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Shree Maharjan and Keshav Maharjan

ABSTRACT

Community seed banks are an effective local institution to conserve quality seeds, to strengthen farmers' accessibility to social seed networks, and improve agrobiodiversity and food security. This article analyses the prospects and challenges of community seed banks in climate change contexts. It finds that community seed banks serve as sources of climate-resilient seeds to withstand in local climates and improve community resilience. Community seed banks provide landraces for participatory crop improvement to develop resistant varieties to improve quality and productivity. They also strengthen participatory seed exchange to cope with climate adversity. However, there are challenges with defining specific and common goals, functions, approaches, and governance.

Les banques de semences communautaires sont des institutions locales efficaces dans la conservation des semences de qualité, le renforcement de l'accessibilité des agriculteurs à des réseaux sociaux autour de ces semences et l'amélioration de l'agrobiodiversité et de la sécurité alimentaire. Cet article analyse les perspectives et les difficultés des banques de semences communautaires dans le contexte du changement climatique. Il révèle que les banques de semences communautaires servent de sources d'approvisionnement de semences résistantes au climat pour supporter les climats locaux et améliorer la résistance des communautés. Les banques de semences communautaires fournissent des espèces primitives afin que l'amélioration de la récolte participative entraîne la production de variétés résistantes pouvant renforcer la qualité et la productivité. Elles renforcent aussi l'échange participatif de semences dont l'objectif est la possibilité de faire face à l'adversité climatique. Cependant, définir des objectifs, des fonctions, des approches et une gouvernance spécifiques et communs peut relever du défi.

Los bancos de semillas comunitarios constituyen instituciones locales efectivas; en este sentido, conservan semillas de calidad, facilitan el acceso de los campesinos a redes sociales de semillas, y mejoran la agrobiodiversidad y la seguridad alimentaria. El presente artículo analiza las perspectivas y los retos que deben afrontar los bancos de semillas comunitarios en contextos de cambio climático. Al respecto, se pudo determinar que dichos bancos sirven como fuentes de semillas resilientes a los cambios climáticos locales, lo que fortalece la resiliencia comunitaria. Además, proporcionan semillas criollas seleccionadas a programas participativos de mejoramiento de cultivos que producen variedades resistentes, optimizando su calidad y productividad. Asimismo, hacen posible el intercambio participativo de semillas para hacer frente a la adversidad del clima. A pesar de todo, la definición de metas específicas compartidas, funciones, enfoques y gestión, se presenta como un desafío.

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Introduction

In Nepal, the majority of the poor and smallholders are highly dependent on agriculture for their livelihood and income. This has significantly changed in recent years due to many factors, such as increased human pressures, changes in agricultural practices, increased climate change impacts, and climate-induced disasters (Maharjan, Gurung, and Sthapit 2011a). Climate change impacts have been rapidly affecting agriculture and food security because of increased unpredictability and irregularity of climatic patterns such as erratic rainfall and floods (MoE 2010). It is predicted that a large number of crops and wild relatives will become extinct due to climate change impacts in next few years if the proper conservation actions are not taken (Bhatta, Joshi, and Gauchan 2013). Nevertheless, in Nepal the poor and smallholders have been practising small-scale agriculture, mainly sustenance and rain-fed. They are mostly persistent and have managed locally available resources sustainably to cope with the changing climatic contexts. They conserve, manage, and use landraces and introduced seeds that are resilient to biotic and abiotic stresses. Furthermore, they use family labour and labour exchange for traditional and mixed farming based on traditional knowledge and experience, which is very important for better yields and climate change adaptation.

