: Reconnecting Food, Nature and Community*; Wittman, H., Desmarais, A.A., Wiebe, A., Eds.; Pambazuka: Cape Town, South Africa, 2010; pp. 15–32.
49. Reardon, J.A.S.; Alemán Pérez, R. Agroecology and the development of indicators of food sovereignty in Cuban food systems. *J. Sustain. Agric.* **2010**, *34*, 907–922.
50. Wittman, H., Desmarais, A.A., Wiebe, N., Eds.; *Food Sovereignty: Reconnecting Food, Nature and Community*; Pambazuka Press: Cape Town, South Africa, 2010.
51. Andersen, R.; Winge, T. Linking community seedbanks and farmers' rights. In *Banking for the Future: Savings, Security and Seeds*; Development Fund: Oslo, Norway, 2011; pp. 5–6.
52. Vernooy, R.; Halewood, M.; López-Noriega, I.; Otieno, G.; Wedajoo, A. *Strengthening National Capacities to Implement the International Treaty on Plant Genetic Resources for Food and Agriculture: Report of the Mid-term Review Workshop, 16–19 July 2013*; Bioversity International: Rome, Italy, 2013. Available online: http://www.bioversityinternational.org/e-library/publications/detail/strengthening-national-capacities-to-implement-the-international-treaty-on-plant-genetic-resources-f-1/ (accessed on 16 June 2014).
53. International Treaty on Plant Genetic Resources for Food and Agriculture. Third call for project proposals under the treaty's Benefit-sharing Fund. Available online: http://www.planttreaty.org/content/bsfcall3 (accessed on 14 October 2014).
54. Da Vià, E. 2012. Seed diversity, farmers' rights, and the politics of repeasantization. *Int. J. Sociol. Agric. Food* **2012**, *19*, 229–242.
55. Farmer's Seeds Project—Best Practices in Sustainable Agriculture and Food Sovereignty: Development of an inclusive approach in the fight against poverty. Available online: http://www.farmerseeds.org/index.php?option=com_content&view=article&id=2&Itemid=3 (accessed on 16 June 2014).
56. Sobhan, M.A.; Jony, J.A. Farmers are happy with Mamudpur Seed Hut. Available online: http://www.ubinig.org/index.php/home/showAerticle/48/english (accessed on 13 October 2014).
57. Unnayan Bikalper Nitinirdharoni Gobeshona. About Nayakrishi Andolon. Available online: http://www.ubinig.org/index.php/campaigndetails/showAerticle/6/13 (accessed on 16 June 2014).

58. Worede, M. Establishing a community seed supply system: Community seedbank complexes in Africa. In *Climate Change and Food Systems Resilience in Sub-Saharan Africa*; Ching, L.L., Edwards, S., El-Hage Scialabba, N., Eds.; Food and Agriculture Organization: Rome, Italy, 2011; pp. 361–377.
59. Vernooy, R. Powerful crops—Empowering Farmers through Community Seedbanks in South Africa. Available online: http://www.bioversityinternational.org/news/detail/powerful-crops-empowering-farmers-through-community-seed-banks-in-south-africa/ (accessed on 16 June 2014).
60. Vernooy, R.; Sthapit, B.; Tjikana, T.; Dibiloane, A.; Maluleke, N.; Mukoma, T. Embracing Diversity: Inputs for a Strategy to Support Community Seedbanks in South Africa's Smallholder Farming Areas. Available online: http://www.bioversityinternational.org/e-library/publications/detail/embracing-diversity-inputs-for-a-strategy-to-support-community-seedbanks-in-south-africas-smallh/ (accessed on 16 June 2014).
61. Santilli, J. *Community Seedbanks and Brazilian Laws, Unpublished Case Study*; Bioversity International: Rome, Italy, 2013.