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Whose Knowledge, Whose Development? Use and Role of Local and External Knowledge in Agroforestry Projects in Bolivia

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Abstract Agroforestry often relies on local knowledge, which is gaining recognition in development projects. However, how local knowledge can articulate with external and scientific knowledge is little known. Our study explored the use and integration of local and external knowledge in agroforestry projects in Bolivia. In 42 field visits and 62 interviews with agroforestry farmers, civil society representatives, and policymakers, we found a diverse knowledge base. We examined how local and external knowledge contribute to livelihood assets and tree and crop diversity. Projects based predominantly on external knowledge tended to promote a single combination of tree and crop species and targeted mainly financial capital, whereas projects with a local or mixed knowledge base tended to focus on food security and increased natural capital (e.g., soil restoration) and used a higher diversity of trees and crops than those with an external knowledge base. The integration of different forms of knowledge can enable farmers to better cope with new challenges emerging as a result of climate change, fluctuating market prices for cash crops, and surrounding destructive land use strategies such as uncontrolled fires and aerial fumigation with herbicides. However, many projects still tended to prioritize external knowledge and undervalue local knowledge—a tendency that has long been institutionalized in the formal educational system and in extension services. More dialogue is needed between different forms of knowledge, which can be promoted by strengthening local organizations and their networks, reforming agricultural educational institutions, and working in close interaction with policymakers.

Keywords Traditional agricultural knowledge · Local knowledge · Agroforestry · Knowledge co-production · Bolivia

Introduction

Agroforestry is increasingly recognized as an important agroecological practice that may balance farming families' ability to meet their food and income needs with the sustainable management and conservation of (agro)biodiversity, while contributing to climate change adaptation and mitigation (Nair and Garrity 2012). Past research and development projects among smallholders in the tropics have demonstrated positive relationships between agroforestry and improved livelihoods (Roshetko et al. 2007; Johansson et al. 2013). Diversified agroforestry systems can significantly enhance smallholders' social-ecological resilience by increasing and diversifying productivity while mitigating economic and environmental risks (Jacobi et al. 2015). Moreover, they play an important role in sustaining biodiversity in mosaic landscapes, as well in revegetating and restoring degraded agricultural areas (Schroth et al. 2004).

Agroforestry systems are knowledge intensive (e.g., regarding species selection and combination and management

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techniques) as compared to mechanized agricultural packages such as green-revolution technologies (Franzel et al. 2004; Jacobi et al. 2015). Furthermore, agroforestry practices are highly context-specific, making it difficult to develop scaling-up strategies (Johansson et al. 2013; Coe et al. 2014). While agricultural research and extension in the Andean region and in the Amazon lowlands have been dominated by a Western-centered approach that privileges scientific knowledge (Gonzales 2012; Urioste 2012; Boillat 2014), many agroforestry techniques are the product of traditional or local knowledge (Sorgedrager et al. 1991; Thapa et al. 1995; Altieri 2004). Aware that local and external knowledge cannot always be clearly separated, by local knowledge in this study we refer to both traditional and new experimental knowledge that has been developed, used, and reproduced by farmers and other local actors. By external knowledge, we refer to scientific and practical knowledge brought in from a different region; for example, about techniques and species that were not common in a given place before a project was initiated or before an organization started to work there.

In parallel with the rise of applied and action research that has promoted the active participation of local actors, a growing number of scholars have advocated for the recognition and use of local and indigenous forms of knowledge in agricultural research and extension (Scoones and Thompson 1994; Brokensha et al. 1980; Chambers et al. 1989; Powell 2006). A focus on local knowledge has been presented as an alternative to externally driven, top-down development focused on the transfer of technology (Pottier 2003). More recently, the importance of local agricultural knowledge has also been stressed for climate change adaptation and mitigation (Altieri 2004; Mertz et al. 2009; Pokorny et al. 2013). Moreover, agroforestry scholars have highlighted the importance of including local and traditional knowledge in natural resource management planning (Schulz et al. 1994; Thapa et al. 1995; Sinclair and Walker 1998; Couly and Sist 2013). Local knowledge should be used and valued wherever external knowledge, for example about agriculture, ecology, or self-organization in interest groups, is applied; this will advance efforts to achieve social equity and reduce poverty, and it will strengthen local people's efforts to face emerging, often externally induced challenges (see Rist and Dahdouh-Guebas 2006).

Focusing on local knowledge is in line with the concept of endogenous development (Haverkort et al. 2003; Rist et al. 2011) or "development from within," which calls for the concretization of aspirations of local actors based on local potential, resources and knowledge. In development-oriented research, the co-production of knowledge by scientific and nonscientific actors as part of a social learning process has been promoted for the joint building of the normative goal of sustainability (Rist et al. 2006; Pohl et al. 2010; Williams and Hardison 2013). Following Haverkort et al. (2003), endogenous development is based on local resources—including knowledge—and ways of social organization, which are complemented by exogenous knowledge and resources. Therefore, endogenous development "does not imply isolation: nor does it limit its attention to local processes. It actively uses the opportunities provided by globalization" (Haverkort et al. 2003: 30).