Usually, farmers store grains and conserve seeds at the household and community levels for consumption and for the next growing season (Worede n.d.). Community seed banks (CSBs) are the community-based local storage of seeds and grains to conserve and distribute to farmers in a sustainable manner as a loan and payback system. They are led by local institutions and owned by the farmers to maintain and manage local, introduced, and improved seeds to ensure seed, food, and livelihood security (Sthapit 2013). CSBs have emerged as a reliable rural institution to resolve the issue of loss of seed diversity and agrobiodiversity due to human and climate-induced disasters. Crop diversity conserved in the CSBs enables farmers to cope with the changing climate (Pokhrel et al. 2012). CSBs are also considered the local repositories of local genetic resources often adapted to the prevailing climatic and biotic conditions (Vernooy et al. 2017). Thus, there are strong links between crop diversity, food security, and climate change in complex and diverse ways (Bhatta, Joshi, and Gauchan 2013).

Despite the long history of CSBs in conserving and managing local climate-resilient seeds and agrobiodiversity, very few researchers have analysed CSBs from the perspectives of climate change adaptation. Vernooy et al. (2017) have also highlighted the limited scientific literature on CSB initiatives on climate change adaptation. Thus, this article aims to explore CSBs in Nepal from climate change adaptation perspectives, focusing on the existing literature relating to CSBs, on-farm conservation, and community-based adaptation in Nepal and abroad. It further analyses the prospects, issues, and challenges of CSBs in relation to addressing climatic risks and climate change adaptation.

CSBs in Nepal

CSBs have existed for about three decades globally, and almost two decades in Nepal. The concept of CSBs first emerged to address the issue of the loss of agrobiodiversity due to natural disasters such as floods and hurricanes, climate change impacts, and accessibility of quality seeds (Vernooy, Shrestha, and Chaudhary 2013). The forms, sizes, and functions of the CSBs differ across communities and countries (Sthapit 2013; Vernooy, Shrestha, and Chaudhary 2013). CSBs were first introduced in Nepal by the in-situ conservation project as a mechanism of community-based biodiversity management, with the first CSB established in Dalchoki, Lalitpur district in 1995 by USC Canada-Nepal (Joshi 2013).[1] Later on, they were recognised as an effective means of on-farm conservation, and since then a number of CSBs have been established in different parts of the country.[2]

Altogether, 115 CSBs (as of June 2013) have been established in Nepal through community initiatives with the support of NGOs and governmental organisations (GOs) (Joshi 2013; Pokhrel et al. 2012). Some NGOs, particularly USC Canada-Nepal, LI-BIRD, Oxfam Nepal, and Parivartan Nepal have played

significant roles and contributions in the promotion and development of CSBs in Nepal. Governmental organisations, particularly the Department of Agriculture (DOA), National Agriculture Research Council (NARC), and Nepal Agriculture Genetic Resources Center (Gene bank, NARC), have also contributed to CSB promotion and development. NGOs are mainly donor driven, with the limited resources and coverage, whereas the governmental organisations operate throughout the country. The initiatives of governmental organisations on management and promotion of CSBs are recognised as important and comparatively sustainable. Most importantly, farmers actively participate and manage locally emerged issues through locally driven biodiversity management strategies. CSBs are mostly supported by NGOs in Nepal, but recently government agencies are keen to support and promote CSBs as well.

Out of 75 districts in Nepal, CSBs are established in only 25 districts, mainly the Plain areas in southern Nepal. However, some CSBs have also been established in the hills, such as in Tanahu, Dhadhing, Jumla, Doti, and Dadeldhura districts. The largest number of CSBs were established in Dailekh and Dadeldhura by Oxfam Nepal in 2009 (Table 1). Most CSBs have conserved local seeds, except the CSBs established by DOA and Oxfam Nepal, and most CSBs have concentrated on improved seeds, except in certain districts like Dailekh, Dadeldhura, Sindhupalchowk, Okhaldhunga, Gulmi, and Jajarkot. These CSBs have focused more on enhancing the accessibility of farmers to improved seeds, whereas CSBs established in other districts have concentrated on the enhancement of seed accessibility, conservation and maintenance of seed diversity, and strengthening the seed networks among farmers, conservation and distribution of local climate-resilient seeds, and strengthening farmers' capacities for conservation, participatory landrace enhancement, and participatory seed exchange. Improved seeds are seeds that are developed using technology to create a package of disease resistance, quality, and yield potential which can be regenerated in different growing seasons. It is crucial to conserve and protect these seeds in their purest form to harness the maximum potential of the crop varieties. Many CSBs in Nepal have targeted the conservation of local and rare seeds; however, management and promotion of improved seeds are continuously carried out in the CSBs to ensure that conservation and development activities work together. The CSBs have been conserving and promoting these seeds in addition to the local seeds for the benefit of farmers and their livelihoods.

