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An Heuristic Framework for Identifying Multiple Ways of Supporting the Conservation and Use of Traditional Crop Varieties within the Agricultural Production System

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This paper reviews and discusses how studies on (i) on-farm diversity assessment, (ii) access to diversity and information, (iii) extent of use of available materials and information, and (iv) benefits obtained by the farmer or farming community from their use of local crop diversity, are necessary to identify the different ways of supporting farmers and farming communities in the maintenance of traditional varieties and crop genetic diversity within their production systems. Throughout this paper two key themes are emphasized. First, any description or analysis within the four main areas (assessment, access, use and benefit) can, and most probably will, lead to a number of different actions. Second, the decision to implement a particular action, and therefore its success, will depend on farmers and the farming community having the knowledge and leadership capacity to evaluate the benefits that this action will have for them. This in turn emphasizes the importance of activities (whether by local, national and international organizations and agencies) of strengthening local institutions so as to enable farmers to take a greater role in the management of their resources.

Keywords adaptability, agroecosystem resilience, collective action, biodiversity, community management, farmer selection, genetic diversity, incentives, local institutions, participatory breeding, seed systems

I. INTRODUCTION

The last two decades have provided substantial evidence that significant crop genetic diversity continues to be maintained in farmers' fields in the form of traditional varieties (Bellon *et al*., 1997; Brush, 1995; 2004; Jarvis *et al*., 2004, 2008; Bezancon *et al*., 2009; Kebebew *et al*., 2001; Guzman *et al*., 2005; Bisht *et al*., 2007; FAO, 2010). This diversity constitutes an important element for the livelihood strategies of these farmers. Traditional crop varieties are used because of their adaptation to marginal or specific agricultural ecosystems (Barry *et al*., 2007), heterogeneous environments (Bisht *et al*., 2007), rainfall variability, variable soil types (Bellon and Taylor, 1993; Duc *et al*., 2010) and as insurance against environmental risk (Sawadogo, 2005; Bhandari, 2009), to meet changing market demands (Smale, 2006; Vandermeer, 1995; Brush and Meng, 1998; Gauchan and Smale, 2007), for pest and disease management (Thurston *et al*., 1999; Zhu *et al*., 2000; Trutmann *et al*., 1996; Finckh *et al*. 2003; Jarvis *et al*., 2007a), because of post harvest characteristics (Tsehaye *et al*., 2006; Teshome *et al*., 1999, Latournerie-Moreno *et al*., 2006), distance to market, adult labor availablity and other social and economic characteristics of the household (Gauchan *et al*., 2005; Fu *et al*., 2006; Benin *et al*., 2006; Van Dusen, 2006; Bela *et al*., 2006), and cultural and religious needs (Rana *et al*., 2008; Nabban, 1989; Tuxill *et al*., 2009). They may be kept for their dietary or nutritional value (Johns and Sthapit, 2004; Belanger *et al*., 2008), taste (Sthapit *et al*., 2008a) or for the price premiums they attract because of high-quality traditional properties, which compensate for lower yields (Smale *et al*., 2004). A diversity of traditional varieties within the production system can enable the farmers' crop populations to better adapt and evolve to changing environmental and economic selection pressures, through increasing the farmers' option value (Evenson *et al*., 1998; Gollin and Evenson, 1998; Smale *et al*., 2004; Smale, 2006; Swanson, 1998; Brush, 2004; Kontoleon *et al*., 2007; Pascual and Perrings, 2007; Aguilar-Støen *et al*., 2009), and by widening the genetic base of the crop population (Scarcelli *et al*., 2006; Barnaud *et al*., 2008; Sagnard *et al*., 2008; Carpenter *et al*., 2006; Elmqvist *et al*., 2003; Jackson *et al*., 2007; 2010; Bezançon, *et al*., 2009). The utility of crop varietal diversity within the production system also lies in its potential to provide ecosystem services (Hajjar *et al*., 2008; Ceroni *et al*., 2007; IAASTD, 2009), such as the regulation and control of pest and diseases (Finckh and Wolfe, 2006; Abate *et al*., 2000; Garret and Mundt, 1999; Zhu *et al*., 2000; Strange and Schott, 2005), sustain pollinator diversity (Richards, 2001; Kremen *et al*., 2002), and support below-ground biodiversity and soil health (Swift *et al*., 2004; Brown *et al*., 2007). This can in turn reduce the financial and health risks of high levels of agricultural inputs, such as fertilizer and pesticides to small-scale farmers and the environment (Tilman *et al*., 2001; Mosely *et al*., 2010). This diversity maintained both by farmers *in situ* and by genebanks *ex situ,* continues to be fundamental in trying to achieve global food security (Frankel *et al*., 1995; Gollin and Smale, 1999; Gepts, 2006; Jarvis *et al*., 2007b).

The continuing maintenance of traditional varieties is largely undertaken by poor, small-scale farmers, and is often associated with poverty (Keleman *et al*., 2009; Kontoleon *et al*., 2009; IAASTD, 2009). In these areas, diversity of traditional crop varieties is one of the few options that farmers have to meet their livelihood needs (Sawadogo *et al*., 2005). As long as farmers themselves find it in their best interest to grow genetically diverse traditional varieties of crops, both famers and society as a whole will benefit at no extra cost to either party (Smale *et al*., 2001; Dusen *et al*., 2007). In areas where genetic diversity is significant, but farmers have few market or non-market incentives to maintain it, different public activities will be necessary to help support the conservation of this valuable resource (Smale, 2006; Bellon, 2004).

Although it was widely assumed for many years during the 1970s and 1980s that traditional varieties would be rapidly and completely replaced by modern varieties (Frankel and Soule, 1981), this has not been the case in many production systems. Traditional crop varieties still meet the needs of the farmers and communities where they occur. Indeed, recent studies suggest that one of the responses of poor rural communities to climate change is to increase the use of traditional materials in their production systems (Bezançon *et al*., 2009; Platform for Agrobiodiversity Research, 2010). Their continued maintenance *in situ* also meets a wider social need for evolving and adapted materials to meet changing production needs and challenges. Given the continuing importance to the farmers who grow them, there are good reasons to embed the continued use of traditional varieties into development and improvement strategies designed to improve the well-being of some of the world's poorest communities. A part of this will involve the implementation of appropriate different public activities that can support their maintenance and use.

Over the last few decades, a range of actions or practices has become available to help farmers and farming communities continue to benefit from the maintenance and use of local crop genetic diversity in their production systems (Friis-Hansen and Sthapit, 2000; CIP/UPWARD, 2003; Sthapit *et al*., 2006a; Jarvis and Hodgkin, 2008; Lipper *et al*., 2010; Kontoleon *et al*., 2009) (Table 1).

Most actions are small in scale and site and crop specific, resulting from a local evaluation of farmers' constraints to their current use of local crop genetic resources. Along with the advancement of these actions has been the development of tools and methods to work out which action would be most relevant for a specific situation. There has also been an emphasis on the need to understand the different situations and circumstances of different communities with respect to different crops before deciding on an approach to use.

Although the actions that can support the maintenance and use of traditional varieties are often apparently site, culture or crop specific and varied, we suggest that an overall framework can be usefully created to help conservation and development workers and communities discern which action will most likely be the most relevant in different situations. This framework, a kind of heuristic device, is based on categorizing into four main groups the issues or constraints that farmers face, which may decrease their ability to benefit from the conservation and use of crop genetic resources within their agricultural production systems: (1) the lack of sufficient diversity of traditional crop varieties within the production system; (2) the lack of access by farmers to available diversity, (3) the limitations in information on and the performance of varieties available in key aspects, and, (4) the inability of farmers and communities to realize the true value of the materials they manage and use. Figure 1 contains a descriptive diagram of the relations within this heuristic device and connects the outcome of analyses of the different types of information to an array of potential actions (Table 1).

Based on a review of literature, this paper discusses how studies on (i) on-farm diversity assessment, (ii) access to diversity and information, (iii) extent of the use of available materials and information, and (iv) benefits obtained by the farmer or farming community from their use of local crop diversity, are necessary to identify the different ways to support farmers and farming communities in the maintenance of crop genetic diversity within their production systems. Throughout this paper two key themes are emphasized. First, any description or analysis within the four main groups can, and most probably will, lead to a number of different actions. Second, the decision to implement a particular action, and therefore its success, will depend on the farmer and the farming community having the knowledge, institutions and leadership capacity to evaluate the benefits that this action will have for them. This in turn promotes an emphasis on the importance of strengthening local institutions to enable farmers to take a greater role in the management of their resources.

II. ON-FARM DIVERSITY ASSESSMENT

The assessment of diversity provides the necessary description of the extent and distribution of genetic diversity of traditional varieties, and of the way in which that diversity is partitioned within and among varieties at household and community levels. It allows exploration of the relation of the observed diversity to factors such as ecology, gender or poverty. Description in terms of variety names and the traits farmers use to describe their varieties is important for understanding how well their materials are adapted to the farmers' environments and preferences, as well as the farmers' perspectives of diversity distribution. Genetics, particularly molecular genetics, provides further information on patterns of diversity distribution and allows the investigation of the relation of observed diversity with environmental, social and cultural factors, providing a means to reconcile classification schemes using farmers' varietal names with genetic distinctiveness. It also helps determine whether there is a wide enough genetic base for future improvement of the *in situ* materials, or whether there is sufficient diversity to provide system resilience (Figure 1: 1*a*, 1*b*).

A. Understanding Farmers' Diversity Units and Estimating the Diversity of Traditional Varieties

Diversity within the agricultural production system can be assessed at different levels: within and among households, villages, communities and countries. Many studies are now available which describe the amount and distribution of genetic diversity of individual crops in farmers' fields, at different scales, using a wide range of methods. These studies range from counting the names of varieties to biochemical and molecular studies which assess allelic richness and heterozygosity (Berg, 2009; Brown, 2000). Some studies have developed and used indices of diversity or other methods to compare the amount and distribution of diversity within the farmers' production system across sites and crops. Not all production systems have the same amounts of diversity or the same reliance on traditional cultivars (Bajracharya *et al*., 2006; Eyzaguirre and Linares, 2004; Gautam *et al*., 2008). The diversity found within one community may or may not be representative of a much wider geographical area (Chavez *et al*., 2000; Guzman *et al*., 2005).

Many studies have reported the numbers of farmer-named varieties at household and community levels for major crops, including corn (Bellon and Taylor, 1993; Bellon and Brush, 1994; Louette *et al*., 1997), common bean (Martin and Adams, 1987; Voss, 1992), potatoes (Quiros *et al*., 1990; Brush *et al*., 1995; Zimmerer, 2003), sorghum (Tesema *et al*., 1997) and cassava (Boster, 1985; Salick *et al*., 1997; Kizito *et al*., 2007), barley (Kebebew *et al*., 2001; Gupta *et al*., 2003; Banya *et al*.,

TABLE 1

Descriptions and references to actions used to support the conservation and use of traditional crop varieties within agricultural production systems. Numbers and letters in the column, "*Where applicable,*" refer to specific constraints outlined in the heuristic framework shown in Figure 1. Actions can be used to overcome multiple constraints.

General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
Improving availability of materials	Reintroduction of materials from *ex situ* collections	1a, 2a	Local landraces from national gene bank or community gene bank are re-introduced based on ecological adaptive characteristics and human preferences	De *et al*., 2000; Arndorfer *et al*., 2009; Iriarate *et al*., 2000 http://www.actahort.org/books/817/817_35.htm; Feyissa, 2000; Feyissa *et al*., 2005; UNORCAC, 2008
	Reintroduction of materials from similar environments	1a, 1b, 2a	Local varieties collected from farmers from similar environments are integrated into informal seed system	Maurya *et al*., 1988; Sismanto, 2003; Joshi and Sthapit, 1990; Louette *et al*., 1997, Zimmerer 2003, Valdivia 2005, Chavez-Servia *et al*., 2000, Belqadi, 2003; Sthapit and Rao, 2009; Bhandari, 2009
	Seed Cooperative for collection and distribution and multiplication of seeds	1b, 2a, 2b, 2c, 2d, 4c	Community seed production groups; Participatory Seed Exchange (PSE); Grassroots seed savers networks; Cooperative is formed to market successful varieties or to establish seed enterprises for farmers to have a clean source of seeds.	Shrestha, Pitamber *et al*., 2010; Janssen *et al*., 1992 (Colombia), Musa 1998, Tripp 2006, Kabambe *et al*., 2008; Ramirez *et al*., 2009; Thijssen *et al*., 2008; de Boef *et al*., 2010
	Community Seed Bank	1b, 2a, 2b, 2c, 2d 3a,4b, 4c	To improve access to locally adapted varieties, local crops germplasm is collected together with associated information and knowledge, stored, regenerated or multiplied as needed and distributed to fulfill seed demands of farmers.	Shrestha P *et al*., 2006; 2010; Maharjan *et al*., 2010a; Balma *et al*., 2005; Bertuso *et al*., 2000; Lewis and Mulvany, 1997; Ramprasad, 2009; Sateesh, 2000; Feyissa, 2000; Mazhar, 2000; Mujaju, *et al*., 2003; Bertuso *et al*., 2000; Almekinders *et al*., 2007; Garforth *et al*., 2005; Mujaju and Chakauya, 2008; Bezabiha, 2008; Lewis and Mulvany, 1997; Poudel *et al*., 2005; Thijssen *et al*., 2008; Swaminathan, 2001; FAO 2006a
	Community Gene bank	1a, 1b, 2a, 2d	Local crop germplasm accessions are deposited by farmers for short term storage, and later multiplication and regeneration by other groups.	Kesavan and Swaminathan 2008; Ramirez *et al*., 2009; Swaminathan, 2001; Engels *et al*., 2008

Community managed nurseries	1b, 2a, 2b, 2c, 2d 3a,4b, 4c	Community nurseries allow growers to access both mother plants (scion and rootstocks) and the associated information. They also are a place for farmers to learn about better nursery management practices.	Oyedele *et al*., 2009; Shalpykov, 2008; Kerimova, 2008; Djavakyants, 2010
Diversity field flora	1b, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 4b, 4c	In order to supply an evolving diversified gene pool through exchange and selection to allow the continued adaptation to changing conditions through the informal seed system, farmers' groups in low heritability environments test both improved and local cultivars and the selected cultivars are multiplied and disseminated within and outside the groups. The approach can be used to meet preferences of women and men farmers that often different.	BUCAP, 2002; Smolders & Caballeda, 2006, Bioversity International, 2009; Jackson *et al*., 2010; Huvio and Sidibe, 2003; Grum *et al*., 2003; Bhandari, 2009
Diversity Kit	1b, 2a, 2b, 2c, 2d 3a,,4b, 4c	Diversity kit is a set of small quantity of different seeds made available to farmers to enhance their access to a wider range of local varieties. Seeds are harvested from diversity blocks, research farms or farmer's fields and distributed among the farmers.	Sthapit *et al*., 2006d; Sthapit *et al*., 2008b; Joshi and Sthapit, 1990; Sperling *et al*., 2001, Almekinders *et al*., 2006, Halewood *et al*., 2007
Diversity Fairs	1b, 2a, 2b, 2c, 2d 3a,4b, 4c	Diversity fairs aim not only at promoting the exchange of knowledge and germplasm between farmers, but they are also organized to explore diversity-rich areas and to recognize communities as custodians of traditional knowledge and biodiversity. Farmers from different communities are brought together to exhibit a range of traditional varieties and the farmer's knowledge of their varieties. Diversity fairs are organized differently to fit the culture of a specific community.	Tapia, and Rosa 1993;Sthapit, 1998; Rijal *et al*., 2000; Sthapit *et al*., 2003a; Rusike *et al*., 2003; Guerette *et al*., (undated); Sperling *et al*.,. 2008; Adhikari 2006b; UNORCAC, 2008; CIP/UPWARD, 2003; Hardon, and de Boef, 1993; Satheesh, 2000
Seed vouchers	1a,1b,2a,2b,3c,2d,	Seed vouchers are coupons or certificates with a guaranteed cash value that can be exchanged for seed from approved sellers. Seed sellers can then redeem their vouchers for cash from the issuing agency.	CRS, ICRISAT and ODI. 2002; Makokha *et al*., 2004; Remington *et al*., 2002; van der Steeg *et al*., 2004; Alexander *et al*., 2004

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General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
	Reduce transportation costs of traditional variety material closer to farmer communities	2a,2b,2c	In order to reduce transportation costs, NGO, Community based organizations, extension and other development organizations assess transportation costs as a regular annual program. Private fruit processor such as Gallas provides transportation cost of mango and other fruits directly to factories rather than middlemen so they can pay higher price to farmers.	Phiri *et al*., 2004
	Cross site visits for farmers and local extension workers	1a, 2a, 2b,3a, 3c	Cross-site visits aim at exposing each participating farmer to good practices adopted by another community and to demonstrate these practices to five farmers in their site. Participating farmers must present the learning from the visit to rest of the farmers immediately after the completion of the exposure visit.	LI-BIRD, 2005; Jarvis *et al*., 2000; UNORCAC, 2008; Nassif and Birouk, 2002; Nassif, 2002; Jarvis *et al*., 2004
	Microfinance or credit schemes to enable purchase of local materials	2a,2b,2c	Micro credit facilities provided by national banks, foundations, and international and national NGOs.	Kesavan and Swaminathan, 2008, UNORCAC, 2008
Improving information and availablity of information	On-farm Diversity blocks	1b, 2a, 2b, 2c, 2d 3a, 4c	A diversity block is an experimental block of farmers' varieties for research and development purposes managed by local institutions. A group of knowledgeable farmers is invited to observe the diversity block during cultivation. The block can also be used for the multiplication of planting materials, following cultivation of rare germplasm in the block.	Sthapit *et al*., 2006c, 2008c

Field or Laboratory trials comparing traditional and modern varieties	1b, 2a, 2b, 2c, 2d 3a,	Comparing traditional and modern varieties in field and laboratory trials gives quantitative differences of productive and adaptive characteristics under farmers' conditions. It also helps to demystify technology for farmers; Various methods such as Farmer Field Trials (FFT), PVS and Mother-Baby Trials are developed for this purpose.	Bouhassan *et al*., 2003a; Tushmereirwe, 1996; Bertuso *et al*., 2005; Rijal 2009; McGuire *et al*., 2002; Celis-Velazquez *et al*., 2008; Kennedy and Burlingame, 2003; Cazarez-Sanchez, 2004; Cazarez-Sanchez and Duch-Gary, 2004; Demissie & Bjørnstad, 2004; Trutmann *et al*., 1993; Karamura and Karamura 1995; Finckh *et al*., 2000; Joshi and Witcombe, 1996
Community Biodiversity Registries	3a, 3d, 4a, 4b, 4c	Community Biodiversity Register (CBR) is a record, kept in a register by community members, of the genetic resources in a community, including information on their custodians, passport data, agroecology, and cultural and use values. The method is to document traditional knowledge on genetic resources and provide defensive protection from bioprospecting.	Subedi, *et al*., 2005; Aboagye, 2005; Sthapit and Quek, 2005; Anil Kumar *et al*., 2003; Ruis, 2009
Literacy training particularly for poor and vulnerable groups		Literacy training enables farmers, particularly women, to have more access and control over their resources, and to have access to new options.	FAO, 2005; Jarvis *et al*., 2004; Kesavan and Swaminathan 2008
Variety information data bases made in farmer friendly formats	3a, 3d, 4a, 4b, 4c	Variety and plot data linked to GIS systems that are in farmer friendly formats allow farmers to see visually the distribution of different varieties in their community. They may also be used to map soil types and disease infestation to help farmers to make decisions on which varieties would be suitable for different agroecological conditions on their farmers.	Kesavan and Swaminathan, 2008
Setting up information systems and internet connections for farmer access to information	2a, 2b, 2d, 3a, 3d, 4a, 4b, 4c	Knowledge empowerment can be obtained by taking advantage of the new information and communication technology and providing internet connections. Using solar power where electricity is not continuous or available and through cell phone connections, a wire-wireless hybrid technology can be developed.	Kesavan and Swaminathan, 2008; Munyua *et al*., 2009; Lightfoot *et al*., 2008; Kenny, 2000

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	Small weather stations that can be linked to internet sites	3a,3c,4b,4c	In the developed world networks of weather stations in farming regions are becoming the norm. Farmers tap into these for real-time weather data and in some cases, use models for crop growth development and pest/disease forecasts. In some cases, farmers have their own weather stations. A relatively inexpensive weather station can be purchased for a farming community and added to a free weather networks such as Wunderground Weather, the network that makes local data available to others in a region or globally.	T. Murray personal comm, 2010; http://www.wunderground.com/weatherstation/index.asp#hardware
	Rural radio program that includes talks on the importance of crop biodiversity	3a,3d, 4a,4b,4c	Radio broadcasting is one of the quickest and more powerful means for providing information and raising awareness of people living in rural and semi-urban areas. Rural radio not only disseminates information to stakeholders but also provides forum for sharing opinions on various issues related to the conservation and management of biodiversity to a larger audience. Some CBOs have their own farmer-managed station to disseminate information and knowledge useful to the community.	Shah *et al*., 2009; Baral *et al*., 2006; Ballantyne 2009; Balma *et al*., 2005

	Drama, music and poetry traveling shows that have crop biodiversity as the theme	3a,3d, 4a,4b,4c	Often traditional knowledge is embedded in folk songs, poem and folk tales as they reflect social and cultural values in the community. The information or message passed on through this medium is easily acknowledged by the people and acts as an effective tool to sensitize the communities in developing countries when songs, poems and local theater as also a mode of entertainment.	Sthapit, 1999; Rijal *et al*., 2000; Dewan *et al*., 2006; Satheesh, 2000
	Painting and art competitions that reward farmer groups for knowledge and descriptions of agricultural diversity	3a,3d, 4a,4b,4c	A contest takes place among participants from the villages belonging to different communities, or different schools. Prizes decided with the communities are give for the painting or art that best depicts the ideas of conservation and use of traditional varieties.	Tapia, 2000; Sunwar *et al*., 2005
Improving traditional variety matierals and their management	Participatory crop improvement (Grassroots breeding; Participatory Plant Breeding (PPB); Participatory Varietal Selection (PVS))	2d, 3a, 3b, 3c, 3d, 4a,4b,4c	The value of local crop diversity can be enhanced in three broad ways: 1) simple trait selection from existing diversity of local population (e.g. grassroots breeding), 2) selection of fixed (stable variety) for target environment (PVS), and 3) cross local parent with exotic variety to remove the bad traits from local diversity (PPB). Locally based, participatory plant breeding exploits the diversity of local germplasm to produce cultivars that are superior in marginal environments compared to the products of formal, centralized programs, but at the same time continue to have a broad genetic base. The most key elements of this exercise are setting breeding goal by the farming community; plant breeders assist them to improve local materials under thier target environments and farmers contribute to the pre- and post-harvest selection.	Witcombe *et al*., 1996; 2005; 2006; Sthapit *et al*, 1996; Sthapit and Jarvis, 1999; Sthapit *et al*., 2000; 2003b; Joshi *et al*., 2000; Joshi *et al*., 2001; 2002; Ceccarelli and Grando, 2007; Witcombe *et al*., 2005; Gyawali *et al*., 2006a; 2006b; 2007; Gibson, 2009; Chiffoleau, & Desclaux, 2006;Danial *et al*., 2007; Almekinders *et al*., 2006; Ortiz *et al*., 2009; Lacy *et al*., 2006; Valdivia Bernal *et al*., 2007; Sunwar *et al*., 2007; Belay *et al*., 2006, 2009; Ceccareli *et al*., 2009; Halewood *et al*., 2007;

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General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
	Using genomics to improve *in situ* crop populations	2d,3 b, 3c,3d, 4a, 4b	Breeding desirable traits into materials adapted to abiotic and biotic conditions in a specific environment; backcross breeding of specific traits into locally adapted material	Witcombe *et al*., 2008; Steele *et al*., 2004; 2007; Barr, 2010
	Changing the formal breeding institutions to increase the use of farmer selection materials and traditional varieties in their programs	2d, 3a, 3b, 3c, 3d, 4a,4b,4c	National resistance breeding procedures integrate farmer selection practices and local material and participatory breeding practices to improve other production and quality traits of locally-resistant varieties as well as the resistance of locally adapted non-resistant varieties.	Mendum and Glenna 2010; Finckh 2008; Gibson, 2009; Mgonja *et al*., 2005; FAO 2010
	Planting of intra-specific mixtures to reduce pests an diseases	2d, 3a, 3b, 3c, 3d, 4a,4b,4c	Traditionally, farmers use diversity for any adversity by employing mixed farming, intercropping and varietal mixture within the species. Varietal mixtures or sets of varieties should have with non-uniform resistance and a lower probability that migrations of new pathogens or mutations of existing pathogens will damage the crop. Mixtures are based on the analysis of the resistance background, agronomic character, economic value, local cultivation conditions and farmer preferences.Traditional farming practices suggest that cultivation of a mixture of crop species in the same field through temporal and spatial management may be advantageous in boosting yields and stability and preventing disease.	Pradhanag and Sthapit, 1995; Finckh, 2008; Finckh, and Wolfe, 2006; Di Falco and Perrings 2006; Zhu *et al*., 2000; Thinlay *et al*., 2000; Finckh, 2003; Trutmann and Pyndji, 1994; Ghaoti *et al*., 2005, Li *et al*., 2010; Benton *et al*., 2003; Willey, 1997

	Improve seed storage facilities and methods	3c,3d,4a,4c	Seed storage devices and methods determine the vulnerability of seeds to pests, diseases and physiological deterioration. Some common methods are improving the air tightness of containers or head treatment. Some tested examples combine traditional with modern methods e.g. cow dung ash was combined with air tight storage to increase the seed longevity.	Gepts, 1990; Yupit-Moo, 2002; Latourniere *et al*., 2006; Grum *et al*., 2003a; Wambugu *et al*., 2009; Thamaga-Chitja *et al*., 2004; Beckett *et al*., 2007
	Seed cleaning/ seed treatment	3c,3d,4a,4c	Seed cleaning technology for seed born diseases, normally recommend for certified varieties can be used on traditional varieties to increase yield. This includes supporting farmers for small seed cleaning machines.	Sadiki *et al*., 2002
Improved Processing	Shift retailers to use different processing equipment that can use diversified materials	3c,3d, 4a,4a,4c	Complementary technical solutions will be necessary to integrate the future use of agricultural strategies that include the use of diverse traditional varieties. These may include simple adjustments of planting and harvesting devices to new separation of the harvest products.	Finchk, 2008; Walsh *et al*., 2004
	Training of producers in improved processing techniques; and providing credit to acquire processing equipment	3c,3d, 4a,4a,4c	Training of farmers in improved processing techniques enables farmers to process traditional varieties into improved market products. This can be linked to micro credit to purchase processing equipment.	Giuliani, 2007; Devaux *et al*., 2006; Kontoleon *et al*., 2007
Alternatives and modification to seed certification systems	Plant varieties common knowledge (VCK)	2d, 3a, 3d, 4a, 4b, 4c	'Common knowledge' can be defined as having shared information or understanding among members of a specific 'community', including a nation, a region, a city, a particular race, an ethnic group, or a professional society, which permits a variety to be precisely defined and distinguished by the members of that particular community.	Prasann *et al*., 2008; Mazhar, 2000

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General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
	Registration and release of famers' varieties with acceptance of enhanced bulk varieties	2d, 3a, 3d, 4a, 4b, 4c	Following participatory assessment of the enhanced bulk variety in the field together with farmers, mill owners and retailers, a formal seed registration board may establish that a bulk population is phenotypically similar fo agronomic, post-harvest, quality traits and market preferences and can recommend the formal registration and release of the enhanced bulked variety adapted to local conditions.	Joshi *et al*., 1997; Gyawali *et al*., 2007; Bishaw and van Gastel, 2009; Bealy, 2007; Halewood *et al*., 2007
	Geographic Indications	2d, 3a, 3d, 4a, 4b, 4c	A Geographical Indication is a form of protection within the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement of the World Trade Organization (WTO). It protects intangible economic assets such as the quality and reputation of a product through market differentiation. It is a tool to maintain multifunctionality in rural landscapes and involve local populations in biodiversity management and conservation by providing incentive for marketing special products.	Ramakrishnappa 2006; Garcia *et al*., 2007; Nagarajan, 2007; Salazar *et al*., 2007; http://www.origin-gi.com/
	Quality declared seed (QDS) - that certify the vendor rather than the seed	2d, 3a, 3d, 4a, 4b, 4c	Small scale farmers are registered to produce seed for local sale. A QDS producer is trained in QDS production of a crop they can decide later to add additional crops or varieties to their seed production at their own risk. The QDS vendors are inspected by authorized seed inspectors at district level	FAO 2006b; Granquist, 2009

Truthfully labeled seed Laws that focus on seed quality rather than seed purity	2d, 3a, 3d, 4a, 4b, 4c	In India, for example, the truthfully labeled seed law has been designed to focus on seed quality rather than varietal purity.	Lipper *et al*., 2010b
Registries of native crops	2d, 3a, 3d, 4a, 4b, 4c	The register indentifies and recognizes the individuals, institutions or communities who maintain, conserve and work on native crops, but does not grant specific rights to those who are applicants to the register. The registry contains the main agronomic, agroecological and taxonomic characteristics of the varieties of native crops. It clearly identifies the origin and diversification centers, and raises awareness through verified technical and scientific official information. It identifies groups of farmers, individuals and institutions that care about conservation and use of agricultural biodiversity and those persons that have been instrumental in ancestral efforts of conservation. It contributes to preventing actions of biopiracy.	Ruis, 2009; Subedi, *et al*., 2005; Aboagye, 2005; Sthapit and Quek, 2005; Anil Kumar *et al*., 2003
Links between intellectual property rights protection and benefit-sharing	4a, 4b, 4c	Some legislations like the Thai Plant Variety Protection Act requires the holders of plant breeders' rights to give part of the benefits arising from the commercialization of the protected varieties to a fund dedicated to on farm conservation of crop diversity. Similarly, at the international level, the multilateral system on access and benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture creates a benefit-sharing fund for conservation projects where vendors of new plant varieties that are not freely available for research and breeding must put part of the benefits derived from the varieties' commercialization.	Moore and Tymowski, 2005; Gagne and Ratanasatien, *in press*

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TABLE 1

Descriptions and references to actions used to support the conservation and use of traditional crop varieties within agricultural production systems. Numbers and letters in the column, "*Where applicable,*" refer to specific constraints outlined in the heuristic framework shown in Figure 1. Actions can be used to overcome multiple constraints. *(Continued)*

General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
	Plant variety protection systems adapted to farmers varieties	3d	Effective *sui generis* systems of farmers' varieties protection can empower individual farmers and farmers communities and prevent misapropriation of farmers' varieties by others.	Leskien and Flitner, 1997; Correa, 2000
Market creation and Market promotion	Market promotion through taxes and subsidies	4a,4b, 4c	Market promotion through taxes for environmental damage and subsidies for environmental friendly practices or for the use of traditional crop varieties within the farmers' production system.	Kruijssen and Mysore, 2007
	Market creation for traditional varieties or products from traditional varieties including niche markets	2d, 3a, 3b,3d,4a,4c	Demand for unusual heirloom or niche market varieties exists among urban residents or other consumers. Niche markets might be for traditional varieties that are "best fit" to particular ecosystems, such as particular traditional varieties shown to grow well on swampy soil or on poor upland soils. Marketing social-cultural aspects of traditional varieties for particular culinary aspects and associated ethnic identity has also been used to create niche markets.	Lee, 2005; Irungu *et al*., 2007; Giuliani, 2007; van Dusen, 2006; Gauchan and Small, 2003; Rana, 2004; Gruere *et al*., 2007; Caviglia and Kahn, 2001; UNORCAC, 2008; de Boef, 2010; Bhandari *et al*., 2006; Bhandari, 2009
	Education and financial support to farmers' groups to develop a marketing strategy	3a, 4a, 4c	Institutions support farmer unions and cooperatives for educating farmers in production and marketing, assisting with price negotiations, collecting land taxes, information sharing.	Kruijssen and Somsri, 2006; Ramirez *et al*., 2009; Caviglia and Kahn, 2001.