The success of CSBs mainly depends on farmers' commitments in conservation and management of local and introduced landraces. The landraces that are conserved at the household and community level are adapted to the local environment (Shrestha et al. 2012). Nepalese agriculture and seed

Table 1. Number of CSBs in Nepal.

Districts	Number of CSBs	Year of establishment	Supporting agencies[a]	Priority crops
Lalitpur	1	1994	USC Canada Nepal	Local seeds
Bara	1	2003	LI-BIRD/NARC/Bioversity International	Local seeds
Sindhuli	1	2006	Parivartan Nepal	Local seeds
Bardia, Kailali, Kanchanpur	3	2007	LI-BIRD	Local seeds
Kailali, Kanchanpur	3	2008		
Doti, Dang, Nalawparasi, Tanahu, Dhadhing, Sankhuwasabha, Jhapa, Jumla	8	2009		
Dadeldhura, Sindhupalchowk, Okhaldhunga	3	2009	Department of Agriculture (DOA)	Improved seeds
Gulmi, Jajarkot	2	2011		
Dadeldhura, Dailekh	90	2009	Oxfam Nepal	Improved seeds
Sunsari	1	2011	NARC/Gene bank	Local seeds
Total	113			

Notes: [a] LI-BIRD – Local Initiatives for Biodiversity, Research and Development; NARC – Nepal Agriculture Research Council.
Two CSBs in Parbat and Rasuwa districts are not included here due to limited information.
Source: Joshi (2013), modified by the authors.

sectors have been affected by socio-economic, demographic, political, institutional, and biophysical factors (Regmi et al. 2009). The success and potential utility of CSBs are influenced by technological interventions; access to inputs; marginal environment and economies; and frequency of natural disasters such as floods and droughts. Farmers usually prefer the modern varieties in the areas with high access to technologies and inputs such as fertilisers and modern tools. However, they prefer traditional landraces in marginal and disaster-prone areas and in areas with marginal economies, since landraces are better adapted to the marginal environment than modern varieties (Shrestha et al. 2006).

The success of CSBs is also influenced by the political and institutional supports, and demographic and socio-economic contexts in the areas. The support of government and non-government organisations, in addition to the community's commitments, own efforts, social cohesions, and solidarity, is important. The relationships and cohesion among and between farmers and their networks are crucial for the success of CSBs in any area, since they are locally governed and managed through informal institutions and networks. However, institutional and political supports further enhance CSBs' effectiveness in fulfilling goals and objectives in addressing issues and challenges. For instance, the participatory crop improvement efforts in CSBs need support in enhancing new skills for participatory plant breeding (PPB) and to maintain healthy and genetically pure seed locally (Vernooy, Shrestha, and Sthapit 2015).

Extreme or no rain can cause devastating situations in Nepalese agriculture, and CSB is not immune from such harsh climatic conditions. Seeds are very sensitive to climate variables. The seed has a direct and strong relationship with climate variables for its germination, dormancy, and viability, therefore climate change inevitably affects seed ecology. The air temperature and rainfall interact with soil composition and type for seed germination and emergence. Likewise, soil temperature, including timing and magnitude of rainfall, affects seed dormancy (Ooi 2012). Mostly CSBs are constructed utilising local materials, which means harsh climate and extreme weather also affect the CSBs. For instance, CSBs in Terai region are affected by floods, which is why farmers constructed two-storied CSBs to store seeds on the second floor (Maharjan et al. 2011b)

Management and governance of CSBs in Nepal

CSBs are the community managed local institution for conserving and managing local and improved seeds through local and community efforts and practices, from the household to community level. The most important aspect of CSBs is that they are locally managed and locally governed institutions through which local people and resources are mobilised, which ultimately leads to community empowerment and sustainable resources management at the local level (Sthapit 2013). Shrestha et al. (2012) also emphasised the multidimensional approach of CSBs to strengthen social capital through the empowerment and mobilisation of local communities. CSBs have a broad range of purposes and functions that vary in scope, size, governance and management models, infrastructure, and other aspects across countries and communities (Vernooy et al. 2017).

In recent decades, CSBs have been recognised by governmental and non-governmental organisations in various ways because of their contributions to agriculture, food security, and in addressing climate change impacts. Many CSBs are now directly connected to the national gene bank. The government has been regularly inviting model farmers and CSB committee members to national level policy and decision-making dialogues (Sthapit 2013). CSBs have specific mechanisms and strategies to regenerate and replace old seed stocks with the new, healthy, and vibrant seeds through the establishment of diversity blocks, distribution and collection of seeds to the farmers each year, and participatory seed exchange (Shrestha et al. 2012).

Roles of CSBs in addressing climate change

Many researchers have emphasised the importance of crops and seed diversity for climate change adaptation. Over-reliance on limited crop species has increased global food insecurity (Sthapit

2013). There are many common strategies being practised by communities with or without the support of development agencies. One common strategy is to exploit and effectively use resistant and diverse seeds to adapt to climate change (Vernooy et al. 2017). Furthermore, CSBs improve the accessibility and availability of diverse and locally adapted crops, seeds, and varieties and also enhance the adaptive capacities, development, and exchange of tolerant and resistant varieties and crops. Livelihood diversification through onsite or on-farm conservation of crops is an additional strategy that has been practised by farmers (Table 2).

On-farm management of crops for addressing climate adversity

Maintenance of crop diversity and pool of genetic resources and variability has a significant role in sustainable agriculture and also support farmers in adapting to changes in weather and climatic patterns. However, modern agriculture has shrunk that pool of crop genetic resources and increased the dependency of farmers towards external sources. Although traditional and local landraces are resistant to both biotic and abiotic stresses, farmers have to depend on the modern and hybrid varieties because of lack of access to local landraces and also easily available hybrid seeds in the markets. That has led to dependency on external sources of seeds and loss of traditional landraces, and loss of agro-biodiversity, associated knowledge, practices, and the whole evolutionary process of farming (Shrestha et al. 2006).

CSBs have emerged as a reliable option for maintaining the pool of resources and variability through on-farm conservation that provides seed and food security to farmers against biotic and abiotic stresses such as diseases, pests, droughts, and floods (Shrestha et al. 2012; Worede n.d.). Vernooy et al. (2014) further confirmed CSBs as on-farm management of local crop diversity for natural and human selection in agricultural production systems, in which farmers are the custodians and managers in handling the crop diversity and processes (Subedi et al. 2006). CSBs have also empowered farmers in managing and continuing on-farm practices such as diversity blocks, community biodiversity registers (CBRs), community-based seed productions (CBSPs), community-based management fund (CBM fund), and participatory landrace enhancement such as participatory plant breeding, among others (Sthapit, Shrestha, and Upadhyay 2006). All of these on-farm practices have strengthened socio-economic, cultural, and environmental relationships and benefits among the community.

Farmers' accessibility and adaptive capacities enhancement

CSBs have enhanced seed availability and accessibility to the poor and needy farmers based on a cash or loan basis. Borrowers need to return 50 to 100% more seeds than they borrowed as seed loans,

Table 2. The climate adaptation-related functions of CSBs in Nepal.