Micro credit facilities to set up small businesses particularly for rural men and women	4a, 4b, 4c	Micro-finance and micro-insurance schemes are innovative ways of providing the poor with access to capital and thus a way out of poverty. Micro credit is a small amount of money loaned to a client by a bank or other institution. Micro credit can be offered, often without collateral, to an individual or through group lending. Micro credit schemes can enable farmers, especially women to engage in economic activities and join social networks through which both poverty and social dependency can be overcome.	Kesavan and Swaminathan, 2008; UNORCAC, 2008; Kapila and Mead, 2002; Gine and Yang, 2009; Andersen *et al*., 2008
Advertisement campaigns to improve consumer and retailer awareness of important traits (nutritional, adaptive)	3a,3b, 3c,3d,4a,4b,4c	Marketing nutritional and health (both human and environmental) related information to wider consumers to add value. This includes providing consumers and retailers with information on traditional variety traits.	Johns and Sthapit 2004; Kennedy and Burlingame 2003.
Cook books with traditional recipes; gardening books that promote traditional varieties for particular management practices	3a,3b,3d,4b,4c	Recipes that require traditional varieties; organized synthesized and published; Gardening books that promote traditional varieties for their uses can be useful for raising awareness.	Yucatan cook book; Sthapit *et al*., 2008a; Gruere *et al*., 2007; Ramirez *et al*., 2009
Fair trade price premiums - Eco-labeling (paying the full production value through price premiums)	2d, 3a, 3b, 3c, 3d, 4a, 4c	Fair trade or eco-labeling is a conservation strategy that is market based, in which consumers pay a price premium for a product which is produced on certified farms that are committed to the preservation of biodiversity or fair working conditions; the label of fair trade requires that the buyers agree to: pay a price that covers the production costs and a social premium; make an advance payment; purchase directly from the producer; and establish long-term contracts.	Kitti *et al*., 2009; Perfecto *et al*., 2005; Swallo and Sedjo, 2000; 2002; Renard, 2003

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TABLE 1

Descriptions and references to actions used to support the conservation and use of traditional crop varieties within agricultural production systems. Numbers and letters in the column, "*Where applicable,*" refer to specific constraints outlined in the heuristic framework shown in Figure 1. Actions can be used to overcome multiple constraints. *(Continued)*

General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
Building Partnerships and Trust	Organization of meetings involving market-chain actors to discuss how to enhance market potential.	3a,3b,3c, 4a, 4c	Stakeholder meetings, involving as many as possible of the market chain actors including producers and traders, cultivation experts, NGOs, representative of relevant ministries, and community members to develop ideas for enhancing market potential for traditional varieties.	Giuliani, 2007; Kruijssen *et al*., 2009
	Private and public partnership for the construction of small infrastructure for the production of a better quality product	3a,3b,3c, 4a, 4c	The formulation of producer marketing groups, and micro-enterprise that provides better access to local, national, and international markets for locally grown and processed products.	Giuliani, 2007; Audi *et al*., 2010; Friss-Hansen, 2008; Pretty, 2008; Jarvis, and Ndung'u-Skilton, 2000; Swaminathan, 2003; UNORCAC, 2008
	Strengthened and cooperative extension service that includes farmers, are more demand driven or establishment of new farmer-governed local institutions	1a, 1b, 2a,2b,2c, 2d, 3a, 3b, 3c, 4a, 4b, 4c	Transformation of local government staff and establishment of new farmer-governed local institutions specifically focusing on the management of local varieties; Particularly for poor and marginalized groups.	Triomphe *et al*., 2008; Sthapit *et al*., 2008c; Adhikari *et al*., 2006a; Friis-Hansen *et al*., 2008; Birner and Anderson, 2007; Neuchatel Group, 2007 (http://www.neuchatelinitiative.net/english/index.htm)

Changing norms	Advertising and social campaigns that promote better adapted varieties that reduce need for chemical inputs to change social norms such as nutritional cultural values of food	3a, 3d, 4a, 4b, 4c	Advertsing campaigns to change norms on nutrition and taste, and to reduce chemical inputs for better environmental protection. These campaigns may opt to demonstrate the full cost to the environment and human health of high input fertilizer and pesticide systems and emphasize social obligations to the reduction of pesticides and fertilizer and other harmful practices for the environment.	McGuire, 2008; Meinzen-Dick and Eyzaguirre, 2009; Sthapit *et al*., 2008a
	School biology curriculum include traditional crop varieties as an agricultural resource and ecosystem service	1a, 1b, 3a, 3d, 4a, 4b, 4c	Modification of curriculum content of primary and middle school, and high education institutes to include traditional crop varieties as an agricultural resource and provider of ecosystem services	Ramirez *et al*., 2009; Jarvis *et al*., 2000; Visser and Jarvis, 2000; Bioversity International, 2008
	Gender sensitive response policy	1,2,3,4	Promoting women in decision-making and project management roles, has increased the number of women who are given training opportunities; Women are actively sought after for decision making positions in projects	MEA 2005, Tapia and De la Torre, 1998
Promoting ecological land management practices	Environmentally sensitive areas (ESA) include high agrobiodiversity areas	3a, 3b, 3c, 4b, 4c	Areas oriented to the conservation and sustainable use of native cultivated species by indigenous peoples	Mar 2002; Birol *et al*., 2006; Amend *et al*., 2008
	Agriobiodiversity Zones	3a, 3b, 3c, 4b, 4c	Agricultural zones of important native cultivated germplasm under management of native communities are designated formal legal status	Ruis, 2009; UNORACA, 2008

TABLE 1

Descriptions and references to actions used to support the conservation and use of traditional crop varieties within agricultural production systems. Numbers and letters in the column, "*Where applicable,*" refer to specific constraints outlined in the heuristic framework shown in Figure 1. Actions can be used to overcome multiple constraints. *(Continued)*

General category actions (*Note: Actions can be applicable to more than one category)*	Actions	Where the action is applicable to specific constraints outlined in the Heuristic Framework (Figure 1)	Description of Actions	References
	Agrobiodiversity Ecotourism	3a, 3b, 3c, 4a, 4b, 4c	Agrobiodiversity ecotourism is aimed toward amateur interest in the diversity of cultivated plants and in the cultural practices associated with crop. Agrobiodiversity toursim projects are managed in close partnership with local communities and can involve such activities as farm and market visits, participation in agricultural activities and food preparation, tastings of local foods and beverages and attendance at specific feasts and celebrations	Ramirez, 2001, Ramirez and Williams, 2003; Ramirez *et al*., 2003; UNORACA, 2008
	Organic farming and organic seed breeding with traditional variety used as planting materials	2d, 3a, 3b, 3c, 3d, 4a, 4b, 4c	Utilize traditional varieties in organic farming where traditional varieties are well adapted to local conditions. Organic farmers are obliged to use organically produced seeds and propagating material.	Bela *et al*., 2006
	Investment in agricultural research that includes the use of agricultural biodiversity within the production system	1, 2, 3, 4	Investment in agricultural research and extension has contributed significantly to agricultural growth and rural poverty reduction in rural areas.	MEA, 2005; Fan *et al*., 2007

	Biodiversity included in Environmental Impact Assessment of individual projects, policies and programmes	1, 2, 3, 4	By integrating biodiversity, including agriculture biodiversity, in the legislation on environmental impact assessment, decision-makers can adopt informed decisions with regard to agrobiodiversity conservation and use.	Slootweg *et al*., 2006; Wale, *in press*
Payment schemes for ecosystem services	Payment for Environmental Services (PES)	2d, 3d, 4b, 4c	The real value of agrobiodiversity and its services is not captured by the market because of a failure to internalize external costs. Farmers who provide environmental services are compensated, either by the immediate beneficiary or by the general public. Payment for Environmental Services (PES) schemes permit “capture” of public conservation values at the farmer level, thereby creating incentives for the conservation of agrobiodiversity and supporting poverty alleviation.	Pascual and Perrings, 2007; van Noordwijk, *et al*., 2005; FAO, 2007; Wunder *et al*., 2008
	Linking upstream and downstream communities	2d, 3d, 4b, 4c	An example is an environmental payment system initiated in 2002 in the Rupa Lake area, Nepal. The Rupa Lake Cooperative pays 10% of its income from fishery management to the upstream communities. The realization among the users of the Rupa Lake about the potential role of upstream and downstream communities in management of the lake has led to expansion of members within the cooperative. The 360 membership in the cooperative in 2006 is now more than 600 members.	Pradhan *et al*., 2010
	Sharing of monetary benefits	4a, 4b, 4c	A way of realizing farmers’ rights and support farmers who conserve and generate crop diversity is by sharing the monetary benefits arising from the commercializaiton of new varieties with farmers, in combination with other forms of benefit-sharing. A number of countries have developed legislation on benefit-sharing and some of them refer to traditional farmers as final beneficiaries.	Andersen, 2005

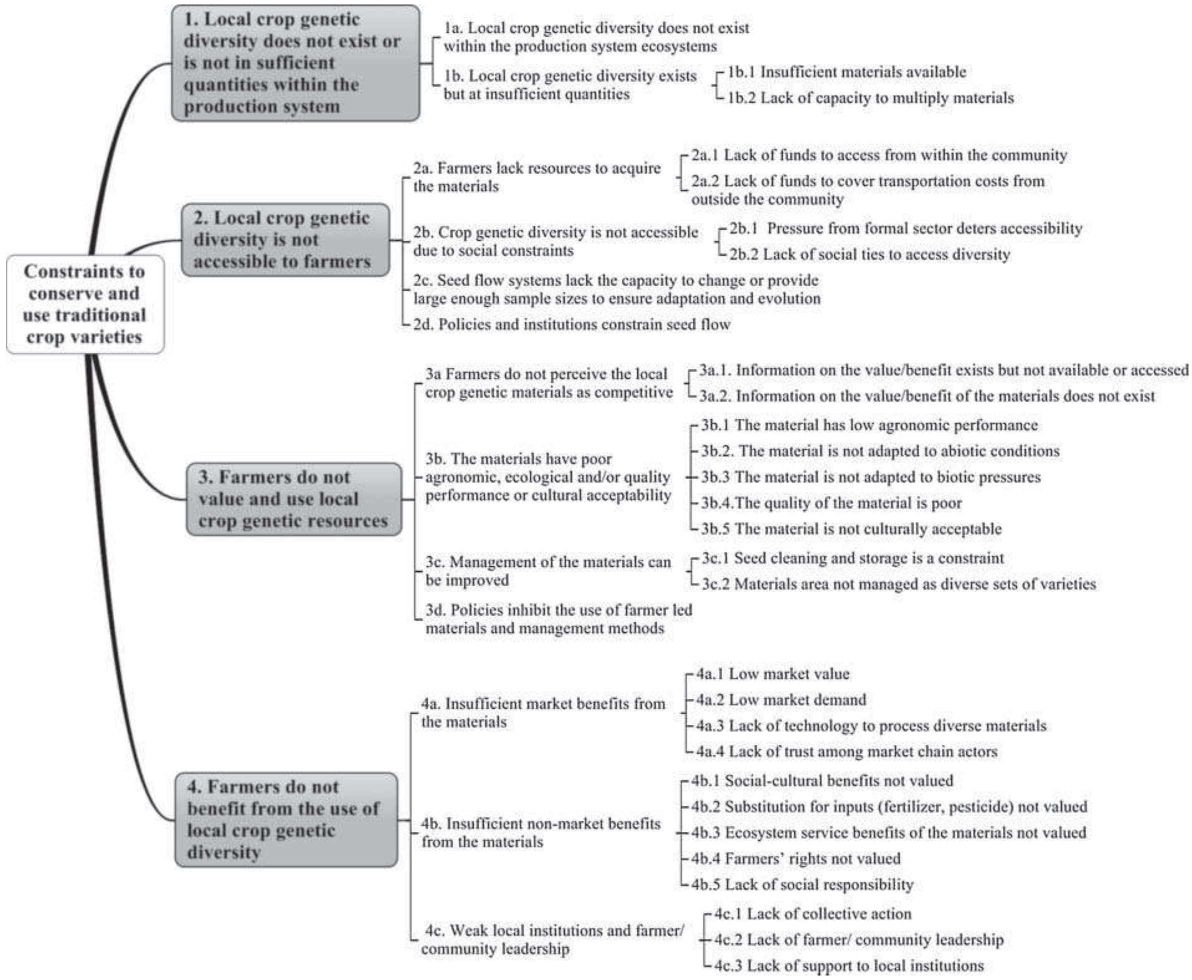

FIG. 1. Heuristic framework for identifying constraints and related actions to support the conservation and use of traditional crop varieties within agricultural production systems.

2003; Tanto *et al*., 2009), apricot (Baymetov *et al*., 2009), walnut (Butkov and Turdieva, 2009; Djumabaeva, 2009), apple and pear (Djavakyants, 2010), and grape (Djavakyants, 2009; Turgunbaev, 2009). While the numbers of varieties provides a useful first approximation of the extent and distribution of diversity, there has been discussion both of the extent to which variety names adequately reflect agro-morphological, biochemical or molecular diversity, and of whether variety names are used consistently by farmers at different geographic scales.

Sadiki *et al*. (2007) reviewed studies which correlated names of varieties to the agromorphological descriptors used by farmers. He and his colleagues compiled information globally for different communities, which suggested that variety names, when complemented by farmer descriptions, could be used as a basis for arriving at estimates of traditional variety numbers, and provide a useful estimate of the amount of genetic diversity within the farmers' production systems. As shown by Jarvis *et al*. (2008), variety names can also be used to provide a valuable global estimate of diversity, focusing attention on the role of farmers themselves in the maintenance of crop diversity in production systems.

Variety names also provide information on the nature, status and management of varieties. Nuijten *et al*. (2008) found that three types of names could be distinguished for rice in the Gambia; those referring to common old varieties, common new varieties, and uncommon varieties, thus showing that variety names supply information on the period of time the variety was used in a village and on the flow of varieties between and within villages. The farmers' or community beliefs that a named recognizable population has particular properties and identity is likely to lead to management practices that tend to reinforce separate identities. This creates a powerful selection practice able to maintain the preferred traits in specific populations (Brown and Brubaker, 2002).

Methods to analyze diversity information when farmers use the same name for different varieties or different names for the same varieties, have been discussed by Chavez-Servia *et al.* (2000), Arias *et al.* (2000), and Tuxill *et al.* (2009) for maize and beans in Mexico, by Sawadogo *et al.* (2005) for sorghum in Burkina Faso, by Karamura and Mgnezi (2004) and Gold (2002) for banana, and by Bajracharya *et al.* (2006) and Bisht *et al.* (2007) for rice. Gender has been shown to play a role in the number of descriptors used (Rijal, 2007), and the type of characteristics described (Karamura *et al.*, 2004). The work has also shown the importance of using information from farmers on the traits they use for distinguishing their traditional varieties, to define consistent units of farmer managed diversity (Sadiki and Jarvis, 2005).

A range of studies is now available which have tried to quantify the amount of diversity within farmers' fields by comparing the descriptions given by farmers to distinuguish their varieties according to agromorphological field data: in faba bean (Sadiki *et al.*, 2001; 2002), barley (Tsehaye *et al.*, 2006; Tanto *et al.*, 2009), maize (Mar and Holly, 2000; Arias, 2004; Burgos-May *et al.*, 2004; Latournerie-Moreno *et al.*, 2006) and taro (Rijal, 2007; Canh *et al.*, 2003; Hue *et al.*, 2003). Other studies have examined the diversity of adaptive and ecophysiological traits within the production system (Teshome *et al.*, 2001; Weltzien *et al.*, 2006; Thinlay *et al.*, 2000; Hue *et al.*, 2006). The diversity of quality and nutritional traits (Duch-Gary, 2004; Cazarez-Sanchez, 2004) has also been described, as has the relationship of levels of crop genetic diversity to geographical regions (Taghouti and Saidi, 2002; Bouzeggaren *et al.*, 2002; Teshome *et al.*, 2001).

Brown and Hodgkin (2007) reviewed some of the molecular methods available to assess the extent and distribution of diversity, including single nucleotide polymorphisms (SNPs), phylogentic analysis (Clegg, 1997; Brown and Brubaker, 2000) and functional genomics (Aharoni and Vorst, 2001; Peacock and Chaudhar, 2002). Kumar and colleagues (2009) reviewed the potential advantages and disadvantages of different molecular markers in assessing genetic diversity, while Witcombe *et al.* (2008) reviewed the use of traditional and new genomic technologies for breeding for tolerance to abiotic stress of low nitrogen, drought, salinity and aluminum toxicity. Laurentin (2009) recently synthesized data analysis methods for molecular characterization of plant genetic resources.

Various studies have tried to compare the descriptions supplied by farmers to distinguish their crop varieties by means of agromorphological, biochemical and molecular descriptors, so as to provide an overall diversity assessment in traditional varieties. In some cases, genetic data have substantially confirmed information that the number of traditional varieties distinguished by their names is a good representation of diversity within a production system. In other cases, names were not correlated with diversity patterns of either agromorphological or molecular descriptors, but with the sets of traits farmers used to describe different units (Sadiki *et al.*, 2007; Baymetov *et al.*, 2009).

Sagnard *et al.* (2008) showed a low correlation between the diversity of farmer names and the genetic diversity assessed by microsatellites for sorghum in West Africa. The relationship between molecular markers, variety names and agromorphological traits, has also been reported to be poor or complex in sorghum traditional varieties from Mali (Chakauya *et al.*, 2006), cassava in Uganda (Kizito *et al.*, 2007), and sorghum in Zimbabwe (Mujaju *et al.*, 2003; Mujaju and Chakauya, 2008). Busson *et al.* (2000) found that farmer management of the outcrosser–pearl millet–resulted in more differences with respect to microsatellite marker variation among farmers, than among same named varieties grown by different farmers; thus, the traits used by farmers to distinguish the different named varieties did not give genetic identity at the molecular level. Pressoir and Berthaud (2004) found that high variation in flowering time among populations of maize in Mexico suggested that these agromorphological traits would be different from those described with molecular markers. In Jumla, Nepal (a high altitude site), over 20 traditional rice varieties were identified by farmers using grain color. These 20 varieties were found to differ with respect to a small number of key morphological traits, and by using SSR analysis had only limited molecular genetic diversity (Bajracharya *et al.*, 2001; 2006). In contrast, in the low lands and middle hill sites of Nepal, the richness of farmer named rice diversity agreed with the diversity measured by SSR markers (Bajracharaya *et al.*, 2010).

Most of the molecular studies were undertaken using what are believed to be neutral markers on a rather small scale and, particularly for cross-pollinated crops, it is perhaps not surprising that it is difficult to find a good correlation between variety names, or agromorphological traits, and molecular markers. There is a need to collect much more complete data sets using a much wider range of markers.

An understanding of the extent and distribution of diversity using both farmer-determined categories and a range of genetic markers, underpins the identification of ways of supporting the maintenance of traditional varieties. Community biodiversity registers (Subedi *et al.*, 2005) (Table 1) enable farmers to maintain information on diversity within their community and to provide the information needed to address bio-piracy concerns. Information on the extent and distribution of diversity also provides the information needed to assess whether there is enough diversity within the system for selection, or whether the system will be able to adapt to environmental and economic change (Figure 1: 1*a*, 1*b*).

Information on consistency with respect to names is also essential when reintroduction of materials is envisaged and various approaches have been tested to support this process, in Ethiopia and elsewhere (Worede, 1997; Worede *et al.*, 2000; Feyissa, 2000; 2006; De, 2000) (Table 1). Ecuador won the 2008 Ecuador Initiative award for the return of 10,000 plants of 15 traditional crop varieties (roots, tubers, grains, and fruit) to local communities (UNORCAC, 2008). In Burkina Faso, a series of local genebanks are being established in high-priority conservation areas. These gene banks are part of the National Plant Genetic resources system and will both emphasize conservation of local varieties and be a source of local seeds that can be deployed in the event of natural disasters such as extreme drought (Balma, *et al*., 2004; Bragdon *et al*., 2009).

B. Patterns of Diversity Within and Among Households, Communities and Landscapes

The analysis of patterns of diversity and the distribution of diversity over greater or lesser areas has provided information on the importance of biological, ecological, environmental, and social characteristics, which can usefully guide the development of supporting management practices for traditional varieties (Brown, 2000). Measurements of richness, evenness and divergence, often used in ecological studies, have more recently been applied to the partitioning of traditional varieties within and among communities on-farm (Jarvis *et al*., 2008). Richness is the number of different kinds of individuals regardless of their frequencies; evenness describes how similar the frequencies of the different variants are, with low evenness indicating dominance by one or a few types (Frankel *et al*., 1995; Magurran, 2003). Divergence is a measurement of the proportion of community evenness displayed among farmers. A recent evaluation of Jost (2010) discusses evenness related to the maximum and minimum possible for a given richness, by decomposing richness into independent diversity and evenness components.

Measurements of richness, evenness, and divergence were used to bring together varietal data of 27 crop species over five continents, collected by partners from over 50 government and non-government institutes, to determine overall trends in crop varietal diversity on-farm (Jarvis *et al*., 2008). As well as showing that considerable crop genetic diversity continues to be maintained on-farm, in the form of traditional crop varieties, this synthesis provides a baseline for estimating future genetic erosion on-farm, and information on the relationship between richness and evenness for traditional varieties maintained at farm and community levels. The results showed that as farmers increase the number of traditional varieties they grow, they often plant relatively even areas for each of the different varieties.

The mode of reproduction (whether inbreeding, outbreeding or vegetatively propagated) of a species is an important factor in understanding the patterns of genetic diversity observed in traditional varieties. The breeding and reproductive systems of crop species affect the farmer's perception of diversity and his or her management practice. Clonal and inbred species are more strongly differentiated genetically and can be more easily separated into identified types or varieties. In a number of cases, fields of clonal or inbred crops are planted to a mixture of traditional varieties, which can later be separated at harvest (Brown, 2000; Jarvis *et al*., 2000). In contrast, for outcrossed species such as maize, a traditional variety appears to be a more polymorphic entity in which any particular genotype is ephemeral (Louette *et al*., 1997; Teshome *et al*., 2001). Hamrick and Godt (1997) summarized the effect of breeding systems on partitioning variation within and among crop populations, with self-pollinating crops showing twice as much population differentiation as outcrossers. Clearly, breeding systems and crop biology are important in identifying supportive management options. Communities and farmers are usually both aware of this and have embedded a variety of procedures for crops with different characteristics (Jarvis *et al*., 2004).

It is widely expected that patterns of diversity will reflect differences in climate, altitude and other agro-ecological factors. In fact, the amount of variation that can be attributed to agro-ecological factors has often been found to be relatively small by comparison with that found within populations, although clustering of varieties with similar agromorphological characteristics has been described (e.g., sorghum in Zimbabwe, Mujaju and Chakauya, 2008). Thus, in rice in Nepal, genetic variation was mostly due to intra-population diversity (within a farmer-named variety) and was independent of agroclimatic zones, variety names, and altitude (Bajracharya *et al*., 2006). In contrast, phenotypic traits in Ethiopian barley arid sorghum were strongly related to altitudinal range (Demissie and Bjørnstad, 2004; Teshome *et al*., 2001). Microsatellite diversity of traditional sorghum varieties across Mali, Burkina Faso and Niger, has shown that sorghum exhibited more genetic diversity in terms of allelic richness in Niger than in Mali, despite a lower agroclimatic range in Niger, suggesting that anthropogenic management practices, together with agro-ecological factors, form the structure of sorghum genetic diversity in this region (Sagnard *et al*., 2008). On balance, the evidence suggests that when introduction of new diversity is planned, it is better to use materials that come from similar agro-ecological zones.

The area in which individual varieties occur varies substantially and while some are maintained very locally, others may be part of extremely extensive seed systems extending over more than one region or country (Louette *et al*., 1997; Zimmerer, 2003; Valdivia, 2005). The agromorphological diversity of 15 traditional maize varieties from a single site, Yaxcaba in the Yucatan State, was comparable with that of 314 maize varieties from all three States of the Yucatan Peninsula (Chavez-Servia *et al*., 2000; Camacho-Villa and Chavez-Servia). Similary, in Morocco, Belqadi (2003) showed that a major portion of agromorphological variation diversity for the Moroccan faba bean was captured in populations from the two northern provinces, and Barry *et al*. (2007) reported that in Guinea each of the villages studied had more than half of the regional allelic diversity of African rice, with genetic differentiation among varieties from the same village accounting for 70% or the regional variation. These studies have helped identify areas where local diversity is representative of a much wider area for a given crop and could be used to reintroduce diversity into a larger area.

At a more local level, the "four cell" analysis has proved to be a useful method of exploring the distribution of varieties in Nepal, Vietnam, Brazil, Ethiopia, Mali, India, Indonesia and Malaysia (Sthapit *et al*., 2006b; reviewed in Sadiki *et al*.,

2007) (Table 1). This approach brings together farmers and researchers to categorize varieties according to whether they are grown by many or few households, and whether they cover small or large areas of the community (Rana *et al*., 2007; Hue *et al*., 2003). Grum *et al*. (2003) used this method to give opportunities to farmers in Sub-Saharan Africa to discuss their perceptions on whether they considered varieties rare or common, or widespread or local for rice, yam, sorghum, millet, and cowpea. The tool can be used too for farmers to collect information for self-directed action at community level (Sthapit *et al*., 2008b).

C. Ensuring the Existence of Sufficient Quantities of Materials

Estimating the extent and distribution of diversity provides the information needed to determine whether there is sufficient diversity of a crop within a production system to meet the various needs of farming communities (Figure 1: 1*b*). This is not always the case, as illustrated by Smale *et al*. (2009) who describe the shortage of well-adapted millet and sorghum seed in the Sahel. They found that local markets were important sources of seed in riskier, more isolated villages, indicating a need to legitimize local seed markets and, perhaps, to separate them from grain markets, through product information including marking with geographic origin. Such studies also provide information that can guide support for local seed systems, the introduction or reintroduction of traditional varieties and conservation actions.

A number of projects and studies have explored the ways in which varieties are best introduced when it is believed that farmers do not have the desired diversity. However, the majority of such programs had the aim of facilitating dissemination of new varieties (Rohrback *et al*., 2002; Tripp *et al*., 2001; Scheidegger *et al*., 2000; Bentlay *et al*., 2001) and took little or no account of existing traditional varieties and traditional seed systems (Tripp, 2006).

While the decision to add new diversity into the farmers' production systems, or to rehabilitate an area with lost diversity, rests ultimately with the farmers, the provision of traditional varieties is associated with a number of difficulties, in addition to those associated with establishing the identity and the range of the desired materials mentioned above. Kouressy *et al*. (2008) have argued that population sizes of varieties should be large enough to allow adaptation. Kouressy *et al*. (2008) have shown that large enough population sizes of traditional sorghum varieties allowed farmers in Mali to shift to short cycle varieties in adaptation to changing environmental conditions. However, few gene banks are equipped to provide sufficient seeds for direct sowing by farmers or to provide population sizes sufficient for adaptation to changing environmental conditions and management practices (Iriarate *et al*., 2000). Further, most genebanks are not easily accessible to farmers and communities. In the absence of a gene-bank, the Western Terai Landscape Project (WTLCP), in Western Terai, Nepal, used a systematic, participatory, seed exchange meeting to exchange seeds of local varieties of traditional crops and vegetables that are neglected by commercial seed retailers and extension system (Shrestha, 2009).

One approach that appears to be successful has involved the development of community seed banks and community gene banks (FAO, 2006a). This has occurred in several countries, including Ethiopia, Nepal, India, Bangladesh and the Philippines (Bertuso *et al*., 2000; Ramprasad, 2007; Poudel and Johnsen, 2009; Swamanathan 2001; De Boef *et al*., 2010) (Table 1). These banks are usually established in collaboration with local organizations and national or regional genebanks, and sometimes universities, to conserve and distribute local varieties through a farmer-led on-farm conservation approach. The selection of the materials to be multiplied relies on an assessment of the local diversity and on ensuring that the diversity of the population of the different traditional varieties is adequately covered. Deciding which varieties to target may be based on whether they are rare versus common, on particular traits for particular soil types or on market opportunities. Empowerment of local communities and their institutions is a precondition to implementing such community-based activities (Cromwell and Almekinders, 2000; Bartlett, 2008). The varieties can be used also to target the niche markets discussed in Section 5 below. The analysis of diversity also provides conservation guidance. Measurements of richness and evenness indicate which varieties are more likely to be lost and how much of the landscape they represent; they guide decisions on the maintenance of representative samples in community seed banks, or in national and international gene banks, or on whether to develop incentive mechanisms to promote endangered varieties.

III. ACCESS TO DIVERSITY

Access to crop seed or planting material diversity requries people having adequate land (natural capital), income (financial capital) or connections (social capital) to purchase or barter for the varieties they need (Sperling *et al*., 2008). Used in this sense, "seed" includes other planting materials such as tubers, cuttings or bulbs. Farmers may not have the desired access they need because they lack the resources necessary to acquire planting materials. They may lack funds to purchase or exchange the preferred planting material from within their communities (Figure 1: 2*a*.1). Appropriate seeds may not be available within the village, and the farmers may lack the resources to go to where seeds are being sold or exchanged (Figure 1: 2*a*.2). Planting materials for traditional varieties may also not be accessible due to social constraints. There may be pressure from both formal extension services and community peers against obtaining and using planting materials of local varieties (Figure 1: 2*b*.1). In addition, a farmer may lack the correct social ties or social status to obtain varieties (Figure 1: 2*b*.2). Seed quality and seed management practices can also be an issue and are discussed in Section 4, as can seed regulations (Figure 1: 1*d*). The availability of materials and the ways in which farmers access and manage seeds are expected to affect genetic diversity both within and among traditional varieties and, over time, may lead to changes in patterns of diversity (Hodgkin *et al*., 2007; Figure 1: 2*c*).

A. Seed Sources, Scale, and Patterns

The seed system is composed of individuals, networks, institutions and organizations involved in the development, multiplication, processing, storage, distribution and marketing of seeds (Maredia and Howard, 1998; Locha and Boyceb, 2003; Dominguez and Jones, 2005). Seed flows influence the pattern and dynamics of material that move in and out of the farmers' systems, and analysis of these flows give an insight into the constraints farmers face in acquiring preferred and quality planting material at the time it is needed for planting (Brocke vom *et al*., 2003).

Although there is no one systematic way in which farmers acquire and manage seeds, many, if not most rural farming communities in developing countries continue to use traditional or informal sources to meet most of their seed needs (Almekinders *et al*., 1994; Gaifani, 1992; Hardon and de Boef, 1993; Tripp, 2001; Cromwell *et al*., 1993; Tahiri, 2005; Muthoni and Nyamongo, 2008; Thijssen *et al*., 2008). The seed a farmer plants may have been selected from his or her own crop in the preceding season, exchanged or purchased from other farmers or institutions, or be a mixture of seeds from a combination of sources (Jarvis *et al*., 2000; Bellon and Risopoulos, 2001; Sperling and Mcguire, 2010; Badstue *et al*., 2002: Asfaw *et al*., 2007). Recent studies have quantified the amounts of farmers' own saved seeds versus seeds obtained from friends, relatives, neighbors, or local markets, and have confirmed that farmers prefer to save their own seeds in most situations (Gildemacher *et al*., 2009; Rana *et al*., 2008; Hodgkin *et al*., 2007; Lipper *et al*., 2010). These studies have described a range of techniques and opportunities that farmers use under different circumstances to access and save seeds (Cromwell and Almekinders, 2000). The different practices used are expected, over a period of years, to produce a dynamics of movement and mixing in which the progenies of individual populations are transferred among farmers, become mixed during exchange or marketing, become sources for new exchanges, or are lost.

Farmers' demands for off-farm seeds often result from an emergency, which may be personal (poor health, individual production failure) or more general (floods, drought, war), and affect the whole community or region. Reasons identified for accessing new seed stocks include low yields, consumption or sale of seed stocks, poor seed quality, the desire to access new varieties, and changes in national policy that affect subsidies and grain imports (Tripp, 2000; Mosely *et al*., 2010). There have been a number of studies on the ability of informal seed systems to meet users' needs during emergencies and disasters, such as floods, drought, or war (Almekinders *et al*., 1994; Richards and Ruivenkamp, 1997; Sperling, 2001; Asfaw *et al*., 2007). In a number of cases, informal markets were found to be critical to restocking traditional variety seed resources, both in normal and stress periods (Sperling and Mcguire, 2010). Diversity fairs, diversity-kits, micro-credit schemes, and community seed banks are also interventions which can increase access (e.g. Mazhar, 2000; Sthapit *et al*., 2006a, c, d; UNORCAC, 2008) (Table 1).

Seeds may be acquired via cash transactions, barter, as gifts, by exchanging one variety of seed for another, as a loan to be repaid upon harvest, or even by surreptitious expropriation from another farmer's field (Badstue *et al*., 2002; Mbabwine *et al*., 2008). Seeds of varieties developed by the formal sector are often maintained and distributed informally (Mellas, 2000; Bellon and Risopoulos, 2001), largely independently of government institutions. In some societies, there is a significant dependence on farmer-to-farmer seed transactions for traditional varieties (Hodgkin *et al*., 2007) as these sources are regarded as more trustworthy than alternatives such as local markets (Latourniere-Moreno *et al*., 2006). In South Asia, community seed banks are becoming an increasingly important intervention which also preserves local varieties and provides a source of local material for seed multiplication (Mazhar, 2000; Satheesh, 2000).

Various approaches are being used by non-government and government research, education and development agencies at local and national levels to support seed acquisition and increased numbers of transactions within and among communities, including community seed banks and seed diversity fairs (Tapia and De la Torre, 1998; Guerette *et al*., 2004; Shrestha *et al*., 2006; UNORCAC, 2008; De Boef *et al*., 2010) (Table 1). During a diversity fair, farmers from different communities are brought together to exhibit a range of landraces: this allows farmers to locate rare and unique diversity and provides an opportunity to exchange seeds and associated knowledge. Participatory seed dissemination (Rios, 2009) integrates seed diversity fairs and farmers' seed experimentation and dissemination. Seeds from diversity fairs are tested in the farmers' production systems to be further multiplied and diffused to other farmers. Identifying whether there are farmers who are known for reliably and regularly producing a good crop which provides seeds of high quality can be important for developing local practices that help maintain traditional varieties.