Climate adaptation-related functions	Main functions of CSBs
On-farm management of crop diversity to address climate adversity	Conservation of diverse seeds and crop genetic resources
Enhance climate resilience and stress-tolerant seeds	Restoration of rare and lost seeds and varieties
Maintenance of locally adapted seeds at low cost	Enhance farmers' accessibility and availability of diverse seeds and crop genetic resources
Provision of adapted seeds to poor and marginalised communities	Maintenance of local control over seed conservation, community based management of seed
Enhance capacity of farmers to respond to local crisis, disasters, and shortages	Income generation through conservation and sales of seeds
Sources of resources for participatory crop enhancement and seed exchange	Contribution to ecological agriculture and food sovereignty
	Linkage between in-situ and ex-situ conservation and sharing of knowledge through farmers' seed networks

Source: Sthapit (2013), modified by the authors.

which will be stored and distributed to other farmers or replicated in diversity blocks to maintain viability (Vernooy, Shrestha, and Sthapit 2015). Thus, CSBs have become a successful and reliable local institution that enhances the farmers' accessibility and capacities to locally adaptable and improved seeds through the process of collection, conservation, distribution and sustainable use of seeds and its diversity, to ultimately support on local food security.

CSBs have conserved rare and unique crop varieties and enhanced the availability of the diverse seeds and planting materials to local communities in Nepal. For instance, the CSBs in Dang district have conserved 26 varieties of rice and made them available to farmers, including drought-resistant varieties such as Sukkha-2, Sukkha-3, and Kachorwa-4. These varieties have become popular in the areas with a shortage of water for irrigation, as most farmers have to rely on rainwater for planting rice. Furthermore, the CSBs in the district have conserved 33 varieties of cereals, 13 varieties of vegetables, four varieties of legumes, eight varieties of oil seeds, six varieties of roots and tubers, and seven varieties of spices which farmers can easily access in their own locality. In the past farmers had to travel to Ghorahi, the district headquarters 12 kilometres away from the community, for seeds (Vernooy et al. 2017). Shrestha et al. (2012) reported 68 varieties of cereals and nine species of pulses conserved in the CSB in Rampur, Dang district.

CSBs have mostly conserved and distributed rare and tolerant seeds to the farmers that have made them more common, ensuring seed and food security in the local context (Maharjan et al. 2011c). The availability of quality seeds is very important for the production of enough food (Progressio 2009). Shrestha et al. (2012) also reported that the CSBs have increased abundance and accessibility of landraces and overall diversity. Maharjan, Gurung, and Sthapit (2011a) and Pokhrel et al. (2012) further confirmed that CSBs have enhanced the easy availability of seeds, conservation of landraces, and associated knowledge and livelihood security. Similarly, a study in Kachorwa, Bara district of Nepal showed that increased accessibility of farmers to quality seeds has reduced farmers' dependency on external sources. In addition, it has increased the control over the seeds, since the local community manages the CSB by themselves (Shrestha et al. 2012).

Furthermore, Progressio (2009) claimed that conservation of diverse seeds has enhanced the adaptive capacities of farmers to adapt to climate change. Farmers' capacities on seed conservation, distribution, multiplication, marketing, seed/diversity fairs, and diversity blocks become more sustainable due to CSBs, which also strengthened the seed networks among farmers. Likewise, farmers have gained skills in conservation farming, home gardens, sloping agriculture land technologies (SALT), and participatory seed exchange to address seed shortages and climate change issues. Some CSBs have also focused on empowering farmers, promoting ecological agriculture, establishing farmers' rights over seeds, and developing mechanisms for fair and equitable benefits (Vernooy, Shrestha, and Sthapit 2015).