Analysis of patterns of seed transfer and exchange of traditional varieties provides important information for maintenance of traditional varieties helping to assess, for example, the effective population size, extent of mixing, degree of gene flow, and existence of defined subpopulations (Hodgkin *et al*., 2007). Studies among diverging subpopulations in model systems have shown that an uneven migration rate reduces the effective population size of the system, particularly when the seed of one farm is replaced (Maruyama and Kimura, 1980; Wang and Caballero, 1999; Whitlock, 2003). Heerwaarden and colleagues (2010) have used empirical data from maize in traditional agricultural systems in Mexico to demonstrate that seed dynamics in human-managed environments differ from existing mega-population models of natural ecosystems. In particular, the assumptions of most meta-population models (Kimura and Weiss, 1964; Slatkin, 1991, Wang, 1997) as to the absence of population bottlenecks following extinction and single-source migration, do not apply to systems under farmer management (Louette *et al*., 1997; Dyer and Taylos, 2008; Heerwaarden *et al*., 2010). High levels of pollen migration, such as occur in cross-pollinated crops such as maize and pearl millet may mask the effects of seed management on structure (Heerwarrden *et al*., 2010). In general it seems that farmer selection practices may not be a constraint in terms of having the diversity needed, as long as the effective population sizes are large enough to allow for evolution and adaptation, supported by adequate seed or gene flow.

Seed migration in traditional varieties can be fairly local–within communities or among neighboring communities (Collado-Panduro *et al*., 2005; Mar, 2002; Bela *et al*., 2006; Latourniere-Moreno *et al*., 2006; Banyia *et al*., 2003). Along the central Amazon River in Peru, most seed exchange of maize, cassava, peanut, chili peppers and cotton, occurred within rather than among the 13 communities. This seemed to reflect difficulties of access and communication among communities. Similarly, Tanto *et al*. (2009) found that seed flow for barley does not occur independently across the years within two seasons in areas of Ethiopia where there are two cropping seasons for the crop. Sagnard *et al*. (2008) found no genetic structuring among traditional sorghum varieties in villages in Burkina Faso, Mali and Niger, indicating that traditional seed systems operate at a very local scale in these study sites. However, some seed networks can be extensive covering distances that cross national boundaries and ecosystems (Zimmerer, 1996; Valdivia, 2005; Coomes, 2001).

While farmers may prefer to obtain desired seeds from others immediately after harvest, they may also need to obtain seeds at planting time when germination failed. At this point, farmers often have little choice in the variety obtained although they may try to obtain material from a microenvironment similar to theirs (Rana, 2004). Usually under such situations, farmers rely on social connections for their immediate needs, but community seed banks can be seed sources. Community biodiversity registers can provide information to locate the relevant variety within the community, but this requires very good documentation of local crop diversity in the register (Subedi *et al*., 2005), as well as access by farmers to the information. In cases of difficulty in acquiring seeds, local markets, middlemen, NGOs and experts, or nodal farmers, become increasingly important as sources of seed supply (Table 1).

B. Seed Custodians and Social Networks

Trust has been shown to be an important factor in farmers' choice of which seeds to acquire (Badstue, 2007). Public extension services may not always be seen as a trusted source, because the system is perceived to deliver too narrow a range of varieties which are not suited to the diverse growing conditions that a farmer may be managing (Adato and Meinzen-Dick, 2007). The response to seed needs is usually to look first for a family member or a friend as a reliable source (Almekinders *et al*., 1994; Badstue *et al*., 2007; Barnaud *et al*., 2008), and social relations play an important role in seed acquisition throughout the world (e.g., Ethiopia; McGuirre, 2008). Poudel *et al*. (2005) reported that communities with weak social networks are more vulnerable to accessing locally adapted seeds in adverse conditions, compared to those with strong social networks. Social seed networks can be strengthened by interventions that improve access to existing varieties and new diversity (e.g., seed fairs, diversity kits, community seed banks, participatory variety selection programs; Table 1). With better exposure of farmers to breeding skills and knowledge, participatory plant breeding (PPB) can strengthen farmer seed systems and promote on-farm management and sustainable use of local crop diversity (Sperling *et al*., 2001; Almekinders *et al*., 2006; Halewood *et al*., 2007) (Table 1).

Access to seeds may require appropriate social ties and kin networks (Lopez, 2004). Heritage and cultural identity values can be enhanced when a traditional variety is acquired from someone who is a relative or an elder in the community (Meinzen-Dick and Eyzaguirre, 2009). Analysis of rice seed supply networks in Nepal (Subedi *et al*., 2003) revealed their complexity and dependence on a range of social variables. In many communities, certain individuals may act as nodal farmers, characterized by their involvement in a large number of exchanges (Subedi *et al*., 2003; Subedi and Garforth, 1996). Further investigation has shown that the people who act as"nodal" farmers may change from one year to another (Poudel *et al*., 2008). Social prestige and religious values can be used to enhance the incentives to both maintain and share traditional crop varieties (Meinzen-Dick and Eyzaguirre, 2009).

Seed networks can be dependent on gender, wealth status, and age (Lope, 2004; Rana *et al*., 2008; Howard, 2003; Sillitoe, 2003; Song and Jiggins, 2003; Morales-Valderrama and Quiñones-Vega, 2000), but in some cases, they have been found to be gender-independent (Subedi and Garforth, 1996). Poor women often have less access to finance, markets, technologies, education systems, thus inhibiting ability to diversify (Vernooy and Fajber, 2004). Community seed networks, which were men-men, men-women (men led), women-men (women led), and women-women, have all been found in certain communities (Belem, 2000; Okwu and Umoru, 2009).

Gender, wealth, social status, and market-related variables have different effects on diversity in different parts of the world. In Ethiopia, education positively influenced the amount of diversity on farm for maize, wheat, and teff, but not for barley. Female-headed households grew more evenly distributed wheat varieties. Households with substantial outside sources of income grow a greater range of barley varieties, but this was not the case for maize (Benin *et al*., 2006). Labour policies that affect household labour supply and its composition are likely to have a large impact on traditional crop variety diversity. Loss of adult male labour has been correlated with the reduction of the diversity of crops and varieties grown (Van Dusen, 2006; Gauchan *et al*., 2006). Several studies have found that female-headed households are more likely to grow more traditional varieties (Gauchan *et al*., 2006; Edmondes *et al*., 2006; Benin *et al*., 2006; Dossou, 2004).

A number of ways to support key groups and hence increase the use of traditional varieties have been proposed and tested (Table 1). Most methods include training key seed producers and women in seed cleaning, multiplication and distribution and support for local institutions and social networks. Common approaches involve the development of community seed banks and diversity fairs and the identification of reliable farmers who can underpin farmer-to-farmer exchanges, as in Syria (Aw-Hassan *et al*., 2008). Diversity seed fairs that are organized by public institutions together with communities or non-governmental organizations, can help to increase transparency in seed quality and bridge knowledge across institutions and farmers on variety quality (Meinzen-Dick and Eyzaguirre, 2009; Nathaniels and Mwijage, 2006). Such interventions are likely to work best when the characteristics of the different families, communities and groups (gender, ethnic, religious, and wealth) who are most likely to conserve diversity are known (Smale *et al*., 2004).

C. Adaptability and Change

The characteristics of the seed systems and the ways in which they change over time are likely to have a substantial impact on the genetic diversity present in individual crops and varieties. The seed systems of specific crops are subject to substantial variation in the availability of different materials as a result of variation in production, market fluctuations, government policies, climate variability, and in the framework of catastrophes such as droughts and hurricanes (Latourniere-Moreno *et al*., 2006). The ability to access seeds promotes resilience in the farmers' production systems. Access to seeds can buffer against uncertainty and periods of rapid change across temporal and spatial scales. Lack of funds to purchase seeds, particularly during times of environmental uncertainty, reduces where coping strategies are needed, such as high seeding rates to counter uncertainty (Mcguire, 2007; Tuxil *et al*., 2009; Latourniere-Moreno *et al*., 2006; Bisht *et al*., 2007). Analysis is needed to ensure that the planting materials have enough diversity to adapt to farmer selection and management. Modeling social-ecological systems are needed to explore attributes that affect resilience, particularly in systems with high predictability (Walker *et al*., 2010).

The extent of migration can change substantially from year to year with significant migration occurring in years where production is poor, or as a result of major seed losses through disasters such as floods and hurricanes (Hodgkin *et al*., 2007). In the Western Terai of Nepal, farmers maintain a portfolio of local rice varieties (usually of short duration such as Sauthariya) to replant the crop when total crop failed because of stochastic events or poor rain after planting (Bhandari, 2009). Every year small nurseries are maintained for such cultivars in case the crop fails by community seed banks where farmers "borrow" seeds at planting time and return them after harvest (Table 1).

D. Seed Regulations and Access to Diversity

Farmers' ability to maintain and acquire seed from the informal sources described above may be affected by the establishment of formal seed systems, e.g., seed distribution and release systems are regulated and monitored by the state (Figure 1; 3*d*). The original elements that defined the formal seed systems were put in place as a result of the development of specialized plant breeding products in Europe in the mid-nineteenth century, in order to create transparency in a seed market where variety names were rapidly proliferating. (Bishaw and Van Gastel, 2009; Louwaars and Burgoud, *in press*). Current variety registration for commercial purposes requires that the new variety be distinct from all varieties of common knowledge, uniform in its essential characteristics and highly stable after repeated multiplication (DUS = Distinctness, Uniformity and Stability, Bishaw and Van Gastel, 2009). These criteria guarantee that when a farmer buys seeds of a registered variety, these will be indeed of that variety and it will perform as such over time. In addition, testing for cultivation and use values (VCU) was introduced as a requirement for commercial release, in order for farmers to have an independent assessment of the yield, quality and value of the grain. As developing countries have established seed production systems greatly inspired by the ones in Europe, they have adopted seed certification and variety registration schemes that are similar to the European model (Louwaars and Burgoud, *in press*; Grain, 2005).

Some civil society organizations, organic food producers and environmentalists have denounced the rigidity of the uniformity criteria, and the costs involved in variety registration and seed certification, which make the formal system unfriendly for farmers' varieties such as landraces and new varieties developed through participatory plant breeding, leaving these varieties outside the legal market of seeds (Farm Seed Opportunities, 2009). In addition to limiting the opportunities for farmers to obtain revenues from the varieties they produce, this situation results in less genetic diversity available in the market and may ultimately threaten diversity on farm (Leskien and Flitner, 1997; Louwaars, 2000; Kastler, 2005; Farm Seed Opportunities, 2009).

A number of studies have shown that the formal seed sector does not have the capacity to supply the variability needed in low input farming systems, nor to meet the need for locally adapted varieties (De Boef *et al*., 2010; Kesavan and Swaminathan, 2008; Lipper, 2010). Common figures suggest that the formal system provides for around 15% of the total seeds used by farmers in developing countries (Cooper, 1993; FAO, 1998; 2010; Hodgkin *et al*., 2007), although the situation varies by crop and region. In Europe, there is still an important demand for traditional varieties among small farmers and amateurs for direct cultivation and for participatory breeding programs sponsored by organic agriculture associations (Toledo, 2002; Negri, 2003; Chable, 2005; Negri *et al*., 2009). According to European Union regulations, farmers are allowed to reproduce non-certified seeds for themselves, but they are not able to sell it. Depending on how strict governments are, exchange of non-registered seeds may be considered illegal as well (Louwaars and Burgaud, in press). The situation in developing countries is quite different: Seed regulations are rarely enforced at the local level, and both traditional and modern varieties are exchanged freely among farmers and sold in local markets (Louwaars, 2002). However, the existence of a formal seed system can affect the dynamics of the informal systems and have an impact on the diversity available to farmers. Firstly, the use of certified seeds of modern varieties is either recommended by extension services, linked to credit facilities and subsidies, or is obliged by the processing industry (Jaffe and Van Wijk, 1995; Tripp, 1998, Pascual and Perrings, 2007; Mosely, 2010). Subsidies can lock farmers into a pest-control technology linked to the distribution of modern crop varieties (Wilson and Disdell, 2001). Secondly, the illegality of selling noncertified seeds discourages the development of alternative models of seed supply (Birol, 2007; Lipper, 2010).

Different models have been proposed and tested to create a space for different ways of seed production and supply, within the formal seed system. Keeping the formal system's original objectives of providing transparency and ensuring seed quality, these models try to address the information gaps commonly found in informal seed systems by regulating the commercialization of traditional and modern varieties in a way that better adapts to farmer and small breeder needs. The European Union has recently approved a special treatment for the so called conservation varieties by which landraces adapted to local and regional conditions and threatened by genetic erosion can be registered for commercialization under certain conditions.[1] The special treatment consists, of 1) a certain degree of flexibility in the level of uniformity that is required, and 2) an exemption from official examination if the applicant can provide sufficient information about the variety through other means such us unofficial tests and knowledge gained from practical experiences. In Nepal, the uniformity requirements of the Nepalese Seed Act were applied in a relaxed manner in order to accommodate farmers' application for the registration of certain varieties developed by participatory plant breeding together with traders and hoteliers in 2006 (Gyawali *et al*., 2009; Halewood *et al*., 2007). In Argentina, seeds of ancient varieties of forages can be commercialized as "Clase Identificada Común" (Common Identified Variety), without indicating the name of the variety on the seed package. An alfalfa landrace known as alfalfa pampeano can therefore be sold under the general name of alfalfa seed. Since the name of the variety is not required in this case, the landraces can be legally sold without having to meet the DUS criteria required for variety registration (Gutierrez and Penna, 2004). This alternative, however, may lead to information gaps once the landraces' seeds are commercialized beyond a limited and reliable circuit.

Some countries recognize partial or full auto-certification systems for traditional varieties (Table 1). The Quality Declared Seed System proposed by the Food and Agriculture Organization of the United Nations (FAO, 1993) has been widely used in areas where seed markets are not functional and government resources are too limited to effectively manage comprehensive certification systems. Under this system, seed producers are responsible for quality control, while government agents check only a very limited portion of seed lots and seed multiplication fields. The system has been recently revised with the aim of recognizing the role of national policies and providing a clearer explanation on how quality declared seeds can accommodate local varieties (FAO, 2006b).

IV. IMPROVING USE THROUGH BETTER INFORMATION, MATERIALS AND MANAGEMENT

The use of the traditional crop diversity by farmers or communities might often be increased (i) if there were more information on the characteristics (eco-physiological, adaptive, quality traits) or uses of these materials, (ii) if the materials themselves were enhanced, or (iii) if the agronomic management of the materials were improved. Farmers may perceive that traditional varieties are not competitive with other options because of a lack of characterization and evaluation information on the varieties, or because of a lack of information on appropriate management methods (Figure 1: 3*a*). This lack of information may occur either because the information does not exist, e.g., the varieties have never been characterized or evaluated on farm (Figure 1: 3*a*.2) or because the information is not available to the user community (Figure 1: 3*a*.1).

Even when traditional varieties meet some of the farmers' needs, there may be a number of constraints which limit their use and prevent them reaching their full potential. Thus, environmental or market conditions may have changed, or varieties may have become susceptible to new pests and diseases (Figure 1: 3*b*). If the varieties available to the community lack the diversity needed to adapt to these changes, new materials may be needed with the required traits, or different management methods that improve the performance of the varieties may be required (Figure 1: 3*c*).

A. Producing and Providing Characterization and Evaluation Information for Traditional Varieties

Farmers who have to access seed from other sources have to depend on information offered by the seed provider or on common shared knowledge on traits, consumption characteristics, environmental adaptation and seed quality etc. to manage their crops. Often their information about crop varieties

[1]Directive 2008/62/EC of 20 June 2008 provides for certain derogations for the acceptance of agricultural landraces and varieties which are naturally adapted to the local and regional conditions and threatened by genetic erosion and for marketing of seed and seed potatoes of those landraces and varieties.

is extremely limited (Tripp, 2001) and seeds obtained from farmers, market vendors, or seed companies are frequently reported to be accompanied by a lack of adequate information (Badstue, 2007). Farmers may also lack access to information on management methods, particularly, for example, for nursery practices for fruit trees (Oyedele *et al*., 2009; Shalpykov, 2008).

There is a widening recognition by the agricultural research and development community of the value of farmer knowledge, and an increasing use of new information and communication technologies to disseminate this information (Ballantyne, 2009; Kesavan and Swaminathan, 2008; Liang and Brookfield, 2009). Despite the reports that farmers often lack information (as noted above), there are also reports that farmers exchange information on individual varieties, local uses of plant parts, cropping systems, and eating qualities, along with seeds (Rijal, 2007). Farmers also share ecological information together with seeds through local networks. The technical messages derived from failures are shared among local farmers faster than those associated with success (Rijal, 2007; Rana, 2004; Shah *et al*., 2009). In some cases, information may be shared through cultural media, such as folksongs that characterize different traditional varieties and promote genetic enhancement in Ethiopia (Mekbib, 2009) (Table 1).

Lack of both formal and informal inter-agency and interministerial (e.g., ministries and departments of the environment and of agricultural) information sharing is a barrier to successful policy formulation to support innovative land management technologies and strategies that support local crop genetic diversity in the production system (Grarforth *et al*., 2005). Robertson and Swinton (2005) and Pretty and Smith (2004) discuss the increasing importance of new communication methods among agricultural professionals and farmers. Modern information and communication technologies in village-based knowledge centers have been used to provide timely and local-specific information that meets farmers' demands (Kesavan and Swaminathan, 2008). Nursery growers in Central Asia and India can now access information related to scion and rootstock compatibility, and contact custodians of diversity of both mother plants (scion block) and rootstocks (Kerimova, 2008; Djavakyants, 2010; Singh, *pers. Comm*., 2010) (Table 1). Radio and television are also effective and easily accessible sources of agricultural information (Shah *et al*., 2009; Baral *et al*., 2006; Ballantyne, 2009; Balma *et al*., 2005) (Table 1). In the developed world, networks of weather stations in farming regions are becoming the norm. Farmers tap into these for real-time weather data. A relatively inexpensive weather station can be purchased for a farmer community and added to a free weather network such as Wunderground Weather (http://www.wunderground.com/weatherstation/index.asp#hardware) (Table 1).

In addition to information, access to traditional varieties may often be limited within the community, even when a sufficient quantity of seed is available (Badstue, 2006), simply because of poor access to information, weak social networks, social exclusion, and weak institutional mechanisms for collective actions (Sthapit and Joshi, 1996; Shrestha *et al*., 2006) (Figure 1: 3*a*.1). In some instances, many farmers may not be aware that useful resources are available, particularly when a variety is only grown by a few farmers within a community (Sthapit and Rao, 2009). For example, Sthapit *et al*. (2006d) reported that while aromatic sponge gourd was grown by only a few farmers in a mid-hills community in Nepal, the number increased significantly after a diversity fair was organized and locally multiplied seeds were distributed.

Most of the work on the evaluation and characterization of traditional varieties is undertaken in the context of the description of materials from genebank collections (Dudnik, *et al*., 2001; Fowler and Hodgkin, 2004). It has been suggested that this may have limited value with respect to evaluation data, as many traditional varieties are specifically adapted to their abiotic and biotic environment (Budenhagen, 1983; Harlan, 1977; Teshome *et al*., 2001). Recently, there has been an increased interest in testing varieties collected directly from farmers and in comparing their performance with modern varieties (as checks or controls) under low input conditions, in order to have data that compares traditional varieties with other options available to farmers (Bouhassan *et al*., 2003; Tushmereirwe, 1996; FAO, 2010). These studies have included multi-locational trials on farm and on research stations for adaptive traits such as drought tolerance (Sadiki, 2006; Jackson *et al*., 2008); Magorokosho *et al*., 2006; Weltzien *et al*., 2006), salt stress (Rhouma *et al*., 2006; Hue *et al*., 2006), nitrogen fixation (Sadiki, 2006), cold tolerance (Thinlay, 1998; Thinlay *et al*., 2000) and disease resistance (Trutmann et. al., 1997; Gauti *et al*., 2005; Finckh and Wolf, 2007). In one study, the relative performance of rice varieties was tested by reciprocal planting in different moisture regimes using upland, rain-fed and irrigated rice ecosystems. Interestingly, the results showed that some rice varieties had higher yields outside their home environments (Rijal, 2007).

While traditional knowledge (and variety names) may provide some information about the nutritional value of different varieties, specific macro- or micro-nutrient data is often not available (Worede, 1997). Laboratory evaluations comparing nutritional levels among traditional and modern varieties for Bangladesh rice showed that some of the traditional varieties had higher iron and zinc contents than modern ones (Kennedy and Burlingame, 2003). Similar work has been done to compare protein levels across traditional and modern bean varieties (Cazarez-Sanchez, 2004; Cazarez- Sanchez and Duch, 2004) and levels of hotness in chili varieties in the Yucatan, Mexico, (Cazarez-Sanchez *et al*., 2005). Hotness was related also to the different dishes prepared with chili. Surprising little characterization of traditional varieties for systems that adopt certified organic agricultural practices has been done until very recently in Europe (Dawson *et al*., 2008; Bengtsson, 2005).

It is important that characterization and evaluation studies are done under farm conditions, in sites that are accessible to farmers and include appropriate modern varieties as controls or checks. Farmers often do not have sufficient capital or time to experiment with allocating their varieties to different production spaces in replicated trials. Growing varieties from different areas together in replicates on farmers' fields offers farmers the chance to observe comparative reactions of traditional and modern varieties. Interventions, such as the establishment of diversity blocks by community seed banks, and the organization of farm walks, cross-site visits for farmers, or other community events, can act as platforms for social learning. An important aspect is to provide the platform at the community level that allows farmers and researchers to interact and learn.

B. Improving Traditional Varieties

Improving the performance of traditional varieties in participatory crop improvement programs has been undertaken in many programs over the last decade, particularly in low input systems (Table 1). Some of these programs have involved the identification of agronomic traits with molecular characterization so as to exploit the local diversity and produce varieties that are superior in marginal environments, but have a broad genetic base (Chiffoleau and. Desclaux, 2006; Ceccarelli and Gando, 2007; Dawson *et al*., 2008; Gyawali, *et al*., 2007; Joshi *et al*, 2001; Sthapit *et al*., 1996; Witcombe *et al*., 2005; Ceccarelli *et al*., 2009; Danial *et al*., 2007; Almekinders *et al*., 2006; Ortiz *et al*., 2009; Valdivia Bernal *et al*., 2007; Marquez *et al*., 2009). Participatory or decentralized crop improvement begins with an understanding of the farmers' preferred criteria, and often includes describing the management methods that farmers use for selecting the next generation (Smith *et al*, 2001, Mekbib, 2008; Nkongolo *et al*., 2008; Jarvis and Campilan, 2007) (Table 1). Traditional varieties may be improved both by preserving traits which are preferred by farmers and by adding additional traits (e.g., pest resistance) to a preferred traditional variety; the process can be implemented at a large number of locations (Lacy *et al*., 2006). The process helps to link farmer and breeder choices, and analyze tradeoffs that might differ among farmers' and breeders' choices (Gauchan *et al*., 2006). Setting collaborative breeding goals with farmers in Nepal for improving the traditional rice variety *mansara,* adapted to poor soils, resulted in the development of the improved variety, *mansara-4.* This variety is now spreading to areas where no other rice variety could be grown (Sthapit *et al*., 2006a; Gyawali *et al*., 2007).

In several countries resistance breeding procedures are integrating farmer selection and using local material and participatory breeding to improve other production and quality traits of locally-resistant varieties, as well as improving the resistance of locally adapted non-resistant varieties (Mgonja *et al*., 2005; FAO, 2010). Varieties that are made available from participatory programs are most likely to spread through existing seed systems. It is therefore important that methods used to improve crop material and seed quality take account of and are linked to seed supply systems (Bishaw and Turner, 2008; Gyawali *et al*., 2007).

A major concern for farmers is seed quality including purity, high germination rates, and reduced disease problems (Weltzien and vom Brocke, 2000; vom Brocke *et al*., 2003; Asfaw *et al*., 2007). Studies on traditional variety seed germination rates (Celis-Velazquez *et al*., 2008) and resistant to post-harvest pests (Teshome *et al*., 1999) have compared relative levels for traditional and modern varieties and found traditional varieties to perform well in many cases. Village seed systems certainly maintain the identity of varieties and, in central Mozambique, have been shown to maintain the purity of varieties and supply quality seed (Rohrback and Kiala, 2007). On-farm seed quality for traditional sorghum varieties was found to be comparatively good by comparison to modern varieties and met national and regional West Asian and North African standards (Mekbib, 2009). Truthful labeling and declaring the source of seed is being used to ensure quality at the community level (Devkota *et al*., 2008). Actions such as seed sorting machines, training in seed quality improvement, seed health, and processing can improve seed quality. Seed cleaning technology for seed-borne diseases, normally recommended for certified varieties, has been used on traditional varieties to increase faba bean yield for traditional varieties by almost 50% (Sadiki *et al*., 2002). Recommendations have been made to expand agricultural extension packages to include traditional varieties with improved management methods (Jarvis and Hodgkin, 2008).

C. Improving the Management of Traditional Varieties

Management practices may also serve to improve the productivity and stability of traditional varieties within the farmers' production system (Figure 1: 3*c*). Planting mixtures of traditional varieties, or of crop populations with high genetic variability, has the potential to reduce pests and diseases on farm (Li *et al*., 2009). Managing sets of varieties or crop populations with different levels of avoidance or tolerance to abiotic stress can decrease the probability of yield loss due to unpredictable rainfall and temperature regimes (Figure 1: 3*c*.2).

The potential negative consequences of planting large areas to single, uniform crop cultivars were recognized as early as the 1930s by agricultural scientists (Marshall, 1977). The Irish potato famine has been cited as one of the most dramatic examples of genetic uniformity leading to devastating loss of crop (Schumann, 1991). Breeding programs continue to develop new varieties and to replace varieties that have lost their resistance to diseases, but the maintenance cost, particularly in developing countries, is high (Strange and Scott, 2005). Resistant varieties may only remain so for a few cropping seasons as new pathotypes emerge (de Vallavieille-Pope, 2004). When resistance in a monoculture breaks down, the whole area of the crop sown to susceptible varieties may succumb while, in a genetically diverse field or variety, it is much less likely that all the different types of resistance present will break down (Mundt, 1991).

Farmers often have local preferences for growing mixtures of cultivars that provide resistance to local pest and diseases and enhance yield stability (Trutmann *et al*., 1993; Karamura and Karamura, 1995; Trutmann *et al*., 1993; Jarvis *et al*., 2007). High levels of diversity of traditional rice varieties in Bhutan has been shown to have high functional diversity against rice blast (Thinlay *et al*., 2000; Finckh, 2003) while high wheat diversity in Italy has been shown to provide yield stability in conditions of low pesticide application (Di Falco and Chavas, 2007). The development of varietal mixtures, or sets of varieties with non-uniform resistance and with lower new pathogens migration or mutation probability of existing pathogens, is in progress in many parts of the world (Finckh *et al*., 2000; Finckh and Wolfe, 2007; Jarvis *et al*., 2007). Such mixtures are based on the analysis of the resistance background, agronomic character, economic value, local cultivation conditions, and farmer preferences.

There is substantial genetic variation for response to water deficit within and among traditional varieties, and a growing literature on the use of a diversity of traditional varieties to minimize risks dues to climatic variability (Sawadogo *et al*., 2006; Sadiki, 2006; Weltzien *et al*., 2006). Drought is a complex stress, influenced by both heat and drought, and plant response also varies according to timing in relation to the plant growth stage and stress intensity (Witcombe *et al*., 2008). Drought tolerance and drought avoidance seem to involve different mechanisms (Yue *et al*., 2006). While no unified abiotic stress resistance mechanism exists (Blum, 2004), there are certainly genes which are involved in responding to a number of different stresses. Planting a range of varieties or multilines with different drought avoidance and resistance properties could be an attractive option for low input systems. Sorghum growers in West Africa use a diversity of traditional varieties with different flowering dates to minimize risks due to climatic variability (Weltzien *et al*., 2006). Lipper *et al*. (2009), have shown that for sorghum farmers in Ethiopia the adoption of a sorghum improved variety, developed to allow drought evasion, was not an effective means of coping with drought and that landraces were more likely to provide the desired drought tolerance characteristics desired by farmers. They also noted that improving education levels among farmers might allow them access to more varieties adapted to low production conditions.

Brown and Rieseberg (2006) compared methods for managing diversity for abiotic and biotic stress that would enable farmers to cope with the stress factors in their production systems. They noted that the scale of variation of abiotic stress both in time and space was greater for abiotic than for biotic stress, that the degree of abiotic stress is less affected by the plant condition than biotic stress, and that divergence is more important that local polymorphism for abiotic versus biotic stress (Brown and Rieseberg, 2006).

Both farmer selection and natural selection can have substantial effects on the seed produced for future crops. Different farmers may have diverging perspectives and management practices in managing their seed stocks and introducing new material. This can result in differences in the time when seed can be provided and in the population structure of the next generation of seeds (Louette *et al*., 1997). Different farmer selection practices (or different participatory selection procedures will affect the genetic make-up and evolutionary dynamics of crop populations (Ceccarelli *et al*., 2009; Scarcelli *et al*., 2007; Barnaud *et al*., 2008; Sagnard *et al*., 2008; Gautam *et al*., 2009). In the case of vegetatively propagated crops, this reflects farmers' variety-specific handling of seed tubers (Zannou, 2009; Scarcelli *et al*., 2006) and genetic effects are likely to result from mutation, epigenetic influences or mixing by farmers.

Marketing at a desirable price can be a problem when farmers do not have storage facilities but must sell their crop to avoid seed or tuber rot (Figure 1: 3*c*.1). Improved storage allows farmers to sell their seeds or grain at periods when the market price is higher (Agbaje *et al*., 2005). Seed storage devices and methods determine the vulnerability of seeds to pests, diseases and physiological deterioration (Gepts, 1990; Latourniere-Moreno *et al*., 2006; Table 1). Post-harvest losses are a serious cause of production losses in developing countries (Grum *et al*., 2003). Improving the air-tightness of storage containers (Wambugu *et al*., 2009; Thamaga-Chitja *et al*., 2004), heat treatment (Beckett *et al*., 2007), manual seed cleaning, and application of non-toxic materials, are some easily applicable methods that combine traditional and modern seed storage technology to reduce the post-harvest vulnerability of seeds (Table 1). Complementary technical solutions will be necessary to integrate the future use of agricultural strategies that include the use of diverse traditional varieties. These may also include adjustments of planting and harvesting to facilitate separation of the harvest products where the handling of mixtures is not possible or not desirable (Finckh, 2008).

D. Improving Policies to Support Farmers Using Traditional Varieties

In general, there are few incentive structures that promote: the conservation and sustainable use of agricultural biodiversity and farmers' customary practices–the heart of Farmers' Rights (2010); Figure 1: 3*d*). Current legal systems make it difficult to adequately recognize the contributions of farmers and farming communities in conserving, developing and using agricultural biodiversity. National and local governments have not yet adequately given a real content to the overused, but so far rather diffuse concept of Farmers' Rights by translating it into practical measures that effectively support farmers who conserve and generate crop diversity (Andersen, 2005; 2007).

Intellectual property rights have been a recurrent element in the discussions around the concept of farmers' rights. The limitations to use, save, duplicate and exchange plant varieties protected by intellectual property rights, the lack of recognition or compensation for farmers when new products based on their traditional varieties and ancestral knowledge are subject to property rights, the incapacity of the current intellectual property system to adequately protect farmers' varieties and knowledge as well as innovations generated at the community level, are some of the issues that are commonly raised when dealing with the protection of farmers' rights (The Crucible Group, 1994; Leskien and Flitner, 1997; Correa, in press).

Some national laws have attempted to conciliate the different stakeholders' interests with regard to intellectual property protection by combining UPOV-style protection of new plant varieties and a *sui generis* protection of farmers' varieties. Examples of this are the Thailand Plant Varieties Protection Act 1999, the Indian Protection of Plant Varieties and Farmers' Rights Act 2001, and the Malaysian Protection of New Plant Varieties Act 2004. However, the success of such laws in achieving crop diversity conservation and farmers' rights protection is questionable. There is also a great deal of opposition to the belief that conferring private rights to farmer varieties would be beneficial to farmers and farmer communities (Srinivasan, 2003; Eyzaguirre and Dennis, 2007). Jaffe and Van Wijk (1995, p.76) argue that the introduction of plant variety protection causes a change of principle: "When farmers start to use protected varieties, their natural right of seed saving becomes a legal right, or even less, a "privilege." Such a legal right is subjected to political decision–making and possibly prone to restrictions in the future."

Registers of traditional varieties have been promoted by a few national and local governments to help advance the realization of farmers' rights in different ways (Table 1). The registries document and perpetuate traditional knowledge related to the use of crop diversity and have been used to create a sense of ownership over traditional varieties and empower local communities with regards to local activities oriented to the conservation and sustainable use of traditional varieties (Lopez Noriega, in press;Aboagye, 2007). In addition, they have worked as defensive publications and prevent the misappropriation of farmers' genetic resources by acting as a record of the farmer varieties found within the community together with descriptive agronomic, adaptive, quality and other use traits. Examples of local registers can be found in several communities in Nepal (Subedi *et al*., 2005; Sthapit and Quek, 2005). The government of Peru maintains a national register of traditional varieties of potato, and several regional governments in Italy support regional databases of ancient varieties (Lopez Noriega, in press; Ruiz, 2009). In some cases, the registers or databases constitute the basis for the government to provide direct support to the farmers who cultivate traditional varieties. In Hungary, a list of locally-grown traditional varieties targeted for protection is published as an annex to a law, with mechanisms developed for adding new varieties to the list. Farmers who grow crops from the list can receive subsidies, on the condition that they provide a prescribed quantity of seeds to others interested in the growing of the same crop (Mar, 2002, Bela *et al*., 2006.).

Another important aspect of Farmers' Rights, as pointed out by the International Treaty on Plant Genetic Resources for Food and Agriculture,[2] e.g., the farmers' involvement in decision-making processes dealing with plant genetic resources. In reality, due to the complex nature of the trade-offs that genetic resource policies have to address, their development and implementation require the involvement of as many stakeholders as possible (Wale *et al*., 2008). For this reason, innovative governance methods that facilitate communication and understanding among all the actors involved and between science and policy need to be tested and eventually adopted. To a great extent, the local farmers' ability to express themselves in participatory decision-making is linked to the existence of strong and efficient civil society organizations such as farmers' associations representing their interests (Lapena, 2008).

V. BENEFITING FROM THE USE OF LOCAL CROP GENETIC DIVERSITY

Benefits from the use of local crop genetic diversity may come from its current use value, derived from the consumption of a good or service by an individual or a community. Benefits may come from its options value, or the value associated with retaining an option to a good or service in the future. Finally, a resource may be valued for its existence, unrelated to any use of the resource and/or its bequest value, the altruistic value that the individual or community is concerned that the resource should be available to others in the current or future generation (Smale, 2006; Bateman *et al*., 2002). Enhancing the benefits for farmers of local crop diversity means enhancing the net benefits, as there also could be costs to farmers associated with any benefit generating option (Sthapit *et al*., 2008b). This involves ensuring that appropriate incentives for creating and sharing benefits with farmers are developed and that unnecessary or unintended barriers to the flow of benefits to the farmer are not created through the introduction of taxes and subsidies (Bragdon *et al*., 2009).

There are many ways which farmers can derive greater benefits from the traditional crop varieties they manage. The success of these involves *inter alia* supporting local institutions, enhancing collective action and property rights, and enabling farmers to participate and lead the decision making process to the appropriate action and its implementation.

A. Market-Based Actions and Incentives

Markets involve the exchange of goods and services between participants, and as such constitute one of the principal social arenas structuring farmers' management decisions about diversity (Smale, 2006). The market value of agricultural production can be increased through development of new markets, improved marketing, value addition, high value product differentiation; improved processing equipment adapted to diversified

[2]The International Treaty on Plant Genetic Resources for Food and Agriculture was adopted by the FAO General Assembly in 2001 and entered into force in 2004. Today, 112 countries and the European Union are parties to the Treaty. Its objectives are the conservation and sustainable use of plant genetic resources for food and agriculture, and the equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity. Parties to the Treaty recognize their responsibility for realizing Farmers' Rights under Article 9 of the Treaty.

raw materials, and building trust among market chain actors (Kontoleon *et al*., 2007; Lipper *et al*., 2010; Di Falco and Perrings, 2006; Giuliani, 2007; UNORCAC, 2008; Figure 1: 4a; Table 1).

Agricultural communities interact with markets directly and indirectly on a variety of scales, from household to global. The steady integration of traditional farming regions into wider national and international market relationships is a dominant trend of the last half-century. Pascual and Perrings (2007) reviewed the influence, at the micro-scale (household, family farm) and meso- and macro- scale (national and international policies), of economic and institutional failures that have systematically distorted farm-level decisions to conserve agricultural biodiversity. These include agricultural production subsidies,[3] tax breaks, and price controls (Tilman *et al*., 2002; Kontoleon *et al*., 2007; Kitti *et al*., 2009).

Several market practices have been tested and put in place to create incentives for agricultural biodiversity conservation. "Fair trade" for "free trade" are market schemes that support and advocate replacing millions of dollars in aid by paying a decent price for the products purchased from poorer countries and giving producers in those countries an opportunity to take care of their own production environment (Kitti *et al*. 2009; Kesavan and Swaminathan, 2008; Renard, 2003). Price premiums that represent true costs of production have been studied to understand how they can provide an incentive to conserve agricultural biodiversity and, at the same time, to create benefits for poor farmers (Kitti *et al*., 2009; Perfecto *et al*., 2005; Smith *et al*., 2008). Product labeling can provide consumers with important information not only on food quality, but about the conditions under which the commodity was produced (Swallo and Sedjo, 2000; Giuliani, 2007). This labeling practice includes various geographical identification procedures (Ramakrishnappa, 2006; Garcia *et al*., 2007; Nagarajan, 2007; Salazar *et al*., 2007; Ori-Gin, 2010).

Among other factors, creation of appropriate market conditions depends on the provision of accurate and credible information (Pascual and Perrings, 2007, Lipper *et al*., 2010; FAO, 2007; Okwu and Umoru, 2009; Bela *et al*., 2006). Many developing country farmers are aware of market prices before participating in the market, obtaining information most often from neighbors, followed by village traders, the mass media, and Extension agents (Nagaranjan *et al*., 2009). The increased use of mobile and fixed phones has improved the flow of price information among markets for small scale farmers (Nagaranjan *et al*., 2009). Groups working with rural poor communities in India are supporting local market intelligence systems for small-scale farmers in order to improve the availability of data on demand and supply, production capacity and market prices (Kesavan and Swaminathan, 2008). In some cases, creating stable markets for diverse varieties sold as raw agricultural products may not be a valid option although it may be possible to enhance the benefits to farmers of local varieties by processing them for specific markets (Kruijssen *et al*., 2009). This would involve having processing equipment that can be used with diverse raw materials (Finckh, 2008).

Choice models were originally developed by economists during the 1970s to explain patterns of adoption of "green revolution" crop varieties by farmers in Asia and other regions (Smale, 2006). Subsequent researchers applied and refined revealed preference models to identify why many smallholder farm households continue to grow traditional crop varieties even in the presence of agricultural development and widely available improved varieties (Brush *et al*., 1992; Meng *et al*. 1998; Smale *et al*., 2001; Van Dusen 2006; Gauchan *et al*., 2006). Recent studies have shown that although greater on-farm diversity can increase the likelihood that a household will sell traditional varieties, high levels of diversity on farm may not be reflected in local markets (Edmeades and Smale, 2009). Diversity on-farm was reported to be a necessary condition for market involvement, both in terms of the decision to participate and the richness of traditional varieties sold. But this does not guarantee that on-farm diversity will lead to market sales or diversity at the point of sale (Edmeades and Smale, 2009).

Changes in markets linked to infrastructure and rural development may trigger the erosion of traditional crop varieties, both directly and indirectly. For instance, a new paved road that reaches a previously isolated farm community can help farmers to replace local varieties with improved seeds available in more distant markets. The same road can also enable farm households to substitute newly available goods or services for those previously supplied by diverse varieties (Smale and King, 2005). However, improved access to a greater number of markets can also provide potential incentives for farmers to retain crop diversity, such as when demand for unusual heirloom or niche market varieties exists among urban residents or other consumers (Lee, 2005; Irungu *et al*., 2007; Giuliani, 2007; Van Dusen, 2006; Gauchan and Smale, 2003; Rana, 2004; Gruere *et al*., 2007; Ramirez *et al*., 2009; UNORCAC, 2008).

Assisting smallholder groups to produce together and expand niche markets, will include such activities as educating consumers about the values of diverse varieties, providing better packaging (Gruere *et al*., 2007; Devaux *et al*., 2006) and offering credit provisions to support transportation costs (Lee, 2005; Almekinders *et al*., 2010). In the best of cases, niche markets might be useful for traditional varieties that are also "best fit" to particular ecosystems, such as particular traditional varieties shown to grow well on swampy soil or on poor upland soils (Gauchan and Smale, 2003; Rana, 2004; Gruere *et al*., 2007). Marketing social-cultural aspects of traditional varieties for particular culinary aspects and associated ethnic identity have also been used to create niche markets (Gruere *et al*., 2007; Ramirez *et al*., 2009; Williams, 2009; Sthapit *et al*., 2008a).

[3]OEDC developed countries spend approximately US$225 billion annually on agricultural subsidies for their own producers, between one-fourth and one-third the global value of agricultural production in 2000.

Econometric methods have been used to test the effects of crop genetic diversity on expected crop yields and yield variability as well as the probability of crop failure, given levels of pesticide applied (Di Falco and Chavas, 2007). The work has shown that when pesticide use is low crop genetic diversity reduces yield variance, but when pesticide use is high the effect of the crop biodiversity on yield variance is not significant. Indicating that crop genetic diversity is acting as a substitute for pesticides.

Value chain analysis has been used by economists to identify bottlenecks to obtaining increased value from traditional varieties and to map out the relations among actors and flows of crop genetic resources (Andersen *et al*., 2010; Giuliani, 2007; Kruijssen *et al*., 2009). The analysis has shown that stakeholder meetings provide a forum for collecting crucial information about the market chain as the meetings involve as many actors as possible: producers and traders, cultivation experts, NGOS, and representatives of relevant ministries (Giuliani, 2007). These meetings help to design joint ventures with private sector entities. They also create reputation and trust in the areas of quality and prices among farmers, food manufacturers, retailers, NGOs, community-based and government organizations, important in reducing transaction costs (Lipper *et al*., 2010; Almekinders *et al*., 2010; Smith *et al*., 2008) (Table 1). Retailers and other intermediaries are important sources of seed inputs and credit for farmers (Almekinders *et al*., 2010; Giuliani, 2007; Lipper, 2010). They facilitate the flow through the chain by storing, transporting, and reselling seeds and can respond to seed demands from different regions at different planting times.

The role of local markets in seed provision, particularly of traditional varieties has been the subject of a number of important recent studies. Local markets can be more effective in promoting seed movement than specialized traders who may overlook locally sourced seed (Dalton *et al*., 2010). In the case of traditional crop varieties, seed and grain markets are usually the same and the availability and identification of materials that will be used as seed, with information on the desired production and consumption traits may be difficult (Lipper *et al*., 2010). Some studies have suggested that local seed supply channels cannot be enhanced unless they are separated from grain supply channels (Nagarajan and Smale, 2007; Smale *et al*., 2010; Almekinders *et al*., 2010). Enhancing local seed supply channels may involve, for example, developing mechanisms for production and trade of truthfully labeled or quality-declared seed by farmer organizations with building collective action groups that screen and value seed. Certifying the sellers rather than seed may also be an option. Current examples are Producer Marketing Groups (PMGs) in Kenya (Audi *et al*., 2010) and Quality Declared Seeds in Tanzania where small scale farmers are registered to produce seed for local sale and are provided with vendor certification (FAO, 2006b: Granquist, 2009) (Table 1). Smale *et al*. (2010), nevertheless, caution against the formalization of the informal markets in Mali. They suggest that this development could have negative effects on women who would lose the little control they now exert over the grain resources unless they were trained about seed and linked to seed producer groups. It might be more appropriate to develop regulations that shorten the process of certifying seeds or that focus on seed quality rather than seed purity (Lipper *et al*., 2010).

B. Non-Market-Based Actions and Incentives

The full value of agricultural biodiversity and its services is not captured by the market because of a failure to internalize external costs (Thies, 2000). Crop biodiversity has socio-cultural, insurance and option values, that will be underestimated if left to the market (Pascual and Perrings, 2007; Smale, 2006). These different values of traditional varieties may to some extent be realized through non-market incentives (Figure 1: 4*b*;Table 1). They can be realized, for instance, by improving public awareness about sociocultural values of traditional varieties (Birol *et al*., 2007), by providing information on the substitution value of traditional variety diversity for fertilizer and pesticides (Di Falco and Perrings, 2007), moral suasion, regulation and planning, by preventing specific land management practices such as low input zones (Pascual and Perrings, 2007), by designing agroecological parks or agrotourism zones (Ruiz, 2009; Ramirez *et al*., 2009; Ceroni, *et al*., 2007). Other possibilities include compensating farmers for their conservation functions through payment for environmental services (FAO, 2007; Brussaard *et al*., 2010) or by supplying insurance functions and option values (Bragdon *et al*., 2009). Insofar as they exist, the enforcement of Farmers' Rights, and the adaptation and enforcement of intellectual property law could also play a role.

Methods to assess the non-market value of public goods can be divided into two categories (Birol *et al*., 2007): 1) choice experiment studies (or direct methods) that use stated preference (willingness to pay/accept) to investigate the public's valuation of agri-environmental schemes and crop genetic reources (Campell *et al*., 2006; Birol and Ryan-Villalba, 2009); and, 2) hedonic analysis (or indirect methods) that use revealed preference (market information) to estimate the value of attributes of crop genetic resources (Van Dusen and Taylor, 2005; Edmeades, 2006; Edmeades and Smale, 2009). Birol *et al*. (2007) reviewed the different models and experimental data for obtaining not-market values of biodiversity resources. They combined choice experimental data with farm household data and concluded that welfare measures derived form non-market public goods could be more accurate when the methods are combined. Welfare measures (willingness to accept compensation) can be calculated for different agrobiodiversity attributes within the farmers' production system and for the services provided by traditional varietal diversity. These methods have helped to identify least cost agri-environmental schemes that can encourage farmers to undertake home gardens and on-farm management practices to support the conservation and use of traditional varieties (Birol *et al*., 2006; 2007; 2009; Poudel and Johnsen, 2009).

Diversity, in the form of traditional varieties, has also been valued as a deliberate strategy for managing abiotic and biotic pressures in labor-intensive production systems with low levels of chemical inputs (Edmeades *et al*., 2006; Waage *et al*., 2008). Low chemical input or organic farming with local varieties can promote agro-ecosystem stability and health (Østergård *et al*., 2009). Other studies have been used to account for substitution value that traditional varietal diversity may give for pesticide inputs using a damage-abatement framework. These models value the effect of crop varietal diversity not only for the yield effect but also for the damage abatement effect of crop genetic choices as a substitute for pesticide application (Oude and Carpentier, 2001). In this context, it is also worth noting that pesticide manufacturers probably do not pay the full cost of the adverse affects that pesticides have on the environment of human health (Pretty, 2008; Pingali and Roger, 1995).

There are several examples across the world of countries and institutions implementing mechanisms to capture the non-market value of local agricultural biodiversity (Table 1). Environmentally Sensitive Areas (ESAs) in Hungary are a window for promoting organic farming, which could include the use of traditional crop varieties (Bela *et al*., 2006). In Poland semi-subsistence farms are often regarded as a major obstacle to development. However, Siudek (2008) notes that expanding farm businesses to include agrotourism in rural areas of Poland would have the potential to reverse negative economic trends. Agricultural biodiversity for recreation (Ceroni *et al*., 2007; UNORCAC, 2008) includes agrotoursim zones established in Peru (Ruiz, 2009) and agrobiodiversity botanical gardens in Ecuador (Williams and Ramirez, 2006). These emphasize both traditional crop diversity and cultural identity and are a means to share benefits with local farming communities.

Bela *et al*. (2006) have suggested that there is a need to improve communication among stakeholders to understand trade-offs between public attributes and profitability. Advertising campaigns could be used, for example, to change norms on nutrition and taste and or try to reduce the use of chemical inputs. Education on the value of increasing use of traditional varieties can be part of these campaigns. Modification of existing primary and secondary school curricula to include agricultural biodiversity as an adaptive resource in biology courses is another method of introducing new ideas into the education system (Ramirez *et al*., 2009; UNORCAC, 2008) (Table 1).

Case studies compiled in the context of the Convention on Biological Diversity indicate that empowerment and benefit-sharing with farmers and farming communities will only take place if additional measures accompany activities related to access and benefit-sharing (Regine, 2005; Convention on Biological Diversity, 2010). National laws on access to genetic resources, intellectual property and bio-safety need to form part of the legal landscape that supports the use of traditional varieties. This includes advocating that local and national governments integrate biodiversity, including agricultural biodiversity, into their legislation on environmental impact assessment of projects, policies, plans and programs as a method for informing decision-making with regard to agrobiodiversity maintenance and use (Slootweg *et al*., 2006; Wale, in press).

Participatory plant breeding has been shown to help enable farmers to influence the development of materials and technologies in ways that are informed by their specific needs, agro-ecological environments and cultural preferences (Halewood *et al*, 2007; Gyawali *et al*., 2007; in press). The Thai Plant Variety Protection Act is one example of a law that includes a benefit-sharing scheme by which those who are granted plant breeders' rights must pay part of the monetary benefits gained through the commercialization of the variety to a common fund which will support Thai small farmers who conserve and use crop diversity. The practical implementation of the law has been very challenging and the plant variety fund is still empty (Gagne and Ratanasatien, in press). Benefit-sharing policies must combine different approaches; the reality shows that conservation of crop diversity on farm cannot rely only on levies on plant breeders' royalties (Srinivasan, 2003).

It has been argued that true benefit-sharing involves developing mechanisms that support communities and their farming systems and thus agricultural techniques that conserve local agricultural biodiversity. Farmers' Rights implies the development of some means of ensuring benefits flow to farmers and farming communities either through an ownership approach or a stewardship approach[4] (Farmers' Rights, 2010). In this context, creating incentives and removing disincentives to enable farmers to continue their work as stewards and innovators of agricultural biodiversity need to be part of any benefit-sharing mechanism (Bragdon *et al*., 2009). Currently, disincentives to the maintenance of traditional varieties may be associated with various aspects or consequences of agricultural development strategies such as 1) alterations in land tenure systems that threaten the survival of traditional farming communities; 2) subsidy schemes that promote exclusive adoption of uniform agricultural productions; 3) research programs that neglect traditional varieties and their associated knowledge and uses; and 4) food standards that limit entry of traditional farmers' varieties and products into markets.

C. Strengthening Local Institutions and Farmer Leadership

All approaches or activities to enhance benefits to farmers rely on building up social capital, or the ability of men and women farmers to develop and use social networks (Figure 1: 4*c*). Social networks help farmers to obtain access to credit as well as information and knowledge about new options and practices. Furthermore, these networks expand choices available to each household member (Pretty, 2002; Bantilan and Padmaja 2008). Building social capital includes developing appropriate

[4]The ownership approach refers to the right of farmers to be rewarded for genetic material obtained from their fields and used in commercial varieties and/or protected through intellectual property rights. The stewardship approach refers to the rights that farmers must be granted in order to enable them to continue as stewards and as innovators of agro-biodiversity. Benefit-sharing is most promising when the point of departure is the farming communities that actually contribute to the maintenance of plant genetic diversity benefits (Regine, 2005).

collective management practices, which are understood as the voluntary action that is taken by a group to achieve common interests and property regimes (Meinzen-Dick and Eyzaguirre, 2009; Eyzaguirre and Evans, 2007). Through collective action members of the group may act directly on their own or through an organization, such as deciding on and observing rules for use or non-use of a resource through coordinated activities across individual farms. Property rights involve the "the capacity to call upon the collective to stand behind one's claim to a benefit stream" (Bromley, 1991). Interventions to strengthen the property rights of individuals or groups to help them participate in collective activities can improve their bargaining positions (Eyzaguirre and Evans, 2007). This may involve the development of institutional mechanisms that local participants can use to organize themselves, such as through special districts, private associations, and local/regional governments (Meinzen-Dick and Eyzaguirre, 2009) and better link them to policy institutions (Pretty, 2008).

Combinations of farmer innovation and empowerment, the transformation of local government staff, and the establishment of new farmer–governed local institutions that have equitable links to the private sector have resulted in successful collective action for equitable management and use of traditional crop varieties (Friss-Hansen, 2008; Pretty 2008; Swaminathan, 2003; UNORCAC, 2008) (Table 1). Pimbert *et al*. (2010) discusses citizen juries formed by farm leaders, progressive researchers, and NGO technicians to evaluate, deliberate, and publicly address the equity and sustainability of conventional research systems and initiatives in West Africa. Collective action is important in enabling farmers to address market imperfections and transaction costs, such as in surmounting information, credit and marketing constraints. Such institutions support farmer unions and cooperatives for educating farmers in production and marketing, assisting with price negotiations, collecting land taxes, and information sharing (Caviglia and Kahn, 2001).

Diversity field fora (Smale *et al*., 2008), which bear some similarity to farmer field schools (see Van der Berg and Jiggins, 2007), are becoming a new institution in West Africa which can strengthen the capacity of farmers to analyze, manage and improve their own crop plant genetic resources (Bioversity International, 2008). In diversity field flora, farmers acquire both knowledge and leadership skills through experiments that are designed and conducted by the farmers with technical support from project staff, to better manage and benefit from their crop genetic resources (Bioversity International, 2009; Smale *et al*., 2008; Jackson *et al*., 2010). The community-based biodiversity management (CBM) approach, developed in Nepal and now being tested in South and Southeast Asia, is a similar multi-step process that focuses specifically on strengthening the local decision-making and governance capacity of communities to utilize agricultural biodiversity (Sthapit *et al*., 2006a; De Boef *et al*., 2007). Collective action is also supported when participatory plant breeding is not limited to the development of varieties for a specific area, but becomes part of integrated community-based biodiversity management activities (Sthapit *et al*., 2008b).

It has been argued that agricultural policies are required that build human capital (Neuchatel Group, 2007; Smale *et al*., 2006). Policies that support inclusive agricultural extension or advisory services need to go hand in hand with the process of strengthening local institutions. Extension services have to be more responsive to the needs of all farmers, including women and those who are poor and marginalized (Neuchatel Group, 2007; Smale *et al*., 2006). This is likely to involve paying increased attention to contextual factors in the design and implementation of agricultural extension service programs. In addition to the characteristics of the local communities, the types of farming systems and the degree of market access are examples of important contextual factors that need be be taken into account (Birner *et al*., 2010). In the same way it has been suggested that agricultural policies need to be more gender sensitive and designed to empower women by providing knowledge and ensuring access and control of resources toward achieving food security (MEA, 2005). Women have multiple responsibilities within the household and communities but are often ignored at all levels of decision-making.

Most studies agree on the need to improve trust and mutual understanding across different actors and institutions (Kruijssen *et al*., 2009). These studies emphasize the need for reciprocity, obligations, and mutually agreed upon rules, which are structured and connected through groups and networks (Cramb and Culasero, 2003; Pretty, 2008). Cultural institutions, such as weddings and tea houses, are places of trust where information on traditional crop diversity is exchanged and which could be linked to wider support networks (Van Dusen *et al*., 2006). There is potential for local institutional support and capacity building to link individuals of different networks together through a neutral party (NGO or other organization) or to both build smaller networks that could be linked to help diffuse innovations and messages (Granovetter, 1973). Resilience is built into agroecological production systems through supporting institutions and social-ecological networks that create flexibility in problem solving and that can balance power among interest groups (Folke *et al*., 2002; Walker *et al*., 2002; 2010). These many different types of networks can be strengthened by linking them to community-based seed production groups and to participatory plant breeding schemes so as to capitalize on natural pathways of seed flow. Networks can help demystify laboratory-based technologies (Kesavan and Swaminathan, 2008), provide technology empowerment, and support literacy training, to enable farmers to have more control over their resources (Swaminiathan, 2003). These can be supported by knowledge empowerment actions that take advantage of the new information and communication technology (Kesavan and Swaminathan, 2008).

VI. CONCLUSIONS

Over the last two decades a substantial body of information has developed on the continuing maintenance and use of traditional varieties by small-scale farmers around the world.

Farmers appear to find that diversity, in the form of traditional varieties of both major staples and minor crops, remains important to their livelihoods, despite earlier expectations that these varieties would rapidly disappear from production systems.

No doubt the arguments about long-term trends with respect to the continued use of traditional varieties will continue. However, there are a number of reasons for thinking that these varieties will continue to play an important role for many crops in a wide variety of production systems in the future. In addition to the reasons such as adaptation to marginal and low input agriculture, stable performance, and the socioeconomic conditions of many small-scale farmers—who, as Lipton (2006) noted, make up 45–60% of the rural poor—already mentioned in the Introduction, farmers around the world are using traditional varieties to help cope with climate change (Platform for Agrobiodiversity Research, 2010). The growing concern with developing more sustainable production systems and reducing dependence on chemical inputs is also likely to favour the maintenance and use of traditional varieties.

In these circumstances it seems important not only to understand better the nature and contribution of traditional varieties to the production strategies of rural communities around the world, but also ways in which they are maintained and managed. This can help in the development of ways of improving the use of these varieties and their contribution to rural livelihoods. As shown in this review, there is a rich and growing body of information on traditional varieties, and on the problems and benefits associated with their maintenance and use. The review has also demonstrated the importance of work that adopts a multidisciplinary approach and emphasizes working with farmers in collaborative ways. There remain clear gaps in our knowledge. There is still a need to develop better indicators and ways of monitoring diversity that are adapted for the use of farmers, communities, and scientists. Molecular methods, which can now provide significant additional insights into the extent and distribution of diversity and on the ways in which it is correlated with important social, environmental, and management variables have yet to be undertaken on the scale needed except perhaps for sorghum and pearl millet in Africa (e.g. Barnard *et al*., 2008; Bezancon *et al*., 2009; Busso *et al*., 2000; Deu *et al*., 2008; Sagnard *et al*., 2008; Allinne *et al*., 2008). With the rapid improvements in methods over the last decades this is now possible on the required scale.

While each situation may appear to be unique with respect to the amount of diversity present in the system, its distribution and the associated biological, environmental, socioeconomic, and cultural characteristics, it is possible to recognize general properties which can be used to ascertain the sorts of activities that farmers, and those working with them, may find useful in identifying ways in which traditional varieties can both be maintained and contribute to improved livelihoods. The heuristic framework presented here provides a number of overlapping approaches and entry points for such activities. At present this probably should be regarded very much as "work in process" as it is likely to be amended as further information becomes available. However, even at this stage, it is possible to draw some general conclusions based on its application. Firstly, it is essential to develop an appropriate understanding of the extent and distribution of diversity in a system and of how it is maintained through local institutions and practices. Secondly, the analysis is likely to lead to the identification of a number of complementary supporting actions. Thirdly, the success of any actions will depend centrally on local knowledge, the strength of local institutions and the leadership of farmers and communities.

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REFERENCES

Abate, T., van Huis, A., and Ampofo, J. K. O. 2000. Pest management strategies in traditional agriculture: An African perspective. *Ann. Rev. Entomol*. **45:** 631–659.

Aboagye, L. M. 2007. Strategies for sustainable conservation and use of legume genetic resources in Ghana. *Ghana J. Sci*. **47:** 59–67.

Adato, M., and Meinzen-Dick, R. (Eds.) 2007. *Agricultural Research, Livelihoods, and Poverty: Studies of Economic and Social Impact in Six Countries.* International Food Policy Research Institute (IFPRI), Washington, DC 2006, USA.

Adhikari, A., Rana, R. B., Gautam, R., Subedi, A., Upadhyay, M. P., Chaudhary, P., Paudel, I., Rijal, D., and Sthapit, B., 2006b. Diversity fair: Promoting exchange of knowledge and germplasms. **In:** *Good Practices: On-farm management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K. and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Adhikari, A., Upadhyay, M. P., Joshi, B. K., Rijal, D., Chaudhary, P., Paudel, I., Baral, K. P., Pageni, P., Subedi, S., and Sthapit, B. 2006a. Multiple approach to community sensitization. **In:** *Good Practices: On-farm management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Agbaje, G. O., Ogunsumi, L., Oluokun, J. A., and Akinlosotu, T. A. 2005. Survey of yam production system and the impact of government policies in southwestern Nigeria. *J. Food Agric. Environ.* **3:** 222–290.

Aguilar-Støen, M., Moe, S. R., and. Camargo-Ricalde, S. L. 2009. Home gardens sustain crop diversity and improve farm resilience in Candelaria Loxicha, Oaxaca, Mexico. *J. Hum. Ecol.* **37**(1): 55–77.

Aharoni, A., and Vorst, O. 2001. DNA microarrays for functional plant genomics. *Plant Mol. Biol.* **48:** 99–118.

Allinne C., Mariac, C., Vigouroux, Y., Bezancon, G., Couturon, E., Moussa, D., Tidjani, M., Pham, J. L., and Robert, T. 2008. Role of seed flow on the pattern and dynamics of pearl millet (*Pennisetum glaucum* [L.] R. Br.) genetic diversity assessed by AFLP markers: a study in south-western Niger. *Genetica* **133:**167–178.

Almekinders, C. J. M., Cavatassi, R., Terceros, F., Romero, R. P., and Salazar, L. 2010. Potato seed supply and diveristy: dynamics of local markets of Cochabamba province, Bolivia – a case study. **In:** *Seed Trade In Rural Markets: Implications for Crop Diversity and Agricultural Development*. pp. 75–94. Lipper, L., Anderson C. L., and Dalton, T. J., Eds., United National Food and Agricultural Organization (FAO), Italy.

Almekinders, C. J. M., Louwaars, N. P., and de Bruijn, G. H. 1994. Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* **78:** 207–216.

Almekinders, C., Molina-Centeno, J., Herrera-Torrez, R., Merlo-Olivera, S. L., González-Suárez, J. M., and García-Carrasco, J. 2006. Learning experiences obtained from the development of bean varieties through participative breeding in Northern Nicaragua. *Agron. Mesoam.* **17**(3): 327–336.

Almekinders, C. J. M., Thiele, G., and Danial, D. L. 2007. Can cultivars from participatory plant breeding improve seed provision to small-scale farmers? *Euphytica* **153:** 363–372.

Amend, T., Brown, J., Kothari, A., Phillips, A., and Stolton, S. 2008. Protected landscapes and agrobiodiversity values. **In:** *Protected Landscapes and Seascapes* Volume 1. Amend, T., Brown, J., Kothari, A., Phillips, A. and Stolton, S., Eds., IUCN & GTZ, Kasparek Verlag, Heidelberg.

Andersen, R. 2005. *Results of an International Survey on Farmers' Rights*. The Fridtjof Nansen Institute, Norway.

Andersen, R. 2007. *Protecting Farmers' Rights in The Global IPR Regime. Challenges and options for developing countries.* SAWTEE Policy Brief No. 15.

Andersen, E., Kantor, P., and Sim, A. 2008. *Microcredit, Informal Credit and Rural Livelihoods: A Village Case Study in Bamyan Province*. Afghanistan Research and Evaluation Unit. Afghanistan. http://www.ecoi.net/file_upload/1227_1214850224_microcredit-bamyan-cs.pdf Accessed 28 May 2010.

Anderson, C. L., Lipper, L., Dalton, T. J., Smale, M., Hellin, J., Hodgkin, T., Almekinders, C., Audi, P., Bellon, M. R., Cavatassi, R., Diakite, L., Jones, R., Oliver King, E. D. I., Keleman, A., Meijer, M., Osborn, T., Nagarajan, L., Paz, A., Rodriguez, M., Sibide, A., Salazar, L., van Heerwaarden, J., and Winters, P. 2010. Project methodology: using markets to promote the sustainable utilization of crop genetic resources. **In:** *Seed Trade in Rural Markets*. pp. 31–48, Lipper, L., Anderson, C. L., and Dalton, T. J., Eds., Earthscan, London, U.K.

Arias, L. 2004. *Diversidad Genetica y Conservación in Situ de los Maices Locales de Yucatan, México* [Genetic Diversity and In Situ Conservation of Local Maize in Yucatán, Mexico]. PhD thesis, Instituto Tecnologico de Merida, Yucatán, México (in Spanish), Merida, Mexico.

Arias, L., Chávez, J., Cob, B., Burgos, L., and Canul, J. 2000. Agromorphological characters and farmer perceptions: Data collection and analysis. Mexico. **In:** *Conserving Agricultural Biodiversity in Situ: A Scientific Basis for Sustainable Agriculture.* pp. 95–100. Jarvis, D. Sthapit, B.. and Sears, L. Eds., International Plant Genetic Resources Institute, Rome.

Arndorfer, M., Kajtna, B., Vorderwülbecke, B., and Dixon, G. R. 2009. Integrating ex situ and on-farm conservation approaches in the management of local vegetable diversity in Austria. *Acta Hortic.* **817:** 333–340.

Asfaw, A., Almekinders, C., Getahun D., and Fistum, A. 2007. Bean seed flow and exchange networks in Southern Ethiopia. *Seed Info* **33:** 14–17.

Audi, P., Nagrajan, L., Jones, R.. and Ibrahim, M. S. 2010. Pigeonpea seed supply and diveristy: a case study of local seed markets in Makueni District, Eastern Kenya. **In:** *Seed Trade in Rural Markets: Implications for Crop Diversity and Agricultural Development.* pp 95–123. Lipper, L., Anderson, C. L.. and Dalton, T.J., Eds., United National Food and Agricultural Organization (FAO), Italy.

Aw-Hassan, A., Mazid, A., and Salahieh, H. 2008. The role of informal farmer-to-farmer seed distribution in diffusion of new barley varieties in Syria. *Exp. Agric.* **44**(3): 413–431.

Badstue, L. B., Bellon, M., Berthaud, J., Juarez, X., Manuel-Rosas, I., Solano, A. M., and Ramirez, A. 2006. Examining the role of collective action in an informal seed system: A case of study from the Central Valleys of Oaxaca, Mexico. *Hum. Ecol.* **34:** 249–273.