Increased access to climate resilient and stress-tolerant seeds

Climate change and climate-induced disasters such as flood and drought have further intensified the vulnerability of poor and marginalised farmers in Nepal. Many crop genetic resources are extinct because of rapid erosion due to climate change and induced disasters. CSBs have played a crucial role in preserving and reviving such important genetic resources through a collection of resources and associated knowledge, storage, regeneration, multiplication, and distribution of resilient seeds to farmers and their networks, fulfilling their seed demands (Maharjan, Gurung, and Sthapit 2011a; Vernooy, Shrestha, and Sthapit 2015). CSBs have developed a healthy and stable seed system since seeds are distributed to the wider communities and rare seeds become more common. Some drought- and flood-resistant varieties have become more broadly available to the public through CSBs, such as Tilki seeds in far western Nepal, therefore enhancing the resilience of the community and agroecosystems (Maharjan et al. 2011c; Shrestha et al. 2012) that support farmers to prepare for erratic weather events (Zofeen 2014). FAO (2010) revealed that conservation and use of crop diversity help farmers to respond to climate change issues. Regmi et al. (2009) and Maharjan,

Gurung, and Sthapit (2011a) reported that CSBs have played a crucial role in the conservation and distribution of resistant farmers' varieties of rice such as Tilki (flood tolerant) and Mansara (drought resistant) among farmers in the western plains of Nepal. Therefore, CSBs have enhanced farmers' resilience both at the household and the community levels through securing improved access to diverse and locally adapted crops and enhancement of related knowledge and skills (Maharjan et al. 2011c; Vernooy, Shrestha, and Sthapit 2015).

Shrestha et al. (2012) claimed that CSBs are a viable and reliable opportunity for farmers living in marginal and disaster-prone areas. Vernooy et al. (2017) emphasised that the establishment of CSBs in climate vulnerable communities help them to respond quickly to environmental stresses and contribute to the restoration of local food security. For instance, CSBs in Nepal played crucial roles in reviving seeds during the major earthquake in 2015 through the immediate seed relief mechanism. Vernooy et al. (2017) reported the over 20 tons of seeds were dispatched by CSBs for rebuilding the local seed systems in 10 earthquake-hit districts in Nepal.

Progressio (2009) also found CSB as "safe deposits" of farmers' valued seeds, especially during total crop failure caused by drought, floods, or fire. In such crises, CSBs have provided seeds saved by the farmers. Furthermore, farmers have diverse options to utilise the full range of highly varied microclimates and diverse seeds since they saved seeds by themselves in CSBs, which is suitable for different soil types, temperature, altitude, slopes, water availability, and overall fertility (Worebe n.d.). In these areas, CSBs have provided viable traditional landraces, which are better adapted to such stressful conditions. Both farmers and geneticists preferred and valued traditional landraces because of its diversity and heterogeneity, unique traits and adaptability to the local and harsh climate (Gyawali et al. 2006a). Diverse seeds in the field and CSBs act as insurance against losing seeds and crops under adverse climatic conditions, and some of these seeds can withstand extreme climatic conditions (Regmi et al. 2009).

Participatory landrace enhancement and participatory plant breeding (PPB)[3]

Local landraces are important bio-resources for sustainable production and livelihood improvement of the community, providing the foundation for the development of new varieties (Gyawali et al. 2006a) through participatory crop improvement to conserve genetically pure, healthy, and quality seeds at the grassroots level (Vernooy et al. 2014). Farmers have been selecting varieties that would perform better under the changing climate conditions, which has triggered discussion among researchers about the participatory variety selection to select good quality seeds for upcoming growing seasons (Vernooy et al. 2017). One important focus of CSBs and participatory crop improvement is to train farmers on the procedures and requirements of participatory breeding (Sthapit, Shrestha, and Upadhyay 2006). Participatory crop improvement and PPB, selection of farmers' preferred seeds (i.e. grassroots breeding), and community-based seed production are ways to improve the access and availability of improved seeds (Vernooy, Shrestha, and Sthapit 2015). In western Terai of Nepal, farmers are trained in management of CSBs, community biodiversity registers, PPB, seed collections, and viability tests such as diversity blocks and community-based seed production systems (Pokhrel et al. 2012). Regmi et al. (2009) claimed that PPB can reduce the vulnerability of farmers to climate change and variability.