Badstue, L. B., Bellon, M., Berthaud, J., Ramirez, A., Flores, D., and Juarez, X. 2007. The dynamics of seed flow among maize growing small-scale farmers in the Central Valleys of Oaxaca, Mexico. *World Dev.* **35**(9): 1579–1593.

Badstue, L. B., Bellon, M., Juárez, X., Manuel, I., and Solano, A. M. 2002. Social relations and seed transactions among small-scale maize farmers in the Central Valleys of Oaxaca, Mexico: preliminary findings. **In:** *CIMMYT Economics Working Paper* 02–02. CYMMIT, Texcoco, Mexico.

Bajracharya, J., Rana, R. B., Gauchan, D., Sthapit, B.R., Jarvis D.I., and Witcombe, J. R. 2010. Rice landrace diversity in Nepal. Socio-economic and ecological factors determining rice landrace diversity in three agro-ecozones of Nepal based on farm surveys. *Genet. Resour. Crop Ev.* DOI 10.1007/s10722-010-9544-x (*published on line 19 March 2009*).

Bajracharya, J., Steele, K. A., Jarvis, D. I., Sthapit, B. R., and Witcombe, J. R. 2006. Rice landrace diversity in Nepal: variability of agromorphological traits and SSR markers in landraces from a high-altitude site. *Field Crop Res.* **95:** 327–335.

Bajracharya, J., Steele K. A., Witcombe, J., and Jarvis, D. 2001. A study of genetic relationships in rice (*Oryza sativa* L.) landraces of Jumla using microsatellite DNA markers. **In:** *Abstracts of National Workshop 2001 of the Project "Strengthening the Scientific Basis of in Situ Conservation of Agricultural Biodiversity On-Farm."* pp. 7–8. Sthapit B. R., Subedi, A., Upadhyay, M. P.. and Baniya, B. K., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Ballantyne, P. 2009. Accessing, sharing and communicating agricultural information for development: emerging trends and issues. *Inform. Dev.* **25**(4): 260–271.

Balma, D. B., Dossou, M., Sawadogo, R. G., Zangre, J., Ouédraogo, T., and Jarvis, D. I. (Eds.) 2004. *La Gestion de la Diversité des Plantes Agricoles Dans les Agro-Ecosystemes.* Compte-rendu des travaux d'un atelier abrité par CNRST, Burkina Faso et International Plant Genetic Resources Institute. Ouagadougou, Burkina Faso, 27-28 Décembre 2002. International Plant Genetic Resources Institute, Rome, Italy (in Franch).

Bantilan, M. C. S., and Padmaja, R. 2008. Empowerment through social capital build-up: gender dimensions in technology uptake. *Exp. Agric.* **44:** 61–80.

Baniya, B. K., Tiwari, P. R., Pandey, D., and Bajracharya, J. 2003. Field study of two barley landraces of Jumla. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal. Proceedings of a National Workshop, 24-26 April 2001.* pp. 127–135. Sthapit, B. R., Upadhyay, M. P., Baniya, B. K., Subedi, A.. and Joshi, B. K., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute, Lumle, Nepal.

Baral, K. P., Sapkota, T., Bhandari, B., Adhikari, A., Dewan, S., Pageni, S., Subedi, A., and Upadhyay, M. P. 2006. Rural radio programme: an effective tool for reaching unreachable on biodiversity conservation issues. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* number 17. Sthapit, B. R., Shrestha, P. K. and Upadhyay, M. P. Eds., NARC, LI-BIRD, International Plant Genetic Research Institute and IDRC, Kathmandu, Nepal.

Barnaud, A., Trigueros, G., McKey, D., and Joly, H. I. 2008. High outcrossing rates in fields with mixed sorghum landraces: how are landraces maintained? *Heredity* **101**(5): 445–452.

Barr, A. R. 2009. Marker-assisted selection in theory and practice. pp. 479–518. **In:** *Plant Breeding and Farmer Participation*. Ceccarelli, S., Guimarães, E. P.. and Weltzien, E. Eds., ICRISAT, ICARDA and United National Food and Agricultural Organization (FAO), Rome Italy.

Barry, M. B., Pham, J. L., Noyer, J. L., Courtois, B., Billot, C., and Ahmadi, N. 2007. Implications for *in situ* genetic resource conservation from the ecogeographical distribution of rice genetic diversity in Maritime Guinea. *Plant Genet. Resour.* **5:** 45–54.

Bartlett, A. 2008. No more adoption rates! Looking for empowerment in agricultural development programmes. *Dev. Pract.* **18:** 4–5.

Bateman, I. J., Carson, R. T., Day, B., Hamnemann, W. M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D. W., Sugden, R., and Swanson, J. 2002. *Economic valuation with state preference techniques: A manual.* Edward Elgar, Cheltenham.

Baymetov, K. I., Rajametov, S. N., and Nazarov, P. T. 2009. Raznoobrazie i sokhranenie mestnikh sortov abrikosa v fermerskikh khozyaistvakh. (Diversity and conservation of local varieties of apricot on farms). *Materials of the Republican Scientific-Practical, Conference on "Conservation and Sustainable Use of Biodiversity of Agricultural Crops and Their Wild Relatives".* Tashkent, Uzbekistan, pp. 15–18 (in Russian).

Beckett, S. J., Fields, P. G., and Subramanyam, B. H. 2007. Disinfestation of stored products and associated structures using heat. **In:** *Heat Treatment for Post Harvest Pest Control.* pp. 182. Tang, J., Mitcham, E., Wang, S., and Lurie, S., Eds., CABI Publishing, Wallingford, UK.

Bela, G., Balazs, B., and Pataki, G. 2006. Institutions, stakeholders and the management of crop biodiversity on Hungarian family farms. **In:** *Valuing Crop Biodiversity, on Farm Genetic Resources and Economic Change.* pp. 251–269. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Bélanger, J., and Johns, T. 2008. Biological diversity, dietary diversity, and eye health in developing country populations: Establishing the evidence-base. *EcoHealth* **5**(3): 244–256.

Belay, G., Tefera, H., Getachew, A., Kebebew, A., and Gizow, M. 2009. Highly client-oriented breeding with farmer participation in the Ethiopian cereal tef (*Eragrostis tef* (Zucc.) Trotter). *Afr. J. Agric. Res.* **3**(1): 22–28.

Belay, G., Tefera, H., Tadesse, B., Metaferia, G., Jarra, D., and Tadesse, T. 2006. Participatory variety selection in the Ethiopian cereal Tef (*Eragrostis tef.* L.). *Expl. Agric.* **42:** 91–101.

Belem, M. O. 2000. Burkina Faso, gender: methods used to create a framework for implementation and management of in situ conservation on-farm. **In:** *Conserving Agricultural Biodiversity in Situ: A Scientific Basis for Sustainable Agriculture*. pp. 72–73. Jarvis, D., Sthapit, B., and Sears, L., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Bellon, M. R. 2004. Conceptualizing interventions to support on-farm genetic resource conservation. *World Dev.* **32:** 159–172.

Bellon, M.R., and Brush, S.B. 1994. Keepers of the maize in Chiapas, Mexico. *Econ. Bot.* **48:** 196–209.

Bellon, M. R., Pham, J. L., and Jackson, M.T. 1997. Genetic conservation: A role for rice farmers. **In:** *Plant Conservation: The in Situ Approach*. Hawkes, J. G., Eds., Chapman & Hall, London, U.K.

Bellon, M. R. ,and Risopoulos, J. 2001. Small-scale farmers expand the benefits of improved maize germplasm: A case study from Chiapas, Mexico. *World Dev.* **29**(5): 799–811.

Bellon, M.R., and Taylor, J.E. 1993. "Folk" soil taxonomy and the partial adoption of new seed varieties. *Econ. Dev. Cult. Change* **41**(4): 763–786.

Belqadi, L. 2003. *Diversité et ressources génétiques de Vicia faba L. au Maroc: variabilité, conservation ex situ et in situ et valorisation*. Doctorat de thèse ès-sciences agronomiques, Institut Agronomique et Vétérinaire Hassan II, Rabat, Morocco (in French).

Bengtsson, J., Ahnström, J., and Weibull, A. C. 2005. The effects of organic agriculture on biodiversity and abundance: A meta-analysis. *J. App. Ecol.* **42:** 261–269.

Benin, S., Smale, M., and Pender, F. 2006. Explaining the diversity of cereal crops and varieties grown on household farms in the Highlands of Northern Ethiopia. **In:** *Valuing Crop Biodiversity*. pp. 78–96. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Bentley, J. W., Tripp, R., and Delgado de la Flor, R. 2001. Liberalization of Peru's formal seed sector. *Agric. Hum. Values* **18:** 319–331.

Benton, T. G., Vickery, J. A., and Wilson, J. D. 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol. Evol.* **18**(4): 182–188.

Berg, T. 2009. Landraces and folk varieties: a conceptual reappraisal of terminology. *Euphytica* **166:** 423–430.

Bertuso, A., Ginogaling, G., and Salazar, R. 2000. Community gene banks: the experience of conserve in the Philippines. **In:** *Encouraging Diversity- The conservation and Development Of Plant Genetic Resources.* pp. 117–122. Almekinders, C., and de Boef, W., Eds., Intermediate Technology Publications, London, UK.

Bertuso, A. R., van Treuren, R., van Eeuwijk, F. A., and Visser, L. 2005. Characterization of red rice (*Oryza sativa*) varieties developed under on-farm dynamic management on Bohol, Philippines. *Plant Genet. Resour. Newsl.* **142:** 68–72.

Bezabih, M. 2008. Agrobiodiversity conservation under an imperfect seed system: the role of community seed banking schemes. *Agric. Econ.* **38:** 77–87.

Bezançon, G., Pham, J. L., Deu, M., Vigouroux, Y., Sagnard, F., Mariac, C., Kapran, I., Mamadou, A., Gérard, B., Ndjeunga, J., and Chantereau, J. 2009. Changes in the diversity and geographic distribution of cultivated millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor* (L.) Moench) varieties in Niger between 1976 and 2003. *Genet. Resour. Crop Ev.* **56:** 223–236.

Bhandari, B. 2009. *Summer Rainfall Variability and the Use of Rice (Oryza Sativa L.) Varietal Diversity for Adaptation: Farmers' Perceptions and Responses in Nepal.* Master Thesis. CBM Swedish Biodiversity Centre, Uppasala, Sweden.

Bioversity International. 2008. *Manuel de Formation des Fornateurs Sur les Champs de Diversite.* pp. 244. Bioversity International, Rome, Italy (in French).

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D. J., Horna, D., Benin, S., and Cohen, M. 2009. From best practice to best fit: a framework for designing and analyzing pluralistic agricultural advisory services worldwide. *J. Agric. Educ. Exten.* **15:** 341–355.

Birol, E., Kontoleon, A., and Smale, M. 2007. Assessing the private value of agro-biodiversity in Hungarian home gardes using the data enrichment methods. **In:** *Biodiversity Economics.* pp. 594–622. Kontoleon, A., Pascual, U., and Swanson, T. M., Eds., Cambridge University Press, UK.

Birol, E., and Rayan-Villalba, E. 2009. Estimating the value of milpa diversity and genetically modified maize to farmers in Mexico: a choice experiment approach. **In:** *Agrobiodiversity Conservation and Economic Development.* pp. 247–277. Kontoleon, A., Pascual, U. and Smale, M., Eds., Routledge, UK.

Birol, E., Smale, M., and Gyovai, Á. 2006. Using a choice experiment to estimate farmers' valuation of agrobiodiversity on Hungarian small farms. *Environ. Resour. Econ.* **34:** 439–469.

Bishaw, Z., and Turner, M. 2008. Linking participatory plant breeding to the seed supply system. *Euphytica* **163:** 31–44.

Bishaw, Z., and van Gastel, A. J. G. 2009. Variety release and policy options. **In:** *Plant Breeding and Farmer Participation.* pp. 565–587, Ceccarelli, S., Guimareaes, E. P. and Weltzien, E., Eds., United National Food and Agricultural Organization (FAO), Rome, Italy.

Bisht, I. S., Mehta, P. S., and Bhandari, D. C. 2007. Traditional crop diversity and its conservation on-farm for sustainable agricultural production in Kumaon Himalaya of Uttaranchal state: A case study. *Genet. Resour. Crop Ev.* **54:** 345–357.

Blum, A. 2004. The physiological foundation of crop breeding for stress environments. **In:** *Proc. World Rice Research Conf., Tsukuba, Japan, November 2004*. pp. 456–458. International Rice Research Institute, Manila, Philippines.

Boster, J.S. 1985. Selection for perceptual distinctiveness: evidence from Aguaruna cultivars of *Manihot esculenta*. *Econ. Bot.* **39**(3): 310–325.

Bouzeggaren, A., Birouk, A., Kerfal, S., Hmama, H., and Jarvis, D. I. 2002. Conservation in situ de la biodiversité des populations noyaux de luzerne locale au Maroc. **In:** *La conservation in Situ de la Biodiversité Agricole: Un Défi Pour une Agriculture Durable*. Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoune, A. and Jarvis, D., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Bouhassan, A., Sadiki, M., and Tivoli, B. 2003a. Evaluation of a collection of faba bean (*Vicia faba* L.) genotypes originating from the Maghreb for resistance to chocolate spot (*Botrytis fabae*) by assessment in the field and laboratory. *Euphytica* **135:** 55–62.

Bragdon, S., Jarvis, D. I., Gaucham, D., Mar, I., Hue, N. N., Balma, D., Collado, L., Latournerie, L., Sthapit, B., Sadiki, M., and N'dungu-Skilton, J. 2009. The agrobiodiversity policy development process: exploring means of policy development to support the on-farm management of crop genetic diversity. *Int. J. Biodivers. Sci. Manage.* **5:**10–20.

Brocke vom, K. A., Christinck, E., Weltzien, R., Presterl, T., and Geiger, H. H. 2003. Farmers' seed systems and management practices determine pearl millet genetic diversity patterns in semiarid regions of India. *Crop Sci*. **43:** 1680–1689.

Bromley, D. J. 1991 *Environment and Economy: Property Rights and Public Policy*. Basil Blackwell, NY, USA.

Brown, A. H. D. 1990. *Plant Population Genetics, Breeding, and Genetic Resources.* Sinauer Associates Inc., Basingstoke, Hampshire, U.K.

Brown, A.H.D. 2000. The genetic structure of crop landraces and the challenge to conserve them in situ on farms. **In:** *Genes in the Field.* pp. 29–48. Brush, S.B., Eds., IDRC/ International Plant Genetic Resources Institute, Rome, Italy.

Brown, A.H.D., and Brubaker, C. 2000. Genetics and the conservation of Australian wild relatives of crops. *Aust. J. Bot.* **48:** 297–303.

Brown, A. H. D., and Brubaker, C. 2002. Indicators for sustainable management of plant genetic resources: how well are we doing? **In:** *Managing Plant Genetic Diversity.* pp. 249–262. Engles, J. M. M., Rao, V. R., Brown, A. H. D., and Jackson, M. T., Eds., International Plant Genetic Resources Institute, Rome, Italy and CABI Publishing, Wallingford, UK.

Brown, A. H. D., and Hodgkin, T. 2007. Measuring, managing, and maintaining crop genetic diversity on farm. **In:** *Managing Biodiversity in Agricultural Ecosystems.* Jarvis, D. I., Padoch, C., and Cooper, H.D., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Brown, A. H. D., and Rieseberg, L. 2006. Genetic features of populations from stress-prone environments. **In:** *Enhancing the Use Of Crop Genetic Diversity to Manage Abiotic Stress in Agricultural Production Systems.* pp. 2–10. Jarvis, D., Mar, I., and Sears, L., Eds, International Plant Genetic Resources Institute, Rome, Italy.

Brown, G. G., Swift, M. J., Bennack, D. E., Bunning, S., Montáñez, A., and Brussaard, L. 2007. Management of soil biodiversity in agricultural ecosystems. **In:** *Managing Biodiversity in Agricultural Ecosystems*. pp. 224–268. Jarvis, D. I., Padoch, C., and Cooper, H. D., Eds., Bioversity International, Rome, Italy.

Brush, S. B. 2004. *Farmers' Bounty: Locating Crop Diversity in the Contemporary World.* Yale University Press, New Haven, NY, USA.

Brush, S., Kesselli, R., Ortega, R., Cisneros, P., Zimmerer, K., and Quiros, C. 1995. Potato diversity in the Andean center of crop domestication. *Conserv. Biol.* **9**(5): 1189–1198.

Brush, S., and Meng, E. 1998. Farmers' valuation and conservation of crop genetic resources. *Genet. Resour. Crop Ev.* **45:** 139–150.

Brush, S. B., Taylor, J. E., and Bellon, M. R. 1992. Biological diversity and technology adoption in Andean potato agriculture. *J. Dev. Econ.* **39:** 365–387.

Brussaard, L., Caron, P., Campbell, B., Lipper, L., Mainka, S., Rabbinge, R., Babin, D., and Pulleman, M. 2010. Reconciling biodiversity conservation and food security: scientific challenges for a new agriculture. *Curr. Opin. Environ. Sustain*. In press doi:10.1016/j.cosust.2010.03.007.

BUCAP 2002. *Field Guide: Farmers' Field School for Rice Plant Genetic Resources Conservation, Development and Use.* SEARICE, Manila, Philippines.

Budenhagen, I. W. 1983. Breeding strategies for stress and disease resistance in developing countries. *Ann. Rev. Phytopathology* **21:** 385–409.

Burgos-May, L. A., Chavez-Servia, J. L., and Ortiz-Cereceres, J. 2004. Variabilidad morfologica de maices criollos de la peninsula de Yucatan, Mexico. **In:** *Manejo de la Diversidad de los Cultivos en los Agroecosistemas Tradicionales*. pp. 58–66. Chavez-Servia, J. L., Tuxill, J. and Jarvis, D. I., Eds., Instituto Internacional de Recursos Fitogeneticos, Cali, Colombia (in Spanish).

Busso, C. S., Devos, K. M., Ross, G., Mortimore, M., Adams, W. M., Ambrose, M. J., Alldrick, S., and Gale, M. D. 2000. Genetic diversity within and among landraces of pearl millet (*Pennisetum glaucum*) under farmer management in West Africa. *Genet. Resour. Crop Ev.* **60:** 1–8.

Butkov, E.A., and Turdieva, M.K. 2009. Sovremennoe rasprostranenie gretskogo orekha v Uzbekistane i raznoobrazie mestnikh sortov. (Current status of walnut distribution in Uzbekistan and diversity of local varieties). **In:** *Materials of the Republican Scientific-Practical Conference on "Conservation and Sustainable Use of Biodiversity of Agricultural Crops and their Wild Relatives."* pp. 28–31. Tashkent, Uzbekistan (In Russian).

Camacho-Villa, C., and Chavez-Servia, J. L. 2004. Diversidad morfologica del maiz criollo de la region centro de Yucatan, Mexico. **In:** *Manejo de la Diversidad de los Cultivos en los Agroecosistemas Tradicionales.* pp. 47–57. Chavez-Servia, J. L., Tuxill, J., and Jarvis, D. I., Eds., Instituto Internacional de Recursos Fitogeneticos, Cali, Colombia (in Spanish).

Campbell, B., Hagmann, J., Sayer, J., Stroud, A., Thomas, R., and Wollenberg, E. 2006. What kind of research and development is needed for natural resource management? *Water Int.* **31:** 343–360.

Canh, N. T., On, T. V., Trung, N. V., Tiep, C. A. ,and Lam H. V. 2003. Preliminary study of genetic diversity in rice landraces in Ban Khoang Commune, Sa Pa District. **In:** *On-Farm Management of Agricultural Biodiversity in Vietnam. Proceedings of a symposium, December 6–12, 2001, Hanoi, Vietnam.* Tuan, H. D., Hue, N. N., Sthapit, B. R. and Jarvis, D. I., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Cazarez-Sanchez, E. 2004. *Diversidad Genetica y su Relacion con la Tecnologia de Alimentos Tradicionales*. MS thesis, Colegio de Postgraduados, Montecillos, Texcoco, Mexico (in Spanish).

Cazarez-Sanchez, E., and Duch-Gary, J. 2004. La diversidad genetica de variedades locales de maiz, frijo, calabaza y chile, y su relacion con caracteriticas culinarias. **In:** *Manejo de la Diversidad de los Cultivos en los Agroecosistemas Tradicionales.* pp. 250–255. Chavez-Servia, J. L., Tuxill, J., and Jarvis, D. I., Eds., Instituto Internacional de Recursos Fitogeneticos, Cali, Colombia (in Spanish).

Cázares-Sánchez, E., Ramírez-Vallejo, P., Castillo-González1, F., Soto-Hernández, R. M., Rodríguez-González, M. T., and Chávez-Servia, J. L. 2005. Capsaicinoids and preference of use in different morphotypes of chili peppers (*Capsicum annuum* L.) of East-central Yucatan. *Agrociencia* **39:** 627–638.

Carpenter, S. R., Bennett, E. M., and Peterson, G. D. 2006. Scenarios for ecosystem services: an overview. *Ecol. Soc.* **11**(1): 29. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art29/

Caviglia, J. L., and Kahn, J. R. 2001. Diffusion of sustainable agriculture in the Brazilian tropical rain forest: a discrete choice analysis. *Econ. Dev. Cult. Change* **49:** 311–333.

Ceccarelli, S., and Gando, S. 2007. Decentralized-participatory plant breeding: an example of demand driven research. *Euphytica* **155:** 349–360.

Ceccarelli, S., Guimaraes, E. P., and Weltzien, E. 2009. *Plant Breeding and Farmer Participation*. United National Food and Agricultural Organization (FAO), Rome, Italy.

Celis-Velázquez, R., Peña-Valdivia, C. B., Trejo-López, C., Aguirre-Rivera, J. R., Cordova-Téllez, L., and Carballo-Carballo, A. 2008. Consumption of common bean seed reserves for emergence and development of seedlings under different sowing depths. *Agron. Mesoam.* **19**(2): 167–177.

Ceroni, M., Liu, S., and Constanza, R. 2007. Ecological and economic roles of biodiversity in agroecosystems. **In:** *Managing Biodiversity in Agricultural Ecosystems.* pp. 446–472. Jarvis, D. I., Padoch, C., and Cooper H. D., Eds., Columbia University Press, NY, USA.

Chable, V., 2005. Conserving and developing crop biodiversity. **In:** *Biodiversity and Local Ecological Knowledge in France*. pp. 46–49, Bérard, L., Cegarra, M., Djama M., Louafi S., Marchenay P., Roussel B., Verdeaux F., Eds. Publisher Cemagref, Cirad, Ifremer, INR; IDDRI, IFB, Montpellier, France.

Chakauya, E., Tongoona, P., Matibiri, E. A., and Grum, M. 2006. Genetic diversity assessment of sorghum landraces in Zimbabwe using microsatellites and indigenous local names. *Int. J. Bot.* **2**(1): 29–35.

Chaudhary, P., Gauchan, D., Rana, R. B., Sthapit, B. R., and Jarvis, D. I. 2004. Potential loss of rice landraces from a Terai community in Nepal: A case study from Kachorwa, Bara. *Plant Genet. Resour. Newsl.* **137:**14–21.

Chavez-Servia, J. L., Burgos-May, L., Canul-Ku, J., Camacho, T. C., Vidal-Cob, J., and Arias-Reyes, L. M. 2000. Analisis de la diversidad en un proyecto de conservacion in situ en Mexico [Diversity analysis of an in situ conservation project in Mexico]. **In:** *Proceedings of the XII Scientific Seminar, November 14–17, 2000*. Havana, Cuba (in Spanish).

Chiffoleau, Y., and Desclaux, D. 2006. Participatory plant breeding: the best way to breed for sustainable agriculture? *Int. J. Agric. Sustain.* **4**(2): 119–130.

CIP-UPWARDS. 2003. *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol I: Understanding Agricultural Biodiversity.* International Potato Centre (CIP) and User's Perspectives with Agricultural Research and Development (UPWARD), Los Banos, Philippines.

Clegg, M. T. 1997. Plant genetic diversity and the struggle to measure selection. *Heredity* **88:** 1–7.

Collado-Panduro, L., Chavez-Servia, J. L., Riesco, A., and Soto, R. 2005. Community systems of seed supply and storage in the central Amazon of Peru. **In:** *Seed Systems and Crop Genetic Diversity On-Farm. Proceedings of a Workshop, September 16–20, 2003*. pp. 103–108. Jarvis, D. I., Sevilla-Panizo, R., Chavez-Servia J. L., and Hodgkin, T., Eds., Pucallpa, Peru. International Plant Genetic Resources Institute, Rome, Italy.

Convention on Biological Diversity, 2010. Access to Genetic Resources and Benefit-sharing Database on Capacity Building Projects. http://www.cbd.int/abs/projects.shtml

Coomes, O. T. 2001. Crop diversity in indigenous farming systems of Amazonia: the role and dynamics of agricultural planting stock transfers among traditional 112 seed systems and crop genetic diversity farmers. **In:** *Abstracts. International Symposium on Managing Biodiversity in Agricultural Ecosystems,* 27, November 8–10, 2001, Montreal, Canada.

Cooper, D. 1993. *Plant Genetic Diversity and Small Farmers: Issues and Options for IFAD.* Staff Working Paper 13. International Fund for Agricultural Development (IFAD), Rome, Italy.

Correa, C., 2000. *Options for the Implementation of Farmers' Rights at the National Level.* South Centre: Working Paper 8, December 2000.

Correa, C. In press. Sui generis intellectual property protection for farmers' varieties. **In:** *Farmers' Varieties and Farmers' Rights: Addressing Challenges in Taxonomy and Law*. Halewood, M., Ed. Earthscan. London, UK.

Cramb, R. A. and Culasero, Z. 2003. Landcare and livelihoods: the promomotion and adoption of conservation farming systems in The Philippine uplands. *Int. J. Sustain.* **1:** 141–154.

Cromwell, E., and Almekinders, C. 2000. The impact of seed-supply interventions on the use of crop genetic diversity. **In:** *Encouraging Diversity - The Conservation and Development of Plant Genetic Resources.* pp. 223–227. Almekinders, C. and de Boef, W., Eds., Intermediate Technology Publications, London, UK.

Cromwell, E., Wiggens, S., and Wentzel, S. 1993. *Sowing Beyond the State: NGOs and Seed Supply in Developing Countries.* Overseas Development Institute, London UK.

CRS, ICRISAT, and ODI. 2002. *Seed Vouchers and Fairs: A Manual for Seed-Based Agricultural Recovery After Disaster in Africa.* Nairobi: Catholic Relief Services. Available on-line at http://www.foodaid.org/Tzehay/crs8199.pdf.

Dalton, T. J., Anderson, C. L., Lipper, L., and Keleman, A. 2010. Markets and access to crop genetic resources. **In:** *Seed Trade in Rural Markets: Implications for Crop Diversity and Agricultural Development*. pp: 2–30. Lipper, L., Anderson, C. L. and Dalton, T. J., Eds., United National Food and Agricultural Organization (FAO), Rome, Italy.

Danial, D., Parlevliet, J., Almekinders, C., Thiele, G., and Niks, R. 2007. Farmers' participation and breeding for durable disease resistance in the Andean region. *Euphytica* **153**(3): 385–396.

Dawson J. C., Murphy, K. M., and Jones, S. S. 2008. Decentralized selection and participatory approaches in plant breeding for low-input systems. *Euphytica* **160:** 143–154.

De, N. N. 2000. Crop improvement at community level in Vietnam. **In:** *Participatory approaches to the conservation and use of plant genetic resources.* pp. 103–110. Friis-Hansen, E., and Sthapit, B., Eds., International Plant Genetic Resources Institute, Rome Italy.

De Boef, W. S., Dempewolf, H., Byakwell, J. M. and Engles, J. M. M. 2010. Integrating genetic resource conservation and sustainable development into strategies to increase the robustness of seed systems. *J. Sustain. Agric.* **34** :1–28.

Demissie, A., and Bjørnstad, Å, 2004. Phenotypic diversity of Ethiopian barleys in relation to geographical regions, altitudinal range, and agro-ecological zones: as an aid to germplasm collection and conservation strategy. *Hereditas* **124:** 17–29.

Deu, M., Sagnard, F., Chantereau, J., Calatayud, C., Herault, D., Mariac, C., Pham, J. L., Vigouroux, Y., Kapran, I., Traore, P. S., Mamadou, A., Gerard, B., Ndjeunga, J., and Bezancon, G. 2008. Niger-wide assessment of in situ sorghum genetic diversity with microsatellite markers. *Theor. Appl. Genet.* **116**(7): 903–913.

Devaux, A., Bernet, T., Lopez, G., and Velasco, C. 2006. *Papa Andina: Innoavacion Para el Desarrollo en los Andes – Logros y Experiencia de la Seguand Fase: 2002-2006*. International Ptoato Center (CIP), Lima, Peru (in Spanish).

Devkota, K. P., Tripathi, M. P., Joshi, K. D., Shrestha, P. K., and Witcombe, J. R. 2008. Community based seed production groups in Chitwan, Nepal. **In:** *Farmers, Seeds and Varieties. Supporting Informal Seed Supply in Ethiopia.* pp. 263–270. Thijssen, M. H., Bishaw, Z., Beshir, A. and de Boef, W. S., Eds., Wageningen International, The Netherlands.

Dewan, S., Tiwari, R. K., Pageni, S., Rijal, D., Baral, K. P., Chaudhary, P., Rana, R. B., Subedi, A., and Sthapit, B. 2006. Rural poetry journey: an effective approach to sensitize farming community. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K. and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Di Falco, S., and Chavas, J. P. 2007. On the role of crop biodiversity in the management of environmental risk. **In:** *Biodiversity Economics.* pp. 581–593. Kontoleon, A., Pascual, U. and Swanson, T. M., Eds., Cambridge University Press, Cambridge, UK.

Di Falco, S., and Perrings, C. 2005. Crop biodiversity, risk management and the implications of agricultural assistance. *Ecol. Econ.* **55:** 459–466.

Djumabaeva, S. A. 2009. Orekh gretskiy Yujnogo Kyrgyzstana. (Walnut in the South Kyrgyzstan). *Vestnik of Kyrgyz Technical University:* 1. Bishkek, Kyrgyzstan (in Russian).

Djavakyants, Yu. M. 2009; Znachenie sokhraneniya i ispolzovaniya mestnikh sortov i dikorastushikh form vinograda v proizvodstve i selektsii. (Role of conservation and use of local varieties and wild species of grapevine in production and selection). **In:** *Materials of the Republican Scientific-Practical Conference On "Conservation and Sustainable Use of Biodiversity of Agricultural Crops and Their Wild Relatives."* pp. 31–35. Tashkent, Uzbekistan. (in Russian).

Djavakyants, Yu. M. 2010. Tekhnologiya virashivaniya i razmnojenie mestnikh sortov i form yabloni i grushi. (Cultivation and propagation technologies of local varieties and forms of apple and pear.). *Interpress.*Tashkent, Uzbekistan (in Russian).

Dominguez, C. E., and Jones, R. B. 2005. The dynamics of local seed systems in Mozambique, and the roles played by women. **In:** *Seed Systems and Crop Genetic Diversity On-Farm, Proceedings of a workshop, September 16–20, 2003.* pp. 141–148. Jarvis, D. I., Sevilla- Panizo, R., Chavez-Servia, J. L., and Hodgkin, T., Eds., Pucallpa, Peru. International Plant Genetic Resources Institute, Rome, Italy.

Dossou, B., Balma, D., and Sawadogo, M. 2004. Le role et la participation des femmes dans le processus de la conservation in situ de la biodiversite biologique agricole au Burkina Faso. **In:** *La Gestion de la Diversité des Plantes Agricoles dans les Agro-Ecosystemes.* pp. 38–44.Compte-rendu des travaux d'un atelier abrité par CNRST, Ouagadougou, Burkina Faso, 27-28 décembre 2002. Balma, D., Dossou, B., Sawadogo, M., Zangre, R. G., Ouédraogo, J. T., and Jarvis, D. I., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Duc, G., Bao, S., Baum, M., Redden, B., Sadiki, M., Suso, M.J., Vishniakova, M., and Zong, X. 2010. Diversity maintenance and use of *Vicia faba* L. genetic resources. *Field Crop Res.* **115:** 270–278.

Dudnik, N. S., Thormann, I., and Hodgkin, T. 2001. The extent of use of plant genetic resources in research- a literature survey. *Crop Sci.* **41:** 6–10.

Dyer, G. A., and Taylor, J. E. 2008. A crop population perspective on maize seed systems in Mexico. *Proc. Nat. Acad. Sci.* **105**(2): 470–475.

Edmeades, S. 2006. *A Hedonic Approach to Estimating The Supply of Variety Attributes of a Subsistence Crop.* Environmental and Production Technology Discussion paper No. 148. International Food Policy Research Institute, Washington, DC, USA.

Edmeades, S., and Smale, M. 2009. Market participation and crop biodiversity in developing economy: bananas in Uganda. **In:** *Agrobiodiversity, Conservation and Economic Development.* pp. 353–367. Kontoleon, A., Pascual, U., and Smale, M., Eds., Routledge Oxon, UK.

Edmeades, S., Smale, M., and Karamura, D. 2006. Demand for cultivar attributes and the biodiversity of bananas on farm in Uganda. **In:** *Valuing Crop Biodiversity: On-farm Genetic Resources and Economic Change.* pp. 97–118. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Elmqvist, T., Folke, C., Nyström, M., Peterson, G., Bengtsson, J., Walker, B., and Norberg, J. 2003. Response diversity, ecosystem change, and resilience. *Front. Ecol. Environ.* **1**(9): 488–494.

Engels, J. M. M., Polreich, S., and Dullo, M. E. 2008. Role of community gene/seedbanks in the conservation and use of crop genetic resources in Ethiopia. **In:** *Farmer's Varieties and Seeds. Supporting Informal Seed Supply in Ethiopia.* pp. 149–159. Thijssen, M. H., Bishaw, Z., Beshir, A., and de Boef, W. S., Eds., Wageningen, Wageningen International.

Eyzaguirre, P., and Dennis, E. M. 2007. The impact of collective action and property rights on plant genetic resources. *World Dev.* **35**(9): 1489–1498.

Eyzaguirre, P., and Linares, O. F. 2004. *Home Gardens and Agrobiodiversity.* Smithsonian Books, Washington, DC, USA.

Evenson, R. E., Gollin, D., and Santaniello, V. (Eds.) 1998. *Agricultural Values of Plant Genetic Resources*. CABI Publishing, Wallingford, UK.

Fan, S., Brzeska, J., and Shields, G. 2007. *Investment Priorities for Economic Growth and Poverty Reduction. 2020 Focus Brief on the World's Poor and Hungry People.* IFPRI, Washington, DC, USA.

FAO. 1993. *Quality Declared Seed System*. FAO Plant Production and Production Paper No. 117. United National Food and Agricultural Organization (FAO). Rome, Italy.

FAO. 1998. *Developing Seed Security Strategies and Programmes for Food Security in Developing Countries.* Proceedings of the International Workshop on Seed Security for Food Security, 30 November to 1 December 1997, Florence, Italy. Food and Agriculture Organization of the United Nations, Seed and Plant Genetic Resources Service, Rome, Italy.

FAO. 2005. *Building on Gender, Agrobiodiversity and Local Knowledge, A Training Manual.* United National Food and Agricultural Organization (FAO), Rome, Italy.

FAO. 2006a. *Community Diversity Seed Fairs in Tanzania: Guidelines for Seed Fairs.* FAO-LinKS Project. Report No. 51. United National Food and Agricultural Organization (FAO), Rome, Italy.

FAO. 2006b. *Quality Declared Seed System*. FAO Plant Production and Protection Paper No. 185. United National Food and Agricultural Organization (FAO). Rome, Italy.

FAO. 2007. *State of Food and Agriculture Report: Paying Farmers for Environmental Services*, http://www.fao.org/docrep/010/a1200e/a1200e00.htm. United National Food and Agricultural Organization (FAO), Rome, Italy.

FAO. 2010. *Second Report on the World's Plant Genetic Resources for Food and Agriculture.* [in press]. Electronic version ftp://ftp.fao.org/docrep/fao/meeting/017/ak528e.pdf. United National Food and Agricultural Organization (FAO), Rome, Italy.

Farm Seed Opportunities, 2009. http://www.farmseed.net/home/

Farmers' Rights, 2010. http://www.farmersrights.org/about/fr_contents.html

Feyissa, R. 2000. Community seed banks and seed exchange in Ethiopia: a farmer-led approach. **In:** *Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* pp. 142–148. Friis-Hansen, E., and Sthapit, B. R., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Feyissa, R. 2006. *Farmers' Rights in Ethiopia – A Case Study*. FNI report7/2006, FNI, Lysaker, Norway.

Finckh, M. R. 2008. Integration of breeding and technology into diversification strategies for disease control in modern agriculture. *Eur. J. Plant Pathol.* **121:** 399–409.

Finckh, M. R. 2003. Ecological benefits of diversification. **In:** *Rice Science: Innovations and Impact for Livelihood.* pp. 549–564. Proceedings of the International Rice Research Conference, September 16–19, 2002. Mew, T. W., Brar, D. S., Peng, S., Dawe, D., and Hardy, B., Eds., Beijing: International Rice Research Institute, Chinese Academy of Engineering and Chinese Academy of Agricultural Sciences.

Finckh, M. R., Gacek, E. S., Goyeau, H. *et al*. 2000. Cereal variety and species mixtures in practice, with emphasis on disease resistance. *Agronomie* **20:** 813–837.

Finckh, M. R., and Wolfe, M. S. 2006. Diversification strategies. **In:** *The Epidemiology of Plant Disease*. pp. 269–308. Cooke, B. M. *et al*. Eds., Springer, NY, USA.

Folke, C. 2006. Resilience: the emergence of a perspective for social–ecological systems analyses. *Global Environ. Change* **16**(3): 253–267.

Folke, C., Carpenter, S. R., Elmqvist, T. *et al*. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. *Ambio* **31:** 437–440.

Fowler, C., and Hodgkin, T. 2004. Plant genetic resources for food and agriculture: assessing global availability. *Ann. Rev. Environ. Res.* **29:** 143–179.

Frankel, O. H., Brown, A. H. D., and Burdon, J. J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.

Frankel, O., and Soulé, M. 1981. *Conservation and Evolution*. New York, USA.

Friis-Hansen, E., Lilja, N., and Dixon, J. 2008. Impact assessment of farmer institutional development and agricultural change: Soroti district, Uganda. *Dev. Pract.* **18**(4/5): 506–523.

Friis-Hansen, E., and Sthapit, B. R. 2000. *Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* International Plant Genetic Resources Institute Rome, Italy.

Fu YongNeng, Guo HuiJun, Chen AiGuo and Cui JinYun, 2006. Household differentiation and on-farm conservation of biodiversity by indigenous households in Xishuangbanna, China. *Biodivers. Conserv.* **15**(8): 2687–2703.

Gagne, G., and Ratanasatien, C. In press. Commentary on Thailand's plant variety protection act. **In:** *Farmers' Varieties and Farmers' Rights: Addressing Challenges in Taxonomy and Law*. Halewood, M., Ed., Earthscan. London, UK.

Gaifani, A. 1992. Developing local seed production in Mozambique. **In:** *Growing Diversity.* pp. 97–105. Cooper, D., Vellvé, R. and Hobbelink, H., Eds., Intermediate Technology Publications, London, UK.

Garcia, C., Marie-Vivien, D., Kushalappa, C. G., Chengappa, P. G., and Nanaya, K. M. 2007. Geographical indications and biodiversity in the Western Ghats, India. Can labeling benefit producers and the environment in a mountain agroforestry landscape? *Mount. Res. Dev.* **27:** 206–210.

Garforth, C., Holt, G., Subedi, A., Regmi, B., McKemey, K., Gauchan, D., Tripathi, B., Ellis-Jones, J., Stocking, M., Helleman, H., and White, R. 2005. Linking field-level findings to policy and decision-making in Nepal. **In:** *Renewable Natural Resources Management for Mountain Communities.* pp. 239–246. ICIMOD, Kathmandu, Nepal.

Garrett, K. A., and Mundt, C. C. 1999. Epidemiology in mixed host populations. *Phytopathology* **89:** 984–990.

Gauchan, D., and Smale, M. 2003. Choosing the "right tools" to assess the economic costs and benefits of growing landraces: an illustrative example from Bara District, Central Terai, Nepal. *Plant Genet. Resour. Newsl.* **134:** 41–44.

Gauchan, D., and Smale, M. 2007. Comparing the choices of farmers and breeders: the value of rice land races in Nepal. **In:** *Managing Biodiversity in Agricultural Ecosystems*. pp. 407–425. Jarvis, D. I., Padoch, C., and Cooper, H. D., Eds., Columbia University Press, NY, USA.

Gauchan, D., Smale, M., and Chaudhary, P. 2005. Market-based incentives for conserving diversity on farms: the case of rice landraces in Central Tarai, Nepal. *Genet. Resour. Crop Ev.* **52**(3): 293–303.

Gauchan, D., Smale, M., Maxted, N., and Cole, M. 2006. Managing rice biodiversity on-farms: the choices of farmers and breeders in Nepal. **In:** *Valuing Crop Biodiversity: On-farm Genetic Resources and Economic Change.* pp. 162–177. Smale, M. Eds., CABI Publishing, Wallingford, UK.

Gautam, R., Sthapit, B., Subedi, A., Poudal, D., Shrestha, P., and Eyzaguirre, P. 2008. Home gardens management of key species in Nepal: A way to maximise the use of useful diversity for the well being of poor farmers. *Plant Genet. Resour. Charact. Utiliz.* **7**(2): 142–153.

Gautam, R., Suwal, R., and Sthapit, B. R. 2009. Securing family nutrition through promotion of home gardens: underutilized production systems in Nepal. *Acta Hortic.* **806:** 99–106.

Gepts, P. 1990. Biochemical evidence bearing on the domestication of Phaseolus (*Fabaceae*) beans. *Econ. Bot.* **44:** 28–38.

Gepts, P. 2006. Plant genetic resources conservation and utilization: the accomplishments and future of a societal insurance policy. *Crop Sci.* **46:** 2278–2292.

Gibson, R. W. 2009. A review of perceptual distinctiveness in landraces including an analysis of how its roles have been overlooked in plant breeding for low-input farming systems. *Econ. Bot.***63**(3): 242–255.

Gildemacher, P.R., Demo, P., Barker, I., Kaguongo, W., Woldegiorgis, G., Wagoire, W. W., Wakahiu, M., Leeuwis, C., and Struikl, P.C. 2009. A description of seed potato systems in Kenya, Uganda and Ethiopia. *Am. J. Pot. Res.* **86:** 373–382.

Gine, X., and Yang, D. 2009. Insurance, credit, and technology adoption: field experimental evidence from Malawi. *J. Dev. Econ.* **89:** 1–11.

Giuliani, A. 2007. *Developing Markets for Agrobiodiversity. Securing Livelihoods in Dryland Areas*. Earthscan Research Editions, London, UK.

Gold, C. S., Kiggundu, A., Abera, A. M. K., and Karamura, D. 2002. Diversity, distribution and farmer preference of *Musa* cultivars in Uganda. *Exp. Agric.* **38**(1): 39–50.

Gollin, D., and Evenson, R. E. 1998. **In:** *Valuing Genetic Diversity: Crop Plants and Agroecosystems. Biodiversity in Agroecosystems.* Gollin, D. and Smale, M., Eds., 1999, CRC Press, London, UK.

Gollin, D. and Smale, M. 1999. *Valuing Genetic Diversity: Crop Plants and Agroecosystems. Biodiversity in Agroecosystems.* CRC Press, London, UK.

Grain, 2005. Africa's seed laws: red carpet for the corporations. *Seedling*, July. Grain Publications, Barcelona, Spain.

Granovetter, M. 1973. The strength of weak ties. *Am. J. Sociol.* **78:** 1360–1380.

Granquist, B. 2009. *Is Quality Declared Seed Production an Effective and Sustainable Way to Address Seed and Food Security in Africa?* http://knowledge.cta.int/en/Dossiers/Demanding-Innovation/Demanding-Innovation/Articles/Is-Quality-Declared-Seed-Production-an effective-and-sustainable-way-to-address-Seed-and-Food-Security-in-Africa (*accessed 21 May 2010*)

Gruere, G. P., Nagarajan, L., and King, E. 2007. *Collective Action and Marketing of Underutilized Plant Species: Case of Minor Millets in Kolli Hills, Tamil Nadu, India.* CAPRi Working Paper 68. International Food Policy Research Institute, Washington, USA.

Grum, M., Guerette, V., Kone, B., Sidibe, A., Kouressy, M., Huvio, T., Mafa, A., Mujaju C., Bretaudeau, A., Vaxmann, M., Ouatara, M., Traore, I., Butaumocho, B., Zinanga, F., Mamadou, O. 2003. Strategies for in situ conservation of crop genetic resources in dryland areas of Africa. **In:** *Conserving Biodiversity in Arid Regions.* pp. 55–62. Lemons, E., Victor, R. and Schaffer, D. Eds., Kulwer, Academic Publishers, The Netherlands.

Grum, M., Gyasi, E. A., Osei, C., and Kranjac-Berisavljevie, G. 2003. *Evaluation of Best Practices for Landrace Conservation: Farmer Evaluation*. Paper presented at Sub-Saharan Africa Meeting, International Plant Genetic Resources Institute, Nairobi, Kenya.

Guerette, V., Sibdibe, A., Ouatara, M., and Grum M. In prep. *Measuring the Impacts of Seed Diversity Fairs as a Strategy of Support on Farm Conservation of Plant Genetic Resource.* International Plant Genetic Resources Institute and IER/USC-Canada. (unpublished).

Gupta, S. R., Bajracharya, J., Upadhyay, M. P., Baniya, B. K., Tiwari, P. R., Shakya, D. M., and Sthapit, B. R. 2003. Agromophological characterization of barley (*Horedeum vulgare* L.) landraces of Jumla, Nepal. **In:** *On-farm Management of Agricultural Biodiversity in Nepal. Proceedings of a National Workshop, 24-26. April 2001, Lumle, Nepal.* pp: 37–41. Sthapit, B. R., Upadhyay, M. P., Baniya, B. K., Subedi, A., and Joshi, B. K., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute, Kathmandu, Nepal.

Guzman, F. A., Ayala, H., Azurdia, C., Duque, M. C., and Vicente, M. C. 2005. AFLP assessment of genetic diversity of *Capsicum* genetic resources in Guatemala: home gardens as an option for conservation. *Crop Sci.* **45**(1): 363–370.

Gyawali, S., Gautam, R., Upadhyay, M. P., and Gauchan, D. 2006. Travelling seminar: influencing policy. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R, Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute, IDRC, Kathmandu, Nepal.

Gyawali, S., Sthapit, B., Bhandari, B., Gauchan, D., Joshi, B. K., Tripathi, M., Shrestha, P. K., Joshi, K. D., and Mudwari, A. 2006. Participatory landrace enhancement: an economic incentive to support on-farm management. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R, Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Gyawali, S., Sthapit, B., Joshi, B. K., Mudwari, A., and Bajracharya, J. 2006. Participatory plant breeding (PPB): a strategy of enhancing and maintaining local crop diversity. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute, IDRC, Kathmandu, Nepal.

Gyawali, S., Sthapit, B. R., Bhandari, B., Bajracharya, J., Shrestha, P. K., Upadhyay, M. P., and Jarvis D. I. 2009. Participatory crop improvement and formal release of Jethobudho rice landrace in Nepal. *Euphytica*. DOI. 1007/S10681–010–0213–0.

Gyawali, S., Sunwar, S., Subedi, M., Tripathi, M., Joshi, K. D., and Witcombe, J.R. 2007. Collaborative breeding with farmers can be effective. *Field Crop Res.* **101:** 88–95.

Hajjar, R., Jarvis, D. I., and Gemmill, B. 2008. The utility of crop genetic diversity in maintaining ecosystem services. *Agric. Ecosyst. Environ.* **123:** 261–270.

Halewood, M., Deupmann, P., Sthapit, B. R., Vernooy, R. and Ceccarelli, S. 2007. *Participatory plant breeding to promote farmers' rights*. Opinion paper Bioversity International, ICARDA, IDRC and GRPI, Rome, Italy.

Hamrick, J. L., and Godt, M. J. W. 1997. Allozyme diversity in cultivated crops. *Crop Sci.* **37:**26–30.

Hardon, J., and de Boef, W. 1993. Linking farmers and breeders in local crop development.**In:** *Cultivating Knowledge: Genetic Diversity, Farmer Experimentation and Crop Research.* pp. 64–71. de Boef, W., Amanor, K., Wellard, K. and Bebbington, A., Eds., Intermediate Technology Publications. London, UK.

Harlan, J.R. 1975. Our vanishing genetic resources. *Science* **188:** 618–621.

Heerwaarden, van, J., van Eeuwijk, F. A., and Ross-Ibarra, J. 2010. Genetic diversity in a crop metapopulation. *Heredity* **104:** 28–39.

Hodgkin, T., Rana, R., Tuxill, J., Didier, B., Subedi, A., Mar, I., Karamura, D., Valdivia, R., Collado, L., Latournerie, L., Sadiki, M., Sawadogo, M., Brown A. H. D., and Jarvis, D. 2007. Seed systems and crop genetic diversity in agroecosystems. **In:** *Managing Biodiversity in Agricultural Ecosystems*. pp. 77–116. Jarvis, D. I., Padoch, C., and Cooper, D., Eds., Columbia University Press, NY, USA.

Howard, P. L. 2003. Women and the plant world: an exploration. **In:** *Women and Plants, Gender Relations in Biodiversity Management and Conservation.* pp. 1–31. Howard, P., Eds., Zed Books, NY, USA.

Hue, N. and In situ Project staff. 2006. On-farm conservation of rice genetic diversity under salinity stress: case study in a lowland agrosystem of Vietnam. **In:** *Enhancing the Use of Crop Genetic Diversity to Manage Abiotic Stress* *in Agricultural Production Systems.* Proceedings of a workshop, 23–27 May 2005, Budapest, Hungary. pp 49–54. Jarvis, D. I., Mar, L., and Sears, L., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Hue, N., Trinh, L., Ha, N., Sthapit, B., and Jarvis, D. 2003. Taro cultivar diversity in three ecosites of North Vietnam. **In:** *On-Farm Management of Agricultural Biodiversity in Vietnam*. Proceedings of a symposium, December 6–12, 2001, Hanoi, Vietnam. Tuan, H. D., Hue, N. N., Sthapit, B. R. and Jarvis D. I., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Huvio, T., and Sidibe, A. 2003. Strengthening farmers' capacities for plant genetic resources conservation in Mali. *Plant Genet. Res.* **1:** 31–41.

IAASTD., 2009. Agriculture at a crossroads. **In:** *International Assessment of Agricultural Knowledge, Science and Technology for Development.* McIntyre, B. D., Herren, H. R., Wakhungu J. and Watson R. T., Eds, Island Press, Washington, DC, USA.

Iriarte, V., Terrazas, F., Aguirre, G., and Thiele, G. 2000. Local seed system and Proinpa's genebank: working to improve seed quality of traditional Andean potatoes in Bolivia and Peru. **In:** *Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* pp. 154–161. Friis-Hansen, E. and Sthapit, B., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Irungu, C., Mburu, J., Maundu, P., Grum, M., Hoeschle-Zeledon, I., Chadha, M. L., Kuo, G., and Gowda, C. L. L. 2007. Marketing of African leafy vegetables in Nairobi and its implications for on-farm conservation of biodiversity. *Acta Hortic.* **752:** 197–201.

Jackson, L. E., Burger, M., and Cavagnaro, T. R. 2008. Roots, nitrogen, transformations, and ecosystem services. *Ann. Rev. Plant Biol.* **59:** 341–363.

Jackson, L. E., Pascual, U., and Hodgkin, T. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agric. Ecosyst. Environ.* **121:** 196–210.

Jackson, L., van Noordwijk, M., Bengtsson, J., Foster, W., Lipper, L., Pulleman, M., Said, M., Snaddon, J. and Vodouhe, R. 2010. Biodiversity and agricultural sustainability: from assessment to adaptive manage. *Curr. Opin. Environ. Sustain.* On line version, doi:10.1016/j.cosust.2010.02.007.

Jaffe, W. ,and Jeroen Van Wijk, 1995. *The Impact of Plant Breeders Rights in Developing Countries: Debate and Experience in Argentina, Chile, Colombia, Mexico and Uruguay.* DGIS. The Hague, Netherlands.

Janssen, W., Luna, C. A., and Duque, M. C. 1992. Small farmer behaviour towards bean seed: evidence from Colombia. *J. App. Seed Prod.* **10:**43–51.

Jarvis, D. I., Brown, A. H. D., Cuong, P. H., Collado-Panduro, L., Latourniere-Moreno, L., Gyawali, S., Tanto, T., Sawadogo, M., Mar, I., Sadiki, M., et. al. 2008. A global perspective of the richness and evenness of traditional crop variety diversity maintained by farming communities. *Proc. Nat. Acad. Sci.* **108:** 5326–5331.

Jarvis, D. I., Brown, A. D. H., Imbruce, V., Ochoa, J., Sadiki, M., Karamura, E., Trutmann, P., and Finckh, M. R. 2007a. Managing crop disease in traditional agroecosystems: the benefits and hazards of genetic diversity. **In:** *Managing Biodiversity in Agricultural Ecosystems.* pp. 292–319. Jarvis, D. I., Padoch, C, and Cooper, D., Eds., Columbia University Press, NY, USA.

Jarvis, D. I., and Campilan, D.M. 2006. *Crop Genetic Diversity to Reduce Pests and Diseases On-Farm: Participatory Diagnosis Guidelines. Version I.* Bioversity International Technical bulletin No. 12. Bioversity International, Rome, Italy.

Jarvis, D. I., and Hodgkin, T. 2008. The maintenance of crop genetic diversity on farm: supporting the convention on biological diversity's programme of work on agricultural biodiversity. *Bioversity* **9:** 23–38.

Jarvis, D.I., Myers, M., Klemick, H., Guarino, L., Smale, M., Brown, A.H.D., Sadiki, M., Sthapit, B., and Hodgkin, T. 2000. *A Training Guide for in Situ Conservation On-Farm: Version 1.* International Plant Genetic Resources Institute, Rome, Italy.

Jarvis, D., and Ngung'u-Skilton, J. 2000. IPGRI in situ project: research and institutions supporting local management of agrobiodiveristy. **In:** *Encouraging Diversity. The Conservation and Development of Plant Genetic Resources.* pp. 134–141. Almekinders, C. and de Boef, W., Eds., Intermediate Technology Publications, London, UK.

Jarvis, D. I., Padoch, C., and Cooper, H. D. 2007b. *Managing Biodiversity in Agricultural Ecosystems.* Columbia University Press, NY. USA.

Jarvis, D. I., Zoes, V., Nares, D., and Hodgkin, T. 2004. On-farm management of crop genetic diversity and the convention on biological diversity's programme of work on agricultural biodiversity. *Plant Genet. Resour. Newsl.* **138:** 5–17.

Johns, T., and Sthapit, B. R. 2004. Biocultural diversity in the sustainability of developing country food systems. *Food Nutr. Bull.* **25:** 143–155.

Joshi, K. D., Biggs, S., Gauchan, D., Devkota, K. P., Devkota, C. K., Shrestha, P. K., Sthapit, B. R., Harris, D., Richards, J. I., Silverside, P., Ward, A. F., and Wircombe, J. R. 2005. Institutional innovations in the Nepal rice improvement system. *Aspects App. Biol.* **75:** 93–97.

Joshi, K. D., and Sthapit, B. R. 1990. *Informal Research and Development (IRD): A New Approach to Research and Extension. LARC Discussion Paper 1990/4.* Lumle Agricultural Research Centre, Pokhara, Nepal.

Joshi, K. D., Sthapit, B. R., Gurung, R. B., Gurung, M. B., and Witcombe, J. R. 1997. Machhapuchhre 3 (MP-3), the first rice variety developed through a participatory plant breeding approach released for mid to high altitudes of Nepal. *Int. Rice Res. Notes* **22**(2): pp 12.

Joshi, K. D., Sthapit, B. R., Subedi, M., and Witcombe, J. R. 2002. Participatory plant breeding in rice in Nepal. **In:** *Farmers, Scientists and Plant Breeding Integrating Knowledge and Practice.* pp. 239–268. Cleveland D. A., and Soleri D., Eds., CABI Publishing, Wallingford, UK.

Joshi, K. D., Sthapit, B. R., and Witcombe, J. R. 2001. How narrowly are the products of decentralized breeding? The spread of rice varieties from a participatory plant breeding programme in Nepal. *Euphytica* **122:** 589–597.

Jost, L. 2010. The relation between evenness and diversity. *Diversity* **2:** 207–232.

Kabambe, V. H., Mhango, W. G., Msiska, M., Msuku, W. A. B., Nyirenda G. K. C., and Masangano, C. 2008. Facilitating food crop production in Lungwena, Mangochi District in Malawi: lessons from a farmer-based pass-on seed support model. *Afr. J. Agric. Res.***3**(6): 440–447.

Kapila, S., and Mead, D. C., 2002. *Building Businesses with Small Producers: Successful Business Development Services in Africa, Asia, and Latin America.* ITDG Publishing, London UK/ International Development Research Centre, Ottawa Canada.

Karamura, D., and Karamura, E. 1994. *A Provisional Checklist of Banana Cultivars in Uganda*. National Agricultural Research Organization (NARO) and INIBAP, Kampala, Uganda.

Karamura, D., and Mgenzi, B. 2004. On farm conservation of *Musa* diversity in the great lakes region of East Africa. *Afr. Crop Sci. J.* **12**(1): 75–83.

Karamura, D., Mgenzi, B., Karamura, E., and Sharrock, S. 2004. Exploiting indigenous knowledge for the management and maintenance of *Musa* biodiversity on farm. *Afr. Crop Sci. J.* **12**(1): 67–74.

Kastler, G. 2005. Europe's seed laws: locking out farmers. *Seedling*, July 2005. Grain Publications, Barcelona, Spain.

Kebebew, F., Tsehaye, Y., and McNeilly, T. 2001. Morphological and farmers cognitive diversity of barley (*Hordeum vulgare* L. [Poaceae]) at Bale and North Shewa of Ethiopia. *Genet. Resour. Crop Ev.* **48**(5): 467–481.

Keleman, A., Garcia Rano, H., and Hellin, J. 2009. Maize diversity, poverty, and market access: lessons from Mexico. *Dev. Pract.* **19**(2): 187–199.

Kennedy, G., and Burlingame, B. 2003. Analysis of food composition data on rice from a plant genetic resources perspective. *Food Chem.* **80:** 589–596.

Kenny, C. J. 2000. Expanding internet access to the rural poor in Africa. *Inform. Technol. Dev.* **9:** 25–31.

Kerimova, U. S. 2008. Virashivanie plodovikh kultur v fermerskikh khozyaistvakh. (Cultivation of fruit crops on farms). Ashgabat, Turkmenistan (in Russian).

Kesavan, P. C., and Swaminathan, M. S. 2008. Strategies and models for agricultural sustainability in developing Asian countries. *Phil. Trans. R. Soc. B.* **363:** 877–891.

Kimura, M., and Weiss, G. H. 1964. The stepping stone model of population structure and the decrease of genetic correlation with distance. *Genetics* **49:** 561–576.

Kitti, M., Heikkila, J., and Huhtala, A. 2009. Agrobiodiversity in poor countries. Price premiums deemed to miss multifaceted targets? **In:** *Agrobiodiversity, Conservation and Economic Development*. pp. 335–354. Kontoleon, A., Pascual, U. and Smale, M., Eds., Routledge Oxon, UK.

Kizito, E. B., Chiwona-Karltun, L., Egwang, T., Fregene, M., and Westerbergh, A. 2007. Genetic diversity and variety composition of cassava on small scale farms in Uganda: an interdisciplinary study using genetic markers and farmer interviews. *Genetica* **130:** 301–318.

Kontoleon, A., Pascual, U., and Smale, M. 2009. Introduction: agrobiodiversity for economic development: what do we know? Agrobiodiversity conservation and economic development. **In:** *Environmental Economics.* pp. 1–24. Kontoleon, A., Pascual, U., and Smale, M., Eds., Routledge Explorations, UK.

Kontoleon, A., Pascual, U., and Swanson, T. M. 2007. *Biodiversity Economics*. Cambridge University Press, UK.

Kouressy, M., Traoré, S., Vaksmann, M., Grum, M., Maikano, I., Soumaré, M., Traoré, P. S., Bazile, D., Dingkuhn, M., Sidibé, A., Bazile, D. and Weltzien, E. 2008. Adaptation of Malian sorghums to climate variability. *Cah. Agric.* **17**(2): 95–100.

Kremen, C., Williams, N., and Thorp, R. 2002. Crop pollination from native bees at risk 674 from agricultural intensification. *Proc. Nat. Acad. Sci.* **99:** 16812–16816.

Kruijssen, F., Keizer, M., and Giuliani, A. 2009. Collective action for small-scale producers of agricultural biodiversity products. *Food Policy* **34:** 46–52.

Kruiijssen, F., and Mysore, S. 2007. *Developing the Potential of Underutilized Fruits Through the Linkage of Farmers To The Market-A Case of Kokum Marketing in the Western Ghats of India.* Paper presented at the Third International Conference on Linking markets and farmers: exploring leading practices to foster economic growth in rural India, 11-15 March 2007, New Delhi, India.

Kruijssen, F., and Somsri, S. 2006. *Marketing Local Biodiversity in Thailand: Identification of a Possible Good Practices for On-Farm Biodiversity Management of Tropical Fruit Trees.* Presented at the Tropentag conference on International Agricultural Research for Development, 11-13 October 2006, Bonn, Germany.

Kumar, A. N., Balakrishnan, V., Girigan, G., and Raveendran, T. 2003. People's biodiversity registers: a case from India. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol I: Understanding Agricultural Biodiversity.* pp. 236–244. CIP-UPWARDS 2003 Eds., Los Banos, Philippines.

Kumar, P., Gupta, V. K., Misra, A. K., Modi, D. R., and Pandey, B. K. 2009. Potential of molecular markers in plant biotechnology. *Plant Omics J.* **2**(4): 141–162.

Lacy, S. M., Cleveland D. A. and Soleri, D. 2006. Farmer choice of sorghum varieties in Southern Mali. *Hum. Ecol.* **34**(3): 331–353.

Lapeña, I. 2008. *The Genetic Resources Policy Initiative in Peru*. Final report. Available at www.grpi.org

Latournerie-Moreno, L., Tuxill, J., Yupit-Moo, E., Arias-Reyes, L., Cristobal-Alejo, J., and Jarvis, D. I. 2006. Traditional maize storage methods of Mayan farmers in Yucatan, Mexico: implications for seed selection and crop diversity. *Biodivers. Conserv.* **15**(5) 1771–1795.

Laurentin, H. 2009. Data analysis for molecular characterization of plant genetic resources. *Gen. Res. Crop Evol.* **56:** 277– 292.

Lee, D. R. 2005. Agricultural sustainability and technology adoption: issues and policies for developing countries. *Amer. J. Agr. Econ.* **87**(5): 1325–1334.

Leskien, D., and Flitner, M. 1997. Intellectual property rights and plant genetic resources: options for a sui generis system. **In:** *Issues in Genet. Resour.* **6:** June 1997. Engler, J., Eds., International Plant Genetic Resources Institute. Rome, Italy.

Lewis, V., and Mulvany, P. M. 1997. *A Typology of Community Seed Banks*. NRI, UK.

Li, C., He, X., Zhu, S., Zhou, H., Wang, Y., Li, Y., Yang, J., Fan, J., Yang, J., Wang, G., Long, Y., Xu, J., Tang, Y., Zhao, G., Yang, J., Liu, L., Sun, Y., Xie, Y., Wang, H., and Zhu, Y. 2009 Crop diversity for yield increase. *PLoS ONE* **4**(11): 1–6. e8049. doi:10.1371/journal.pone.0008049.

Liang, L., and Brookfield, H. 2009. Sharing knowledge on agrodiversity for conservation and livelihood improvement. *LEISA Mag.* **25**(1): 23–25.

LI-BIRD. 2005 (unpublished). *Home Garden Donor Report Local Initiatives for Biodiversity Research and Development* (I-BIRD). Report to the Swiss Agency for Development and Cooperation, Home Garden Project, Bioversity International, Rome, Italy.

Lightfoot, C., Gillman, H., Scheuermeier, U., Nyimbo, V. 2008. The first mile project in Tanzania: linking smallholder farmers to markets using modern communication technology. *Mount. Res. Dev.* **28:** 13–17.

Lipper, L., Anderson, C. L., Dalton, T. J., and Keleman, A. 2010. Conclusions and policy implications. **In:** *Seed Trade in Rural Markets: Implications for Crop Diversity and Agricultural Development.* pp. 209–222. Lipper, L., Anderson, C.L. and Dalton, T.J., Eds., United National Food and Agricultural Organization (FAO), Rome, Italy.

Lipper, L., Cavatassi, R., and Hopkins, J. 2009. The role of crop genetic divesity in coping with drought: insights from eastern Ethiopia. **In:** *Agrobiodiversity, Conservation and Economic Development.* pp. 183–203. Kontoleon, A., Pascual, W. and Smale, M., Eds., Routeledge, London, UK.

Lipton, M. 2006. Can small farmers survive, prosper, or be the key channel to cut mass poverty*? Electron. J. Agric. Dev. Econ.* **3**(1): 58–85.

Loch, D. S., and Boyce, K. G. 2003. Balancing public and private sector roles in an effective seed supply system. *Field Crop Res.* **84:** 105–122.

Lopez, D. 2004. *Gender Relations as a Basis for Varietal Selection in Production Spaces in Yucatan, Mexico*. M.S. thesis, Wageningen University, The Netherlands.

Lopez Noriega, I. In press. Defensive protection of farmers' varieties. **In:** *Farmers' Varieties and Farmers' Rights: Addressing Challenges in Taxonomy and Law*. Halewood, M., Ed. Earthscan. London, UK.