According to Regmi et al. (2009), farmers analysed and selected eight out of 69 varieties of rice collected in CSBs for PPB, based on the traits they preferred and knowledge of crop improvement. They further emphasised the importance of PPB in maintaining local agrobiodiversity. Sthapit et al. (cited in Gyawali et al. 2006a) also emphasised the importance of farmers' knowledge and value of local diversity in PPB processes to enhance desirable and adaptive traits such as chilling tolerance, blast resistance, and drought and flood tolerance. There are many successful cases of participatory crop enhancement and PPB utilising local landraces conserved in CSBs. Vernooy, Shrestha, and Sthapit (2015) reported that a CSB in Kacharwa, Bara district of Nepal has developed a new drought-resistant rice variety named "Kacharwa-4" in collaboration with a local research organisation

through PPB. This CSB now produces and sells 5 to 10 tons of Kacharwa-4 every year that provides a regular source of income for the CSB.

Participatory seed exchange among farmers during climate hardships

For generations, farmers have been managing the local crop diversities and maintaining informal seed networks and seed systems through bartering or exchanging with their neighbours, relatives, and friends within and outside the community, which is crucial for the maintenance of local crop diversity (Maharjan, Gurung, and Sthapit 2011a; Subedi et al. 2006). It is estimated that globally 80% of seeds are farm-saved through informal networks and exchange (Vernooy, Shrestha, and Sthapit 2015). Subedi et al. (2006) further revealed that farmers in Nepal exchanged almost 20–50% of seeds through informal networks and systems. This shows that many farmers still relying on informal seed networks and systems in Nepal. Informal networks and systems include CSBs as they have been playing significant roles in maintenance and seed exchange. They also enhance social cohesion and inclusion among farmers since it is a collective effort of farmers to manage landraces and exchange (Subedi et al. 2006).

Furthermore, CSBs have prioritised seed access to women, poor and marginalised farmers, who are facing seed shortages since they cannot save and purchase seeds in the market (Shrestha et al. 2006). It is also found that women have played key roles in farmers' seed systems and active participation in participatory seed exchange by sharing seeds and associated knowledge with their neighbours, relatives, and other farmers in CSBs, although their roles are often ignored by research and development actors, policies, and programmes (Maharjan et al. 2011c; Vernooy, Shrestha, and Sthapit 2015).

CSBs have enhanced farmers' seed systems and strengthened social networks for seed exchange, which also help in coping with climate change adversity and impacts. Social seed networks among farmers are a secure source of seeds that are locally adapted to the local climate (Subedi et al. 2006). CSBs have developed a mechanism of participatory seed exchange among farmers within and outside to expand seed exchange and farmers' networks (Maharjan, Gurung, and Sthapit 2011a). Pokhrel et al. (2012) also found that CSBs contributed to sustainable conservation and participatory seed exchange of traditional and improved seeds among farmers in the western Terai landscapes of Nepal.

Issues and key challenges of CSBs

Despite agriculture intensification and other human pressures, local crop genetic resources are still conserved and maintained by farmers in Nepal, both at household and community levels, to fulfil seed demands and also address local climatic conditions. However, these resources and landraces are significantly disappearing over the years at both levels, although landraces have been developed and adapted to the local environment for generations (Shrestha et al. 2006). The reasons behind the are mainly the inaccessibility of resource-poor farmers and their control over on these landraces, lack of quality seeds leading to increased farmers' preference on high yielding modern/hybrid varieties, lack of policy and incentives to farmers on conservation and maintenance of landraces, and increased climatic risks and vulnerabilities.