Louette, D., Charrier, A., and Berthaud, J. 1997. *In situ* conservation of maize in Mexico: genetic diversity and maize seed management in a traditional community. *Econ. Bot.* **51:** 20–38.

Louwaars, N. 2000. Seed regulation and local seed systems. *Biotech. Dev. Monitor*, No. 42, June 2000.

Louwaars, N., Ed. 2002. *Seed Policy, Legislation and Law: Widening a Narrow Focus.* Food Products Press and Haworth Press, Binghamtom.

Louwaars, N., and Burgaud, F. In press. Variety registration: the evolution of registration systems with a special emphasis on agrobiodiversity conservation. **In:** *Farmers' Varieties and Farmers' Rights: Addressing Challenges in Taxonomy and Law*. Halewood, M., Ed. Earthscan. London, UK.

Magorokosho, C., Banziger, M., and Betran, F.J. 2006. Characterization of local maize landraces from Zimbabwe, Zambia and Malawi. **In:** *Enhancing Crop Genetic Diversity to Manage Abiotic Stress.* pp. 25–30. 23–27 May 2005, Budapest, Hungary. Jarvis D., Mar, I. and Sears L., Eds., Bioversity International, Italy, Rome.

Magurran, A. E. 2003. *Measuring Biological Diversity*. Blackwell, Oxford, UK.

Maharjan, S. K., Sigdel, E. R., Sthapit, B. R., and Regmi, B. R. 2010b. Tharu community's perception on climate changes and their adaptive initiations to withstand its impacts in Western Terai of Nepal. *Int. NGO J.* Vol 5: (accepted).

Maharjan, S. K., Subedi, A., Shrestha, P., Sthapit, B. R., Rana, R. B., and Gurung, A. R. 2010a. Enhancing conservation and use of agro-biodiversity on-farm through community seed bank in western Nepal. *Inst. Agric. Anim. Sci. J*. (*in press*).

Makokha, M., Omanga, P, Onyango, A., Otado, J., and Remington, T. 2004. Comparison of seed vouchers and fairs and direct seed distribution: lessons learned in Eastern Kenya and critical next steps, **In:** *Addressing Seed Security in Disaster Response: Linking Relief with Development.* pp. 44. Sperling, L., Remington, T., Haugen, J. M. and Nagoda, S., Eds., International Center for Tropical Agriculture, Cali, Colombia.

Mar, I. 2002. Safeguarding agricultural biodiversity on-farms in Hungary. **In:** *The Economics of Conserving Agricultural Biodiversity On-farm: Research Methods Developed from IPGRI's Global Project 'Strenghtening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity.'* Smale, M., Mar, I., and Jarvis, D. I., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Mar, I., and Holly, L. 2000. Hungary. Adding benefits. **In:** *Conserving Agricultural Biodiversity In Situ: A Scientific Basis for Sustainable Agriculture.* pp. 194–198. Jarvis, D., Sthapit, B. and Sears, L., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Maredia, M., and Howard, J. 1998. *Facilitating Seed Sector Transformation in Africa: Key Findings from the Literature.* Food Security II Cooperative Agreement between U.S. Agency for International Development, Global Bureau, Economic Growth Center, Office of Agriculture and Food Security and Department of Agricultural Economics, Michigan State University. http://www.aec.msu.edu/fs2/polsyn/No33.htm.

Marquez, M., Valdes, N., Perez, D., Ferro, E. M., and Ortiz, R. 2009. Participatory plant breeding impact as part of the local agroinnovation by diffusing genetic diversity in agricultural sectors of Pinar del Rio. *Cultivos Tropicales* **30**(2): 18–23.

Marshall, D. R. 1977. The advantages and hazards of genetic homogeneity [Plant resistance to diseases]. *Ann. N. Y. Acad. Sci.* **287:** 1–20.

Martin, G. B., and Adams, M. W. 1987. Landraces of *Phaseolus vulgaris* (Fabacae) in northern Malawi. I. Regional variation. *Econ. Bot.* **41:** 190–203.

Maruyama, T., and Kimura, M. 1980. Genetic variability and effective population size when local extinction and recolonization of sub populations are frequent. *Proc. Nat. Acad. Sci.* **77:** 6710–6714.

Maurya, D. M., Bottrall, A., and Farrington, J. 1988. Improved livelihoods, genetic diversity and farmer participation: a strategy for rice breeding in rainfed areas of India. *Exp. Agric.* **24:** 311–320.

Mazhar, F. 2000. Seed conservation and management: participatory approaches of Naya Krishi seed network in Bangladesh. **In:** *Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* pp: 149–153. Friis-Hansen, E. and Sthapit, B. R., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Mbabwine, Y., Sabiiti, E. N., Kiambin, D., and Mulumba, J. W. 2008. Ecogeographic genetic erosion, seed systems and conservation of plant genetic resources in Kabale highlands, Uganda. *Plant Genet. Resour. Newsl.* **156:** 33–41.

McGuire, S. J. 2007. Vulnerability in farmer seed systems: farmer practices for coping with seed insecurity for sorghum in Eastern Ethiopia. *Econ. Bot.* **61**(3): 211–222.

McGuire, S. J. 2008. Securing access to seed: social relations and sorghum seed exchange in eastern Ethiopia. *Hum. Ecol.* **36**(2): 217–229.

McGuire, S. J., Cleveland D. A., and Soleri, D. 2002. Farmers' views and management of sorghum diversity in Western Hareghe, Ethiopia: implications for collaboration with formal breeding. **In:** *Farmers, Scientists and Plant Breeding: Integrating Knowledge and Practice*. pp. 107–135. CABI Publishing, Wallingford, UK.

MEA. 2005. *Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Biodiversity Synthesis.* World Resources Institute, Washington, DC, USA.

Meinzen-Dick, R., and Eyzaguirre, P. 2009. Non-market institutions for agrobiodiversity conservation. **In:** *Agrobiodiversity, Conservation and Economic Development.* pp. 82–91. Kontoleon, A., Pascual, W., and Smale, M., Eds., Routeledge, London, UK.

Mekbib, F. 2008. Farmers' breeding of sorghum [*Sorghum bicolor* (L.) Moench] in the center of diversity, Ethiopia: II. Selection process, criteria and methods. *J. New Seeds* **9**(3): 234–265.

Mekbib, F. 2009a. Farmers as treasure chest of biodiversity: the case of sorghum (*Sorghum bicolor* (L.) Moench) in Ethiopia - a five decade analysis. *Maydica* **54**(1): 11–23.

Mekbib, F. 2009b. *Genetic Enhancement of Sorghum (Sorghum Bicolor (L.) Moench) Diversity Through an Integrated Approach.* Doctor of Philosphy (PhD) Thesis. Norwegian University of Life Sciences, Department of Plant and Environmental Sciences, Ås, Norway.

Mellas, H. 2000. Morocco. Seed supply systems: data collection and analysis. **In:** *Conserving Agricultural Biodiversity In Situ: A Scientific Basis for Sustainable Agriculture.* pp. 155–156. Jarvis, D. I., Sthapit, B. and Sears, L., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Mendum, R., and Glenna, L. L. 2010. Socioeconomic obstacles to establishing a PPB program for organic growers in the USA. *Sustainability* **2:** 79–91.

Meng, E., Taylor, J. E., and Brush, S. B. 1998. Implications for the conservations of wheat landraces in Turkey from an household model of varietal choice. **In:** *Farmers, Gene Banks & Crop Breeding: Economics Analyses of Diversity in Wheat, Maize and Rice*. Natural Resource Management and Policy series. pp. 127–142. Smale, M., Eds., Kluwer Academic, Boston, Massachusetts; Dordrecht, The Netherlands.

Mgonja, M. A., Subhash, C., Gwata, E. T., Obilana, A. B., Monyo, E.S., Rohrbach, D. D., Chisi, M., Kudita, S., and Saadan, H. M. 2005. Improving the efficiencies of national crop breeding programs through region-based approaches: the case of sorghum and pearl millet in southern Africa. *J. Food Agric. Environ.* **3**(3/4): 124–129.

Moore, G., and Tymowski, W. 2005. *Explanatory Guide to the International Treaty on Plant Genetic Resources for Food and Agriculture.* IUCN. Gland, Switzerland and Cambridge, UK.

Morales-Valderrama, C., and Quiñones-Vega, T. 2000. Social, cultural and economic data collection and analysis including gender: methods used for increasing access, participation and decision-making. **In:** *Conserving Agricultural Biodiversity In Situ: A Scientific Basis for Sustainable Agriculture.* pp. 49–50. Jarvis, D., Sthapit, B., and Sears, L., Eds.,International Plant Genetic Resources Institute, Rome, Italy.

Moseley, W. G., Carney, J., and Becker, L. 2010. Neoliberal policy, rural livelihoods and urban food security in West Africa: a comparative study of The Gambia, Côte d'Ivoire and Mali. *Proc. Nat. Acad. Sci.* **107**(13): 5774–5779.

Mujaju, C., and Chakauya, E. 2008. Morphological variation of sorghum landrace accessions on-farm in semi-arid areas of Zimbabwe. ANSInet, Asian Network for Scientific Information, Faisalabad, Pakistan. *Int. J. Bot.* **4**(4): 376–382.

Mujaju, C., Rusike, E., and Zinhanga, F. 2003. Community seedbank for semi-arid agriculture in Zimbabwe. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol I: Understanding Agricultural Biodiversity.* pp. 294–301. CIP-UPWARDS 2003 Eds., International Potato Centre (CIP) and User's Perspectives With Agricultural Research and Development (UPWARD), Los Banos, Philippines.

Mundt, C. C. 1991. Probability of mutation to multiple virulence and durability of resistance gene pyramids: Further comments. *Phytopathology* **81:**240–242.

Munyua, H., and Adera, E., Jensen, M. 2009. Emerging ICTs and their potential in revitalizing small scale agriculture in Africa. *Agric. Inform. Worldwide* **2:** 1–9.

Musa, T.M. 1998. *Farmer Seed System a Background Paper for the International Workshop on Developing Institutional Agreements and Capacity to Assist Farmers in Disaster Situations to Restore agricultural Systems and Seed Security Activities.* 3-5 November 1998. United National Food and Agricultural Organization (FAO), Rome, Italy.

Muthoni, J., and Nyamongo, D. O. 2008. Seed systems in Kenya and their relationship to on-farm conservation of food crops. *J. New Seeds* **9**(4): 330–342.

Nabban, G. P. 1989. *Cultures of Habitat: On Nature, Culture, and Story.* Counterpoint, Perseus Book Group, Washington, DC, USA.

Nagaranjan, S. 2007. Geographical indications and agriculture-related intellectual property rights issues. *Curr. Sci. India* **92:** 167–171.

Nagaranjan, L., Oliver King, E. D. I., Jones, H., and Vedhamoorthy, A. 2009. *Market Participation and Farmer Welfare: Case of Minor Millets in Pennagaram Market Hub, Dharmapuri District, India.* IFPRI, Washington, DC, USA.

Nagaranjan, L., Oliver King, E. D. I., Smale, M., and Dalton T. J. 2010. Access to minor millet genetic resources in rural market towns of Dharmapuri District, Tamil Nadu, India. **In:** *Seed Trade in Rural Markets*. pp. 125–145. Lipper, L., Anderson, C. L. and Dalton, T.J., Eds., United National Food and Agricultural Organization (FAO), Rome, Italy and Earthscan, London, UK.

Nagaranjan, L., and Smale, M. 2007. Local seed systems and village level determinants of millet crop diversity in marginal environments of Indai. *Euphytica* **155:** 167–182.

Nassif, F. 2002. Tuornee inter sites en faveur des femmes associees au project in situ Maroc. **In:** *La conservation In-Situ de la Biodiversite Agricole: Un Defi Puor Une Agriculture Durable*. Actes du Seminaire National Rabat, 21-22 Janvier 2002. pp. 349–355. Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoun, A., and Jarvis, D., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Nassif, F., and Birouk, A. 2002. Tournee inter sites au profit des agriculteurs partenaires du project in situ Maroc. **In:** *La Conservation In-Situ de la Biodiversite Agricole: Un Defi Puor Une Agriculture Durable*. Actes du Seminaire National Rabat, 21 et 22 Janvier 2002. pp. 344–348. Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoun, A. and Jarvis, D., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Nathaniels, N. Q. R. and Mwijage, A. 2006. *Seed Fairs And The Case Of Marambo Village, Nachingwea District, Tanzania: Implications of Local Informal Seed Supply and Variety Development for Research and Extension.* Network Paper No. 101. Agricultural Research and Extension Network (AgREN), Overseas Development Institute (ODI), UK.

Negri, V. 2003. Landraces in central Italy: where and why they are conserved and perspectives for their on-farm conservation. *Genet. Resour. Crop Ev.* **50:** 871–885.

Negri, V., Maxted, N., and Veteläinen, M., 2009. European landrace conservation: an introduction. **In:** *European Landraces on Farm Conservation, Management and Use.* pp. 1–22. Veteläinen M., Negri V., and Maxted N. Eds.,. Bioversity Technical Bulletin No. 15. Bioversity International. Rome, Italy.

Neuchatel Group. 2010. http://www.neuchatelinitiative.net/english/content_about.htm (*accessed 16 May 2010*)

Nkongolo, K. K., Chinthu, K. K. L., Malusi, M. and Vokhiwa, Z. 2008. Participatory variety selection and characterization of Sorghum (*Sorghum bicolor* (L.) Moench) elite accessions from Malawian gene pool using farmer and breeder knowledge. *Afr. J. Agric. Res.* **3**(4): 273–283.

Nuijten, E., and Almekinders, C. J. M. 2008. Mechanisms explaining variety naming by farmers and name consistency of rice varieties in The Gambia. *Econ. Bot.* **62**(2): 148–160.

OriGin. 2010. Organization for an International Geographical Indications Network http://www.origin-gi.com/

Okwu, O. J., and Umoru, B. I. 2009. A study of women farmers' agricultural information needs and accessibility: A case study of Apa local government area of Benue State, Nigeria. *Afr. J. Agric. Res.* **4**(12): 1404–1409.

Ortiz, R., Rios, H., Marquez, M., Ponce, M., Gil, V., Cancio, M., Chaveco, O., Rodriguez, O., Caballero, A., and Almekinders, C. 2009. Participatory plant breeding achievements evaluated by involved farmers. *Cultivos Tropicales* **30**(2): 106–112.

Østergård, H., Finckh, M. R., Fontaine, L., Goldringer, I., Hoad, S. P., Kristensen, K., Lammerts van B., Edith, T., Mascher, F., Munk, L., and Wolfe, M. S. 2009. Time for a shift in crop production: embracing complexity through diversity at all levels. *J. Sci. Food Agric.* **89**(9): 1439–1445(7).

Oude, L. A., and Carpentier, A. 2001. Damage Control Productivity: an input damage abatement approach. *J. Agric. Econ.* **52**(3): 11–22.

Oyedele, O., Yahaya, M. K. and Aldous, D. E. 2009. Citrus farmers' accessibility to horticultural information in South-Western Nigeria. *Acta Hortic.* **832:** 171–176.

Pascual U., and Perrings, C. 2007. Developing incentives and economic mechanisms for in situ biodiversity conservation in agricultural landscapes. *Agric. Ecosyst. Environ.* **121:** 256–268.

Platform for Agrobiodiversity Research, 2010. *The Use of Agrobiodiversity by Indigenous and Traditional Agricultural Communities in: Adapting to Climate Change.* Synthesis paper. PAR, Bioversity International, Rome, Italy. http://www.agrobiodiversityplatform.org/blog/wp-content/uploads/2010/05/PAR-Synthesis_low_FINAL.pdf (*accessed 28 May 2010*)

Peacock, J., and Chaudhury, A. 2002. The impact of gene technologies on the use of genetic resources. **In:** *Managing Plant Genetic Diversity.* pp.33–42. Engels, J. M. M., Rao, V. R., Brown, A. H. D., and Jackson, M. T., Eds., CABI Publishing, Wallingford, UK.

Perfecto, I., Vandermeerb, J., Mas, A. and Soto Pinto, L. 2005. Biodiversity, yield, and shade coffee certification. *Ecol. Econ.* **54:** 435–446.

Phiri, M. A. R., Chirwa, R., and Haugen, J. M. 2004. A review of seed security strategies in Malawi. **In:** *Addressing Seed Security in Disaster Response: Linking Relief with Development.* Sperling, L., Remington, T., Haugen, J. M., and Nagoda, S., Eds., International Center for Tropical Agriculture, Cali, Colombia. http://www.ciat.cgiar.org/africa/seeds.htm.

Pimbert, M. P., Boukary, B., and Holt-Giménez, E. 2010. Democratising research for food sovereignty in West Africa. *J. Peasant Stud.* **37**(1): 220–226.

Pingali, P. L., and Roger, P. A. 1995. *Impact of pesticides on farmers' health and the rice environment.* Kluwer, Dordrecht, The Netherlands.

Poudel, D., and Johnsen, F. H. 2009. Valuation of crop genetic resources in Kaski, Nepal: farmers' willingness to pay for rice landraces conservation. *J. Environ. Manage.* **90**(1): 483–491.

Poudel, D., Rijal, D., Johnsen, F. H., Synnevag, G., and Subedi, A. 2005. Conservation of crop genetic resources in community genebank: farmers' willingness to pay for conservation of rice landraces in Kaski, Nepal. **In:** *On-farm Conservation of Agricultural Biodiversity in Nepal. Volume 2: Managing Diversity and Promoting its Benefits.* pp. 149–160. Proceedings of the second national workshop, 25-27 August 2004, Nagarkot, Nepal. Sthapit, B. R., Upadhyay, M. P., Shrestha, P. K. And Jarvis, D. I., Eds., NARC, International Plant Genetic Resources Institute and LI-BIRD, Kathmandu, Nepal.

Poudel, D., Shrestha, P., Basnet, A., Shrestha, P., Sthapit. B., and Subedi, A. 2008. Dynamics of farmers' seed networks in rice seed flow systems: implications for on-farm conservation. pp. 88–96. **In:** *On-farm Management of Agricultural Biodiversity in Nepal: Lessons Learned.* Proceedings of the National Symposium 18-19 July 2006, Kathmandu, Nepal. Sthapit, B. R., Gauchan, D., Subedi, A. and Jarvis, D., Eds., Bioversity International, Rome Italy.

Pradhan N., Providoli, I., Regmi, B., and Kafle, G. 2010. Valuing water and its ecological services in rural landscapes: a case study from Nepal. *Mount. Forum Bull.* January 2010: 32–34.

Pradhanang, P. M., and Sthapit, B. R. 1995. Effect of cultivar mixtures on yellow rust incidence and grain yield of barley in the hills of Nepal. *Crop Prot.* **14**(4):331–334.

Prasanna, B. M., Rao, S. K., Gautam, K., and Singh, R. B. 2008. "Varieties of common knowledge" in the context of plant variety protection. *Curr. Sci. India* **95:** 1522–1524.

Pressoir, G., and Berthaud, J. 2004. Patterns of population structure in maize landraces from the Central Valleys of Oaxaca in Mexico. *Heredity* **92:** 88–94.

Pretty, J. 2002. *Agri-culture: Reconnecting People, Land and Nature.* Earthscan, London, UK.

Pretty, J. 2008. Agricultural sustainability: concepts, principles and evidence. *Phil. Trans. R. Soc. B.* **363:** 447–465.

Pretty, J. and Smith, D. 2004. Social capital in biodiversity conservation and management. *Conserv. Biol.* **18**(3): 631–638.

Quiros, C. F., Brush, S. B., Douches, D. S., Zimmerer, K. S. and Huestis, G. 1990. Biochemical and folk assessment of variability of Andean cultivated potatoes. *Econ. Bot.* **44**(2): 254–266.

Ramakrishnappa, K. 2006. Geographical indications: a legal tool for protection of traditional varieties. *Biomed.* **1:** 91–93.

Ramirez, M. 2001. *Adventures in Agrobiodiversity, Ecotourism for Agrobiodiversity Conservation, a Feasibility Study.* Instituto Internacional de Recursos Fitogeneticos, Cali, Colombia.

Ramirez, M., Nicklin, C., Williams, D. E., Williams, K. A., Tapia, C., and Carrera, V. H. 2009. *Promotion of Andean Crops for Rural Development in Ecuador*. Mountain Forum, Lima, Peru. On line:http://www.mtnforum.org/rs/ol/searchft.cfm?step=vd&docid=4225 (*accessed 16 May 2010*).

Ramirez, M., and Williams, D. E. 2003. *Guía Agro-Culinaria de Cotacachi, Ecuador y Alrededores*. Instituto Internacional de Recursos Fitogeneticos, Cali, Colombia (in Spanish).

Ramprasad, V. 2003. Millet conservation in Southern India. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: Source Book Vol II: Strengthening Local Management of Agricultural Biodiversity.* pp. 362–367. CIP-UPWARDS 2003 Eds., International Potato Centre (CIP) and User's Perspectives With Agricultural Research and Development (UPWARD), Los Banos, Philippines.

Ramprasad, V. 2009. Community seed banks for maintaining genetic diversity. *LEISA Mag. Low Ext. Imput Sustain. Agric.* **23**(2): 20–21.

Rana, R. B. 2004. *Influence of Socio-Economic and Cultural Factors on Aagrobiodiversity Conservation on-Farm in Nepal.* PhD Thesis, The University of Reading, UK.

Rana, R. B., Garforth, C., Jarvis, D., and Sthapit, B. 2007a. Influence of socioeconomic and cultural factors in rice varietal diversity management on-farm in Nepal. *Agric. Hum. Values* **24**(4): 461–472.

Rana, R. B., Garforth, C., and Sthapit, B. R. 2008. Farmers' management of rice varietal diversity in the mid hills of Nepal: Implications for on-farm conservation and crop improvement. *Plant Genet. Resour. Charact. Utiliz.* **28:** 1–14.

Ravi, S. B. 2009. *The Conflict Between Seed Bill and PPVFR Act of India: Lessons for Other South Asian Countries.* Policy Brief. No. 19, Kathmandu, South Asia Watch on Trade, Economy and Environment (SAWTEE), Nepal.

Regine, A. 2005 *Results from an International Stakeholder Survey on Farmers' Rights*, FNI Report 9/2005. The Fridtjof Nansen Institute, Lysaker, Norway.

Remington, T., Walsh, S., Charles, E., Maroko, J., and Omanga, P. 2002. Getting off the seeds-and-tools treadmill with CRS seed vouchers and fairs. *Disasters* **26**(4): 316–328.

Renard, M. C. 2003, Fair trade: quality, market and conventions. *J. Rural Stud.* **19:** 87–96.

Rhouma, A., Nasr, N., Zirari, A., and Belguedj, M. 2006. Indigenous knowledge in management of abiotic stress: date palm geneticresources diversity in the oases of Maghreb region. **In:** *Enhancing the Use of Crop Genetic Diversity to Manage Abiotic Stress in Agricultural Production Systems. 23-27 May, Budapest, Hungary*. pp. 55–61. Jarvis, D., Mar, I., and Sears, L., Eds., Bioversity International, Rome, Italy.

Richards, P., and Ruivenkamp, G. 1997. *Seeds and Survival: Crop Genetic Resources in War and Reconstruction in Africa*. International Plant Genetic Resources Institute, Rome, Italy.

Richards, A. 2001. Does low biodiversity resulting from modern agricultural practice affect crop pollination and yield? *Ann. Bot.* **88:** 165–172.

Richards, P., De Bruin-Hoekzema, M., Hughes, S. G., Kudadjie-Freeman, C., Offei, S., Struik, P. and Zannou, A. 2009. Seed systems for African food security: linking molecular genetic analysis and cultivator knowledge in West Africa. *Int. J. Technol. Manage.* **45**(1-2): 196–214.

Rijal, D. K. 2007. *On-farm Conservation and Use of Local Crop Diversity: Adaptations of Taro (Colocasia esculenta) and Rice (Oryza sativa) Diversity to Varying Ecosystems of Nepal.* Ph. D Thesis. University of Life Science (UMB), Norway.

Rijal, D., Rana, R., Subedi, A., and Sthapit, B. 2000. Adding value to landraces: community-based approaches for *in situ* conservation of plant genetic resources in Nepal. **In***: Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* pp. 166–172. Friis-Hansen, E. and Sthapit, B., Eds., International Plant Genetic Resources Institute, Rome Italy,

Ríos, H. 2009. Participatory seed dissemination: some field experiences. *Cultivos Tropicales* **30**(2): 89–105.

Robbert, P., van der Steeg, R. P., Remington, T., Grum, M., and Kemigisha, E. 2004. Seed vouchers and fairs and agrobiodiversity in Western Uganda. **In:** *Addressing Seed Security in Disaster Response: Linking Relief with Development.* pp. 29–43. Sperling, L., Remington, T., Haugen, J. M. and Nagoda, S., Eds., International Center for Tropical Agriculture, Cali, Colombia.

Robertson, G. P., and Swinton, S. M. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. *Front. Ecol. Environ.* **3**(1): 38–46.

Rohrbach, D., and Kiala, D. 2007. Development options for local seed systems in Mozambique. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, *J. SAT Agric. Res.* **3**(1): 1–29.

Rohrbach, D. D., Mtenga, K., Kiriwaggulu, J. A. B., Monyo, E. S., Mwaisela, F., and Saadan, H. M. 2002. *Comparative Study of Three Community Seed Supply Strategies in Tanzania.* International Crop Research Institute for the Semi-Arid Tropics, Bulawayo, Zimbawe.

Ruiz, M. 2009. *Agrobiodiversity Zones and the Registry of Native Crops in Peru: Learning from Ourselves.* Bioversity International and Sociedad Peruana de Derecho Ambiental, Lima, Peru.

Rusike, E., Mujaju, C., Mafa, A., and Zinhanga, F. 2003. Increasing seed diversity through community seed fairs in Zimbabwe. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol I: Understanding Agricultural Biodiversity.* pp. 277–283. CIP-UPWARDS 2003 eds. International Potato Centre (CIP) and User's Perspectives with Agricultural Research and Development (UPWARD), Los Banos, Philippines.

Sadiki, M. 2006. Diversity of Moroccan local faba bean landraces for reaction to drought stress. **In:** *Enhancing Crop Genetic Diversity to Manage Abiotic Stress.* pp. 11–17. 23-27 May 2005, Budapest, Hungary. Jarvis, D., Mar, I., and Sears, L., Eds., Bioversity International, Italy, Rome.

Sadiki, M., Belqadi, L., Mahdi, M., and Jarvis, D. 2001. Identifying units of diversity management by comparing traits used by farmers to name and distinguish faba bean (*Vicia faba* L.) cultivars with measurements of genetic distinctiveness in Morocco. **In:** *Proceedings of the legumed Symposium "Grain Legumes in the Mediterranean Agriculture,"* October 25–27, 2001, Rabat, Morocco.

Sadiki, M., Birouk, A., Bouizzgaren, A., Belqadi, L., Rh'rrib, K., Taghouti, M., Kerfal, S., Lahbhili, M., Bouhya, H., Douiden, R., Saidi, S., and Jarvis, D. 2002. La diversité génétique in situ du blé dur, de l'orge, de la luzerne et de la fève: Options de stratégie pour sa conservation. **In:** *La conservation In-Situ de la Biodiversite Agricole: Un Defi Puor Une Agriculture Durable*. Actes du Seminaire National Rabat, 21 et 22 Janvier 2002. pp. 37–117. Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoun, A. and Jarvis, D., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Sadiki, M., and Jarvis, D. 2005. Conservation *in situ* de la diversité génétique des clutures par sa gestion à la ferme dans les agro écosystèmes marocains. *Les Actes du BRG* **1:** 347–357 (in French).

Sadiki, M., Jarvis, D., Rijal, D., Bajracharya, J., Hue, N. N., Camacho, T. C., Burgos-May, L. A., Sawadogo, M., Balma, D., Lope, D., Arias, L., Mar, I., Karamura, D., Williams, D., Chavez-Servia, J., Sthapit, B., and Rao, V. R. 2007. Variety names: an entry point to crop genetic diversity and distribution in agroecosystems? **In:** *Managing Biodiversity in Agricultural Ecosystems.* pp. 34–76. Jarvis, D. I., Padoch, C., and Cooper, D., Eds., Columbia University Press, New York, USA.

Sagnard, F., Barnaud, A., Deu, M., Barro, C., Luce, C., Billot, C., Rami, J. F., Bouchet, S., Dembele, D., Pomies, V., Calatayud, C., Rivallan, R., Joly, H., vom Brocke, K., Toure, A., Chantereau, J., Bezancon, G., and Vaksmann, M. 2008. Multi-scale analysis of sorghum genetic diversity: understanding the evolutionary processes for *in situ* conservation. (Special issue: Agrobiodiversites). *Cah. Agric.* **17**(2): 114–121.

Salazar, R., Louwaars, N. P., and Visser, B. 2007. On protecting farmers' new varieties: new approaches to rights on collective innovations in plant genetic resources. *World Dev.* **35:** 1515–1528.

Salick, J., Cellinese, N., and Knapp, S. 1997. Indigenous diversity of Cassava: generation, maintenance, use and loss among the Amuesha, Peruvian upper Amazon. *J. Econ. Bot.* **51**(1): 6–19.

Satheesh, P. V. 2000. Linking to community development: using participatory approaches to in situ conservation. **In:** *Participatory Approaches to the Conservation and Use of Plant Genetic Resources.* Friis-Hansen, E., and Sthapit, B. R., eds., International Plant Genetic Resources Institute, Rome.

Sawadogo, M., Balma, D., Some, L., Fadda, C. and Devra, J. 2006. Management of the agrobiodiversity under the clinal variation of rainfall pattern in Burkina Faso: the example of okra drought resistance. **In:** *Enhancing Crop Genetic Diversity to Manage Abiotic Stress*. pp. 18–24. 23-27 May 2005, Budapest, Hungary. Jarvis D., Mar, I. and Sears L., Eds., Bioversity International, Italy, Rome.

Sawadogo, M., Ouedraogo, J., Belem, M., Balma, D., Dossou, B., and Jarvis, D. I. 2005. Components of the ecosystem as instruments of cultural practices in the in situ conservation of agricultural biodiversity. *Plant Genet. Resour. Newsl.* **141:** 19–25.

Scarcelli, N., Tostain, S., Baco, M. N., Agbangla, C., Dainou, O., Vigouroux, Y. and Pham, J. L., Maxted, N., Ford-Lloyd, B. V., Kell, S. P., Iriondo, J. M., Dulloo, M. E. and Turok, J. 2007. Does agriculture conflict with *in situ* conservation? A case study on the use of wild relatives by yam farmers in Benin. **In:** *Crop Wild Relative Conservation and Use.* pp. 331–339. CABI Publishing, Wallingford, UK.

Scarcelli, N., Tostain, S., Vigouroux, Y., Agbangla, C., Daïnou, O., and Pham, J. L. 2006. Farmers' use of wild relative and sexual reproduction in a vegetatively propagated crop. The case of yam in Benin. *Mol. Ecol.* **15:** 2421–2431.

Scheidegger, U., and Prain, G. 2000. Support to diversity in potato seed supply. **In:** *Encouraging Diversity – The Conservation and Development of Plant Genetic Resources.* pp. 232–236. Almekinders, C.and de Boef, W., eds., Intermediate Technology Publications, London, UK.

Schumann, G. L. 1991. *Plant Diseases: Their Biology and Social Impact.* APS Press, St. Paul, Minnesota, USA.

Sedjo, R. A., and Swallow, S. K. 2002. Voluntary eco-labeling and the price premium. *Land Econ.***78**(2): 272–284.

Shah, A. A., and Tripathi, R. B. 2009. Effective agricultural information sources for contact and non contact farmers under T and V system of extension in Kashmir. *Asian J. Home Sci.* **4**(1): 64–66.

Shalpykov, K. 2008. Sovremennoe sostoyaniye I perspective izucheniya prioritetnikj plodovikh kultur v Kyrgyzstane (Current status and prospects of study of priority fruit crops in Kyrgyzstan). *Vestnik of Kyrgyz Technical University* (in Russian), Kyrgyzstan.

Shrestha, R. R. 2009. Rainwater harvesting and groundwater recharge for water storage in the Kathmandu valley. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, ICIMOD. *Sustain. Mount. Dev.* **56:** 27–30.

Shrestha, R. R., Pitamber, S., Maharjan, S. K., and Sthapit, B. R. 2010. *Participatory Seed Exchange to Enhance Conservation and Use of Genetic Resources in Home Garden.* Paper presented at the National Workshop on Home Garden of Nepal. Kathmandu, Nepal.

Shrestha, P., Subedi, A., Sthapit, S., Rijal, D., Gupta, S. K., Sthapit, B. 2006. Community seed bank: reliable and effective option for agricultural biodiversity conservation. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sillitoe, P. 2003. The gender of crops in the Papua New Guinea highlands. **In:** *Women and Plants, Gender Relations in Biodiversity Management and Conservation.* pp. 165–180. Howard, P., Eds., Zed Books, NY, USA.

Singh, I. P. 2010. National Research Centre for Citrus (NRCC, Nagpur India), pers. comm.

Sismanto, Y. 2003. Rediscovering local rice for improved food security in Indonesia. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol I: Understanding Agricultural Biodiversity.* pp. 177–182. CIP-UPWARDS 2003 eds. International Potato Centre (CIP) and User's Perspectives with Agricultural Research and Development (UPWARD), Los Banos, Philippines.

Siudek, T. 2008. Regional economic development: theory and practice in Poland economic science for rural development. **In:** *Economic Science for Rural Development.* Proceedings of the International Scientific Conference on Finances, Taxes, Investment and Support Systems **17:** 136–144. Jelgava, Lettonia. (http://ef.llu.lv/files/p2/Finances_Taxes_Investment_and_Support_Systems_17_1.pdf#page=135 *accessed May 8 2010*).

Slatkin, M. 1991. Inbreeding coefficients and coalescence times. *Genet. Res.* **58**(2): 167–175.

Slootweg, R., Kolhoff, A, Verheem, R., and Hoft, R., 2006. *Biodiversity in EIA and SEA*. Background Document to CBD Decision VIII/28. Voluntary Guidelines on Bioversity-Inclusive Impact Assessment. Secretariat of the Convention on Biological Diversity. Montreal, Canada.

Smale, M., 2006. *Valuing Crop Biodiversity: On-Farm Genetic Resources and Economic Change.* CABI Publishing, Wallingford, UK.

Smale, M., Bellon, M., and Aguirre A. 2001. Maize diversity, variety attributes, and farmers' choices in southeastern Guanajuato, Mexico. *Econ. Dev. Cult. Change* **50**(1): 201–225.

Smale, M., Bellon, M. R., Jarvis, D., and Sthapit, B. 2004. Economic concepts for designing policies to conserve crop genetic resources on-farms. *Genet. Resour. Crop Ev.* **51:** 121–135.

Smale, M., Cohen, M. J., and Nagarajan, L. 2009. *Local Markets, Local Varieties: Rising Food Prices and Small Farmers' Access to Seed.* Issue Brief 59, IFPRI, Washington, DC, USA.

Smale, M., Diakité, L., and Grum, M. 2009. *Mali: Millet and Sorghum seed in the Sahel.* IFPRI, Washington, DC, USA.

Smale, M., Diakité, L., and Grum, M. 2010. When grain markets supply seed: village markets for millet and sorghum in the Malian Sahel. **In:** *Seed Trade in Rural Markets: Implications for Crop Diversity and Agricultural Development.* pp. 53–74. Lipper, L., Anderson, C. L., and Dalton, T. J., Eds., United National Food and Agricultural Organization (FAO), Rome, Italy.

Smale, M., Diakite, L., Sibide, A., Grum, M., Jones, H., Traore, I.S., and Guindo, H. 2008. *The Impact of Farmer Participation in Diversity Field Flora, Mali*. Discussion Paper 746. IFPRI, Washington, DC, USA.

Smale, M., and King, A. 2005. *Genetic Resource Policies: What Is Diversity Worth to Farmers?* Briefs 13-18. International Plant Genetic Resources Institute and IFPRI.

Smale, M., Lipper, L., and Koundouri, P. 2006. Scope, limitation and furture directions. **In:** *Valuing Crop Biodiversity, On Farm Genetic Resources and Economic Change.* pp 280–295. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Smith, B. G., Pollock, C., Pretty, J., Crute, I., Leaver, C., and Dalton, H. 2008. Developing sustainable food supply chains. Philosophical transactions of the Royal Society of London. *Biol. Sci. Series B* **363:** 849–861.

Smolders, H., and Caballeda, E. 2006. *Field Guide for Participatory Plant Breeding in Farmer Field Schools.* CGN, the Netherlands, Eds., 136 pp, PEDIGREA publication.

Song, Y., and Jiggins, J. 2003. Women and maize breeding: the development of new seed systems in a marginal area of South-west China. **In:** *Women and Plants, Gender Relations in Biodiversity Management and Conservation.* pp. 273–287. Howard, P., Eds., Zed Books, NY, USA.

Sperling, L., Ashby, J. A. Q., Smith, M. E., Weltzien, E., and McGuire, S. 2001. A framework for analyzing participatory plant breeding approaches and results. *Euphytica* **122:** 439–450.

Sperling, L., and Cooper, H. D. 2006. Understanding seed system and strengthening seed security: a background paper. **In:** *Towards Effective and Sustainable Seed Relief Aactivities.* United National Food and Agricultural Organization (FAO) plant production and protection paper 181. Rome, Italy.

Sperling, L, Cooper, H. D., and Remington, T. 2008. Moving towards more effective seed aid. *J. Dev. Stud.* **44**(4): 586–612.

Sperling, L., and Mcguire, S. 2010. Understanding and strengthening informal seed markets. *Expl. Agric.* **46**(2): 119–136.

Srinivasan, C.S., 2003. Exploring the feasibility of farmers' rights. *Dev. Policy Rev.* **21**(4): 419–447.

Sthapit, B. 1998. Nepal 'diversity fair' inspires community. Geneflow, International Plant Genetic Resources Institute, Rome, Italy.

Sthapit, B. 1999. Nepal 'poets and farmers unite in Nepal to save native crops'. p.25. Geneflow, International Plant Genetic Resources Institute, Rome, Italy.

Sthapit, B. R., Joshi, K. D., Rana, R. B., Upadhayay, M. P., Eyzaguirre, P., and Jarvis, D. 2000. Enhancing biodiversity and production throught participatory plant breeding: setting breeding goals. **In:** *An Exchange of Experiences from South and South Est Asia.* Proceedings of the International Symposium on Participatory Plant genetic Resource Enhancement, Pokhara, Nepal, 1-5 May 2000. International Center for Tropical Agriculture, PRGA Program, Cali, Colombia.

Sthapit, B., Gautam, R., Gyawali, S., Joshi, B. K., Subedi, A., Yadav, R. B., Chaudhary, P., and Rijal, D. 2006d. Diversity kits: deploying new diversity to farmers. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K. and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sthapit, B. R., Joshi, K. D., and Witcombe, J. R. 1996. Farmer participatory crop improvement. III: participatory plant breeding, a case study for rice in Nepal. *Exp. Agric.* **32:** 479–496.

Sthapit, B. R., and Quek, P. 2005. Community biodiversity register: overview, concepts and some systematic approaches. **In:** *Learning from Community Biodiversity Register in Nepal.* Proceedings of the National Workshop 27-28 Oct 2005, Khumaltar, Nepal. Subedi, A., Sthapit, B., Upadhyay, M. P. and Gauchan, D., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sthapit, B., Rana, R., Eyzaguirre, P., and Jarvis, D. 2008a. The value of plant genetic diversity to resource-poor farmers in Nepal and Vietnam. *Int. J. Agric. Sustain.* **6**(2): 148–166.

Sthapit, B., Rana, R. B., Subedi, A., Gyawali, S., Bajracharya, J., Chaudhary, P., Joshi, B. K., Sthapit, S., Joshi, K. D., and Upadhyay, M. P. 2006b. Participatory four cell analysis (FCA) for local crop diversity. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sthapit, B. R., and Rao, V. R. 2009. Consolidating community's role in local crop development by promoting farmer innovation to maximise the use of local crop diversity for the well-being of people. *Acta Hort.* **806:** 669–676; http://www.actahort.org/books/806/806_83.htm.

Sthapit, B. R., Rijal, D., De, N. N., and Jarvis, D. 2003a. A role for diversity fairs: experiences from Nepal and Vietnam. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol II: Strengthening Local Management of Agricultural Biodiversity.* pp. 271–276. CIP-UPWARDS 2003, Eds., Los Banos, Philippines.

Sthapit, B., Shrestha, P., Baral, K. P., Subedi, A., Bajracharya, J., Yadav, R. B. 2006c. Diversity block: assessing and demonstrating local crop diversity. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K. and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sthapit, B. R., Shrestha, P. K., Subedi, A., Shrestha P., Upadhyay, M. P., and Eyzaguirre, P. 2008b. Mobilizing and empowering community in biodiversity management. **In:** *Farmer's Varieties and Seeds. Supporting Informal Seed Supply in Ethiopia.* pp.160–166. Thijssen, M. H., Bishaw, Z., Beshir, A., and de Boef, W. S., Eds., Wageningen International, Wageningen, The Netherlands.

Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds. 2006a. *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sthapit, B. R., Subedi, A., Gyawali, S., Jarvis, D., and Upadhaya, M. P. 2003b. *In situ* conservation of agricultural biodiversity through participatory plant breeding in Nepal. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol II: Strengthening Local Management of Agricultural Biodiversity.* pp. 311–321. CIP-UPWARDS 2003, Eds., Los Banos, Philippines.

Sthapit, B. R., Subedi, A., Rijal, D., Rana, R., and Jarvis, D. 2003d. Strengthening community-based on-farm conservation of agricultural biodiversity: experiences from Nepal. **In:** *Conservation and Sustainable Use of Agricultural Biodiversity: A Source Book Vol II: Strengthening Local Management of Agricultural Biodiversity.* pp. 344–354. CIP-UPWARDS 2003, Eds., Los Banos, Philippines.

Sthapit, B. R., Subedi A., Shrestha P., Shrestha P. K., and Upadhyay M. P. 2008c. Practices supporting community management of farmers' varieties. 2008. **In:** *Farmer's Varieties and Seeds. Supporting Informal Seed Supply in Ethiopia.* pp.166–171. Thijssen, M. H., Bishaw, Z., Beshir, A. and de Boef, W. S., Eds., Wageningen International, Wageningen, The Netherlands.

Sthapit, B. R., Upadhyay, M. P., Baniya, B. K., Subedi, A., and Joshi, B. K. 2003e. *On Farm Management of Agricultural Biodiversity in Nepal.* Proceedings of a National workshop, 24-26 April 2001, Lumle, Nepal. International Plant Genetic Resources Institute, LI-BIRD and NARC, Eds., Kathmandu, Nepal.

Steele, K. A., Edwards, G., Zhu, J., and Witcombe, J. R. 2004. Marker-evaluated selection in rice: shifts in allele frequency among bulks selected in contrasting agricultural environments identify genomic regions of importance to rice adaptation and breeding. *Theor. Appl. Genet.* **109:** 1247–1260.

Steele, K. A., Virk, D. S., Kumar, R., Prasad, S. C., and Witcombe, J. R. 2004. Field evaluation of upland rice lines selected for QTLs controlling root traits. *Field Crop Res.* **101**(2007): 180–186.

Strange, R. N., and Scott, P. R. 2005. Plant disease: a threat to global food security. *Ann. Rev. Phytopathology* **43:** 83–116.

Subedi, A., Chaudhary, P., Baniya, B., Rana, R., Tiwari, R., Rijal, D., Jarvis, D. and Sthapit, B. 2003. Who maintains crop genetic diversity and how: implications for on-farm conservation and utilization. *Cult. Agric.* **25**(2): 41–50.

Subedi, A., and Garforth, C. 1996. Gender information and communication networks: implications for extension. *Eur. J. Agric. Educ. Exten.* **3**(2): 63–74.

Subedi, A., Sthapit, B., Rijal, D., Gauchan, D., Upadhyay, M. P., and Shrestha, P. K. 2006. Community biodiversity register: consolidating community role in management of agricultural biodiversity. **In:** *Good Practices: On-farm Management of Agricultural Biodiversity in Nepal.* Sthapit, B. R., Shrestha, P. K., and Upadhyay, M. P., Eds., NARC, LI-BIRD, International Plant Genetic Resources Institute and IDRC, Kathmandu, Nepal.

Sunwar, S., Baral, K. P., Joshi, M., Basnet, B. M. S., Gyawali, S., Subedi, A., Upadhayay, M. P., Shrestha, P. K., and Sthapit, B. R. 2005. Developing resource guide book on agrobiodiversity for secondary school. **In:** *On-farm Conservation of Agricultural Biodiversity in Nepal. Vol II. Managing Diversity and Promoting its Benefits.* Proceedings of the Second National Workshop 25-27 August 2004, Nagarkot, Nepal. Sthapit, B. R., Upadhyay, M. P., Shrestha, P. K. and Jarvis D., Eds., International Plant Genetic Resources Institute, NARC, LI-BIRD, Kathmandu, Nepal.

Sunwar, S., Basnet, L. K., Khatri, C., Subedi, M., Shrestha, P., Gyawali, S., Bhandari, B., Gautam, R., and Sthapit, B. 2007. Consolidating farmer's roles in participatory maize breeding in Nepal. **In:** *Bringing Farmers Back into Breeding Experiences with PPB and Challenges for Institutionalisation.* Almekinders, C. J. M., Hardon, J. with Christink, A., Humphries, S., Pelegrina, D., Sthapit, B., Vernooy, R., Visser, B., and Weltzien, E., Eds., AgroSpecial 5, Agromisa Wageningen, The Netherlands.

Swallow, S. K., and Sedjo, R. A. 2000. Eco-labeling consequences in general equilibrium: a graphical assessment. *Land Econ.* **76:** 28–36.

Swaminathan, M. S. 2000. Government-industry-civil society: partnerships in integrated gene management. Volvo environment prize lecture 1999. *Ambio* **29:** 115–121.

Swaminathan, M. S. 2001. Community grain bank movement. **In:** *Community Grain Bank- an Instrument for Local Food Security.* pp. 11–15. Swaminathan, M. S. Research Foundation and World Food Programme, Chennai, India.

Swaminathan, M. S. 2003. Towards an evergreen revolution in agriculture: technology, planning nd management. *Rites J.* **7:** 1–14.

Swanson, T. 1996. Global values of biological diversity: the public interest in the conservation of plant genetic resources for agriculture. *Plant Genet. Resour. Newsl.* **105:** 1–7.

Swanson, T., and Goschl, T. 2000. Property rights issues involving plant genetic resources: implications of ownership for economic efficiency. *Ecol. Econ.* **32:** 75–92.

Swift, M.J., Izac, A. M. N., and van Noordwijk, M. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? *Agric. Ecosyst. Environ.* **104:** 113–134.

Taghouti, M., and Saidi, S. 2002. Perception et désignation des entités de blé dur gérées par les agriculteurs. **In:** *La Conservation in Situ de la Biodiversité Agricole: Un Défi pour une Agriculture Durable.* pp. 275–279. Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoune, A. and Jarvis, D., Eds., International Plant Genetic Resources Institute, Rome, Italy (in French).

Tahiri, A., 2005. Seed systems in Morocco. **In:** *Seed Systems and Crop Genetic Diversity On-Farm*. Proceeding of a Workshop, 16-20 September 2003, Pucallpa, Peru. pp. 133–139. Jarvis, D. I., Sevilla-Panizo, R., Chavez-Servia, J. L. and Hodgkin, T., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Tanto, T. H., Ra, D., Bitocchi, E., and Papa, R. 2009. Genetic diversity of barley (*Hordeum vulgare L.)* landraces from the central highlands of Ethiopia: comparison between the Belg and Meher growing seasons using morphological traits. *Genet. Resour. Crop Ev.* **56:** 1131–1148.

Tapia, M. E. 2000. Mountain agrobiodiversity in Peru: Seed fairs, seed banks, and mountain-to-mountain exchange. *Mount. Res. Dev.* **20:** 220–225.

Tapia, M. E., and De la Torre, A. 1998. *Women Farmers and Andean Seeds. Gender and Genetic Resources Management.* International Plant Genetic Resources/United Nations, Food and Agricultural Organization (FAO), Rome, Italy.

Tapia, M. E., and Rosa, A. 1993. Seed fairs in the Andes: a strategy for local conservation of plant genetic resources. **In:** *Cultivating Knowledge: Genetic Diverity, Farmer Participation and Crop Research.* pp. 111–118. de Boef. W., Amanor, K., Wellard, K. and Beddington, A., Eds., IT Publications, UK.

Teshome, A., Baum, B. R., Fahrig, L., Torrance, J. K., Arnason, T. J., and LAmbert, J. D. 1997. Sorghum (*Sorghum bicolor* (L.) Moench) landrace variation and classification in north Shewa and south Welo regions of Ethiopia. *Euphytica* **97:** 255–263.

Teshome, A., Brown, A. H. D., and Hodgkin, T. 2001. Diversity in landraces of cereal and legume crops. *Plant Breeding Rev.* **21:** 221–261.

Teshome, A., Torrance, J.K., Lamber, J. D. H., Fahrig, L., Baum, B. R., and Arnason, J. T. 1999. Traditional farmers' knowledge or sorghum (*Sorghum biocolor* [Poaceae]) landrace storability in Ethiopia. *Econ. Bot.* **53:** 69–78.

Thamaga-Chitja, J. M., Hendriks, S. L., Ortmann, G. F. and Green, M. 2004. Impact of maize storage on rural household food, security in Northern Kwazulu-Natal. *J. Fam. Ecol. Cons. Sci.* **32:** 8–15. http://ajol.info/index.php/jfecs/article/viewFile/52843/41445 (*accessed 16 May 2010)*.

The Crucible Group. 1994. *People, Plants and Patents. The Impact of Intellectual Property on Trade, Plant Biodiversity and Rural Society*. IDRC, Montreal, Canada.

Thies, E. 2000. *Incentive Measures Appropriate to Enhance the Conservatioin and Sustainable Use of Agrobiodiversity.* Deutsche Gesellschaft Technische Zusammenarbeit (GTZ). Eschborn, Germany. http://69.90.183.227/doc/case-studies/inc/cs-inc-gtz-incentivesagrobiodiv-workshop2009-en.pdf (*accessed* 16 May 2010).

Thijssen, M. H., Bishaw, Z., Beshir, A., and de Boef, W. (Eds.). 2008. *Farmer's Varieties and Seeds. Supporting Informal Sseed Supply in Ethiopia.* Wageningen International, Wageningen, The Netherlands.

Thinlay, X. 1998. *Rice Blast, Caused by Magnaporthe Grisea, in Bhutan and Development of Strategies for Resistance Breeding and Management.* Dissertation Eth No. 127777, Swiss Federal Institute of Technology, Zurich, Swizterland.

Thinlay, X., Finckh, M. R., Bordeosc, A. C., and Zeigler, R.S. 2000. Effects and possible causes of an unprecedented rice blast epidemic on the traditional farming system of Bhutan. *Agric. Ecosyst. Environ.* **78:** 237–248.

Thurston, H. D., Salick, J., Smith, M. E., Trutmann, P., Pham J. L., and McDowell, R. 1999. Traditional management of agrobiodiversity. **In:** *Agrobiodiversity. Characterization, Utilization and Management*. pp.211–243. Wood, D., and Lenné, J. M., Eds., CABI Publishing, Wallingford, UK.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., and Polasky, S. 2002. Agricultural sustainability and intensive production practices. *Nature* **418:** 671–677.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W. H., Simberloff, D., and Swackhamer, D. 2001. Forecasting agriculturally driven global environmental change. *Science* **292:** 281–284.

Toledo, A. 2002. Saving the seed - Europe's challenge. *Seedling*, April 2002, Grain Publications, Barcelona, Spain.

Triomphe, B., Sabourin, E., Hocde, H., Scopel, E., Oliveira de, M. N. de, Xavier J. H. V., Silva da, F. A., Macena da Silva, F. A., and Ramos de Almeida, S. C. 2008. Participatory cropping and farming system design among multiple stakeholders to contribute to sustainable agricultural production. Experiences and lessons with the agriarian reform sector in the Brazilian Cerrados. **In:** *Empowerment of the Rural Actors: A Renewal of Farming Systems Perspectives*. 8th European IFSA Symposium, Clermont-Ferrand, France, 6-10 July 2008. pp. 3–12. Dedieu, B., and Zasser-Bedoya, S., Eds., Clermont-Ferrand, France.

Tripp, R. 1998. Regulatory issues: varietal registration and seed quality control. **In:** *Maize Seed Industries in Developing Countries*. pp. 159–174. Morris M. L., Eds., Lynne Rienner Publishers and the International Maize and Wheat Improvement Center. Boulder, Colorado; London, UK; Mexico DF, Mexico.

Tripp, R. 2000. *GMOs and NGOs: Biotechnology, the Policy Process, and the Presentation of Evidence.* Overseas Development Institute (ODI), London, UK.

Tripp, R. 2001. *Seed Provision and Agricultural Development.* Overseas Development Institute (ODI), London, UK.

Tripp, R. 2002. Seed regulatory reform: an overview. *J. New Seeds***4:** 103–115.

Tripp, R. 2006. Strategies for seed system development in sub-Saharan Africa: a study of Kenya, Malawi, Zambia and Zimbabwe. *J. SAT Agric. Res.* **2**(1): 1–47.

Tripp, R. and Rohrbach, D. 2001. Policies for African seed enterprise development. *Food Policy* **26**(2): 147–161.

Trutmann, P., Fairhead, J., and Voss, J. 1993. Management of common bean diseases by farmers in the Central African highlands. *Int. J. Pest Manage.***39:** 334–342.

Trutmann, P., and Pyndji, M. M. 1994. Partial replacement of local common bean mixtures by high yielding angular leaf spot resistant varieties to conserve local genetic diversity while increasing yield. *Ann. App. Biol.* **125:** 45–52.

Trutmann, P., Voss, J., and Fairhead, J. 1996. Indigenous knowledge and farmer perception of common bean disease in the central African highlands. *Agric. Hum. Values* **13:** 64–70.

Tsehaye, Y., Berg, T., Tsegaye, B., and Tanto, T. 2006. Farmers' management of finger millet (*Eleusine coracana* L.) diversity in Tigray, Ethiopia, and implications for on-farm conservation. *Biodivers. Conserv.* **15**(13): 4289–4308.

Turgunbaev, K. T. 2009. Vinigradarstvo Kyrgyzstana. (Viticulture in Kyrgyzstan) *Vestnik of Kyrgyz Technical University*, Bishkek, Kyrgyzstan (in Russian).

Tushemereirwe, W. K. 1996. *Factors Influencing the Expression of Leaf Spot Diseases of Highland Bananas in Uganda*. PhD thesis, University of Reading, UK.

Tuxill, J., Reyes, L. A., Latournerie, L., Cob, V., and Jarvis, D. I. 2009. All maize is not equal: maize variety choices and mayan foodways in rural Yucatan, Mexico. **In***: Pre-Columbian Foodways: Interdisciplinary Approaches to Food, Culture and Markets in Mesoamerica.* pp. 467–486. Edited by Staller, J. E. and Carrasco, M. D., Eds., Springer, NY, USA.

UNORCAC 2008. *Unión de Organizaciones Campesinas e Indígenas de Cotacachi - Ecuador.* http://www.equatorinitiative.org/index.php?option

=com_content&view=article&id=543%3Aunorcac&catid=107%3Aequator-prize-winners-2008&Itemid=541&lang=en Accessed on 16 May 2010.

Valdivia, R. F. 2005. The use and distribution of seeds in areas of traditional agriculture.**In:** *Seed Systems and Crop Genetic Diversity On-Farm.* Proceedings of a workshop, September 16–20, 2003, Pucallpa, Peru. pp. 17–21. Jarvis, D. I., Sevilla-Panizo, R., Chavez-Servia, J. L. and Hodgkin, T., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Valdivia Bernal, R., Caro Velarde, F. de J., Ortiz Catón, M., Betancourt Vallejo, A., Ortega Corona, A., Vidal Martínez, V. A., and Espinosa Calderón, A. 2007. Participatory development of maize synthetic hybrids and seed production by farmers. *Agric. Técn. Méx.* **33**(2): 135–143.

Vallavieille-Pope de, C. 2004. Management of disease resistance diversity of cultivars of a species in single fields: controlling epidemics. *Comp. Rendus Biol.***327:** 611–620.

Van der Berg, H., and Jiggins, J. 2007. Investing in farmers- the impacts of farmers field schooling relation to integrated pest management. *World Dev.* **35**(4): 663–686.

Van der Steeg, R. P., Remington, T., Grum, M., and Kemigisha, E. 2004. Seed vouchers and fairs and agrobiodiversity in Western Uganda. **In:** *Addressing Seed Security in Disaster Response Linking Relief with Development.* pp. 29–43. Sperling, L., Remington, T., Haugen, J. M., and Nagoda, S., Eds. CIAT, Cali, Colombia.

Vandermeer, J. 1995. The ecological basis of alternative agriculture. *Ann. Rev. Ecol. and Syst.* **26:** 201–224.

Van Dusen, M. E. 2006. Missing markets, migration, and corp biodiversity in the *Milpa* system of Mexico: a household farm model. **In:** *Valuing Crop Biodiversity: On-farm Genetic Resources and Economic Change.* pp. 63–77. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Van Dusen, M. E., Dennis, E, Ilyasov, J., Lee, M., Treshkin, S., and Smale, M. 2006. Social institutions and seed systems: The diversity of fruits and nuts in Uzbekistan. **In:** *Valuing Crop Biodiversity: On-farm Genetic Resources and Economic Change.* pp. 192–210. Smale, M., Eds., CABI Publishing, Wallingford, UK.

Van Dusen, E., Gauchanm, D., and Smale, M. 2007. On-farm conservation of rice biodiversity in Nepal: a simultaneous estimation approach. *J. Agric. Econ.* **58**(2): 242–259.

Van Dusen, M. E., and Taylor, J. E. 2005. Missing markets and crop diversity: evidence form Mexico. *Environ. Dev. Econ.* **10:** 513–531.

Van Noordwijk, M. 2005. *Rupes Typology of Environmental Service Worthy or Reward.* World Agroforestry Centre (ICRAF), Bogor, Indonesia. http://www.worldagroforestry.org:8090/water/downloads/Watershed%20Publications/2005%20van%20noordwijk.pdf

Vernooy, R., and Fajber, L. 2004. Making gender and social analysis work for natural resource management research: an umbrella program for building researcher capacity. **In:** *InterAction's Commission on the Advancement of Women and International Institute of Rural Reconstruction Gender Mainstreaming in Action: Successful Innovations from Asia and the Pacific*. pp. 208–223. Washington: InterAction's Commission on the Advancement of Women and Silang, Cavite: International Institute of Rural Reconstruction, Wa DC., USA.

Visser, B., and Jarvis, D. I. 2000. Upscaling approaches to support on-farm conservation. Encouraging biodiversity-the conservation and development of plant genetic resources. **In:** *Proceedings of the Baarlo Workshop*. pp. 134–141. Almekinders, C. and De Boef, W., Eds., Intermediate Technology Publications, London, UK.

Voss, J. 1992. Conserving and increasing on-farm genetic diversity: farmer management of varietal bean mixtures in central Africa. **In:** *Diversity, Farmer Knowledge and Sustainability*. pp. 34–51. Moock, J.L. and Rhoades, R.E., Eds., Cornell University Press, Ithaca, NY, USA.

Waage, J. K., Mumford, J. D., Pollock, C., Pretty, J., Crute, I., Leaver, C. and Dalton, H. 2008. Agricultural biosecurity. *Phil. Trans. R. Soc. B.* **363**(1492): 863–876.

Wale, E. In press. On biodiversity impact assessment: the rationale, conceptual challenges and implications for future EIA. **In:** *Examining the Impact of Development Interventions on Biodiversity: Lessons from GRPI-Egypt*. Halewood, M. and Wale, E., Eds. Genetic Resources Policy Initiative, Bioversity International. Rome, Italy.

Wale, E., Chishakwe, N., and Lewis-Lettington, R. 2008. Cultivating participatory policy processes for genetic resources policy: lessons from the Genetic Resources Policy Initiative (GRPI) project. *Biodivers.Conserv.* **18:**1–18.

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., Lebel, L., Norberg, J., Peterson, G. D., and Pritchard, R. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conserv. Ecol.* **6**(1): 14. [online] URL: http://www.consecol.org/vol6/iss1/art14 (accessd 9 May 2010)

Walker, B., Sayer, J., Andrew, N. L., and Campbell, B. 2010. Should enhanced resilience be an objective of natural resource management research for developing countries? *Crop Sci.* **50:** 10–19.

Walsh, S., Bihizi, J. M., Droeven C., Ngendahayo, B., Ndaboroheye, B., and Sperling, L. 2004. Drought, civil strife, and seed vouchers and fairs: the role of the trader in the local seed system. **In:** *Addressing Seed Security in Disaster Response: Linking Relief with Development.* pp. 15–28. Sperling, L., Remington, T., Haugen, J. M., and Nagoda S., Eds., International Center for Tropical Agriculture, Cali, Colombia.

Wambugu, P. W., Mathenge, P. W., Auma, E. O., and van Rheenen, H. A. 2009. Efficacy of traditional maize (*Zea mays* L.,) seed storage methods in Western Kenya. *Afr. J. Food Agric. Nutr. Dev.* **9**(4): 1110–1128. http://www.ajfand.net/Issue25/PDFs/Wambugu8010.pdf

Wang, J., and Caballero, A. 1999. Developments in predicting the effective size of subdivided populations. *Heredity* **82:** 212–226.

Wilson, C., and Tisdell, C. 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecol. Econ.* **39**(3): 449–462.

Weltzien, E., Rattunde, H. F. W., Clerget, B., Siart, S., Toure, A. and Sagnard, F. 2006. Sorghum diversity and adaptation to drought in West Africa. **In:** *Enhancing the Use of Crop Genetic Diversity to Manage Abiotic Sress in Agricultural Production Systems. 23-27 May, Budapest, Hungary.* pp. 31–38. Jarvis, D., Mar, I. and Sears, L., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Weltzien, E., and vom Brocke, K. 2000. Seed systems and their potential for innovation: conceptual framework for analysis.**In:** *Targeting Seed Aid and Seed System, Interventions: Strengthening Small Farmer Seed Systems in East and Central Africa.* pp. 9–13. Proceedings of a workshop, June 21–24, 2000, Kampala, Uganda. Kampala*: CIAT.* Sperling, L., Eds., Cali, Colombia.

Whitlock, M. C. 2003. Fixation probabilities and time in subdivided populations. *Genetics* **164:** 767–779.

Williams, K. A. 2009. Conserving crop diversity and a way of life in Ecuador. *Agric. Res.* **57**(7): 10–11.

Williams, D., and Ramirez, M. 2006. Native crop demonstration gardens. Plant conservation in a changing world. Botanic gardens take lead in climate change talks. *Bot. Garden Conserv. Int. Quarterly Newsl. (Cuttings)***3:** 5.

Witcombe, J. R., Gyawali, S., Sunwar, S., Sthapit, B. R., and Joshi, K. D. 2006. Participatory plant breeding is better described as highly client-oriented breeding II. Optional farmer collaboration in the segregating generations. *Expl. Agric*. **42:** 79–90.

Witcombe, J. R, Hollington, P. A., Howarth, C. J., Reader, S., and Steele, K. A. 2008. Breeding for abiotic stresses for sustainable agriculture. *Phil. Trans. R. Soc. B* **363:** 703–716.

Witcombe, J. R., Joshi, K. D., Gyawali, S., Musa, A. M., Johansen, C., Virk, D. S., and Sthapit, B. R. 2005. Participatory plant breeding is better described as highly client oriented plant breeding. I. Four indicators of client orientation in plant breeding. *Exp. Agric.* **41** (3): 299–319.

Witcombe, J. R., Joshi, A., Joshi, K. D., and Sthapit, B.R. 1996. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Expl. Agric.* **32:** 445–460.

Worede, M. 1997. Ethiopian *in situ* conservation. **In:** *Plant Genetic Conservation: The In situ Approach.* pp. 290–301. Maxted, N., Ford-Lloyd, B. V., and Hawkes, G., Eds., Chapman and Hall Ltd. London, UK.

Worede, M., Teshome, A., and Tesemma, T. 2000. Participatory approached linking farmer access to genebanks: Ethiopia. **In:** *Participatory Approaches to the*

Conservation and Use of Plant Genetic Resources. pp. 56–61. Friis-Hansen, E., and Sthapit, B., Eds., International Plant Genetic Resources Institute, Rome, Italy.

Wunder, S., Engel, S., and Pagiola, S. 2008. Taking stock: a comparative analysis of payments for environmental services programs in developed and developing countries. *Ecol. Econ.* **65:** 834–852.

Yue, B., Xue, W., Xiong, L., Yu, X., Luo, L., Cui, K., Jin, D., Xing, Y., and Zhang, Q. 2006. Genetic basis of drought resistance at reproductive stage in rice: separation of drought tolerance from drought avoidance. *Genetics* **172:** 1213–1228.

Yupit-Moo, E. 2002. *Seed Storage Systems of Milpa Crops in Yaxcaba, Yucatan*. Unpublished BS thesis, Instituto Tecnologico Agropecuario No. 2, Yucatán, Mexico.

Zannou, A. 2009. Economic assessment of seed-tuber practices of yam *Dioscorea cayenensis* and *Dioscorea rotundata* planting materials. *Afr. J. Agric. Res.* **4**(3): 200–207.

Zhu, Y., Chen, H., Fan, J., Wang, Y., Li, Y., Chen, J., Fan, J. X., Yang, S., Hu, L., Leung, H., Mew, T. W., Teng, P. S., Wang, Z., and Mundt, C. C. 2000. Genetic diversity and disease control in rice. *Nature* **406:** 718–722.

Zimmerer, K. S. 1996. *Changing Fortunes: Biodiversity and Peasant Livelihood in the Peruvian Andes*. University of California Press, Los Angeles, California, USA.

Zimmerer, K. S. 2003. Just small potatoes (and ulluco)? The use of seed-size variation in “native commercialized” agriculture and agrobiodiversity conservation among Peruvian farmers. *Agric. Hum. Values* **20:** 107–123.