Despite the lack of any incentives to farmers for conservation and management of diversity, CSBs have been conserving and maintaining the landraces. It is difficult to conserve all landraces. Similarly, not all farmers may be interested in conserving the landraces, as it requires resources and commitment of the farmers. Therefore, incentives and motivation play a role in conserving and maintaining such important landraces in the CSBs (Gyawali et al. 2006a). Incentives could be created through linking to the market for conservation and exchange of landraces; creating an enabling environment to cultivate and exchange seeds at the local and national levels; and linking CSBs to the private sector for income generation, and/or national gene bank, and government agencies for the expansion of

seed exchanges. Incentives can also be created through policy support and reform for the conservation of agrobiodiversity and also for commercialisation of high-value products (Gyawali et al. 2006b).

Recently, the Department of Agriculture in Nepal has recognised the importance of CSBs. However, official linkages with the national gene bank and formal seed system are crucial. Development of CSB guidelines is an important initiative taken by the government, yet its implementation still remains a challenge. The guidelines emphasised poor and marginalised farmers, including indigenous and conflict-affected farmers who are vulnerable to climate change impacts and have the least access to the seeds (Chaudhary et al. 2015). Additionally, resources that farmers are not interested in conserving or that are in an endangered status need to be conserved in ex-situ. Thus, the linkage between in-situ (CSBs) and ex-situ (national gene bank) conservation is crucial in the Nepalese context.

Many CSBs have different goals, functions, approaches, and governance, which is reasonable based on the needs and requirements of the farmers. However, in the process of nationalising CSBs through government and mainstreaming it to Crop Development Directorate and National Gene Bank in Nepal, it is important to define specific goals, functions, and approaches. It is important to develop a national CSB strategy in addition to the CSB guidelines to ensure the systematic sustainability of CSBs for farmers' benefits, and even more important to ensure access and control over the resources by the poor and marginalised farmers so they are able to address the challenges faced in agriculture, including adverse climatic conditions.

Additional climate change pressures have been observed recently on farmers' seed and food production systems. The roles of CSBs in addressing climate change impacts are often neglected. It is estimated that climatic impacts will be more severe in future, meaning additional challenges to adapt to new weather dynamics. Very few scientific publications are available on CSBs, their history, evolution, experiences, successes, challenges, and prospects, and their importance in maintaining agrobiodiversity and in addressing climate change impacts are continuously ignored (Vernooy, Shrestha, and Sthapit 2015). Additionally, the roles and contributions of women in CSBs are often neglected in CSB-related programmes and policies, even though they have played significant roles in seed saving and farmers' seed networks (Vernooy, Shrestha, and Sthapit 2015). The main challenge is the commodification and commercialisation of seeds by companies and corporate industries. Farmers are aggressively running after agro-vets for improved seeds and agricultural inputs rather than CSBs.

Conclusions

CSBs have multiple functions in farmers' livelihoods and welfare, and have gained considerable recognition in Nepal, with a long history in conservation, distribution, regeneration, and multiplication of seeds, fulfilling farmers' seed demands. CSBs have made rare seeds more widely available, and enhanced social cohesion and relationships among farmers through different on-farm activities. Additionally, both farmers and researchers have realised that landraces are more tolerant to both biotic and abiotic stresses. However, farmers still prefer improved and hybrid seeds found in the agro-vets and markets because of their easy accessibility. CSBs have played crucial roles in increasing awareness among farmers on the importance of landraces, and enhancing the accessibility of quality seeds to farmers to improve their livelihood and social relationships. They have further strengthened skills and capacities around on-farm conservation and development activities, including adaptive capacities to climatic risks and stresses. However, there are still many issues and challenges for CSBs' sustainability in Nepal due demographic, socio-economic, political, institutional, biophysical, and environmental factors associated with overall development and sustainability.

Notes

1. The in-situ conservation project was jointly implemented by Nepal Agricultural Research Council (NARC) and Local Initiatives for Biodiversity, Research and Development (LIBIRD) in Nepal from September 1997 to December 2001 (first phase).

2. On-farm conservation is the process of conserving a plant and its wild relatives in the farm and place of origin.
3. Participatory plant breeding is the concept of farmers' involvement in the selection of varieties, management of local crop populations, and seed supply systems through informal and formal seed networks (Gyawali et al. 2006a).

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