The case of agroforestry in Bolivia is especially interesting because there is a high level of biological and ecological diversity, combined with a rich cultural heritage that has led to the development of highly productive and resilient traditional agricultural systems (Gilles et al. 2013). Local farmers have a rich traditional knowledge of woody plants in many parts of Bolivia (Sorgedrager et al. 1991; Johnson 1998; Mathez-Stiefel et al. 2012; Brandt et al. 2013): agroforestry has been practiced in the Andes since before the Inca empire (Chepstow-Lusty and Winfield 2000; Morlon 1996), and the people of the Amazon rainforests practiced agriculture with trees already in pre-Columbian times, as we know from the widespread Amazonian dark earths (Hecht 2003).

The local agroforestry knowledge base in Bolivia has been investigated by only a few studies (Sorgedrager, et al. 1991; Johnson 1998; Aguilar et al. 2008; Hinojosa 2010; Brandt et al. 2013; Escalera and Oporto in press), despite its potential to contribute to locally adapted solutions to economic and ecological challenges. There is also an important gap in research on the articulation between different forms of knowledge—local traditional knowledge and external knowledge based on Western science—in the implementation of agroforestry systems and practices. This understanding is, however, needed to help harness local agroforestry knowledge for development policy and practice.

Against this background, the objective of the present essay is to explore the role of local and external agricultural knowledge in agroforestry projects in Bolivia by (1) evaluating the differentiated contribution of the two bodies of knowledge to livelihood assets, as well as tree and crop diversity in Bolivian agroforestry projects; (2) describing how different types of knowledge are incorporated in these projects; and (3) identifying constraints and opportunities for the further integration of local and external knowledge in agroforestry projects in Bolivia.

Methods

Study Area

Bolivia is among the countries with the highest terrestrial biodiversity in the world. Indeed, the tropical Andes are one of the world's acknowledged biodiversity hotspots (Myers et al. 2000). Bolivia's dominant topographical features are the complex body of the Andes with the altiplano (highlands); the sub-Andean mountain ranges with the inter-Andean valleys, and the eastern plains in the lowlands (Ibisch and Mérida 2004). Being the home of at least 36 indigenous groups, the country is also very culturally diverse. Awareness of this high biological and cultural diversity informed Bolivia's 2009 constitution and several laws: the new constitution established Bolivia as a plurinational state, granting indigenous groups and peasant communities extensive rights regarding territorial control, self-determination (including autonomy), and political representation (Arts. 1, 211, 289, 403), and new governmental bodies such as the Authority of the Rights of Mother Earth or the National Assembly of Agroecological Production (CNAPE) have been established.

Data Collection

We broadly defined agroforestry as the use of trees and shrubs in agricultural production systems and livestock keeping (Nair 1992). Using a snowball sampling method, we identified more than 50 agroforestry projects (including some initiatives of individual farmers) across Bolivia's nine departments (Fig. 1). Of these projects we visited 42, as permitted by weather and road conditions. The inventory is by no means exhaustive; many agroforestry activities may have remained unaccounted for, due to their physical remoteness or to the fact that not all farmers and extension workers use the term "agroforestry" to refer to the use of woody plants in agriculture. We conducted 62 in-depth, semi-structured interviews with farmers, civil society organization (CSO) workers, and government representatives. For each agroforestry project, we interviewed farmers (24 in total) and/or CSO representatives involved (31 in total, from 24 organizations). Furthermore, we interviewed seven government representatives in the Bolivian cities of La Paz, Cochabamba, Santa Cruz, and Tarija who worked in the field of family farming and forestry at the subnational or national level.

For each of the agroforestry projects investigated, tree and crop species and their benefits were recorded by means of free-listing exercises, in which agroforestry farmers were asked to describe all the plants they cultivated and their uses. A transect walk was conducted for each agroforestry project, together with someone from the organization in charge or the farming family. During these walks, we discussed agroforestry practices and explored related knowledge. The accompanying person was asked since when this knowledge and the related techniques had been in use locally and how they had been transmitted. Detailed notes were taken of the observations and discussions. The findings were later discussed in more detail during a semi-structured interview. We asked in the interviews how and by whom the agroforestry project had been initiated (upon endogenous or exogenous initiative) and where the knowledge had come from. Furthermore, we asked about the project's activities and benefits, for example regarding food security, the families' financial situation, soils, productivity, adaptation to climate stress, capacity building, local infrastructure, and interest groups. This assessment was based on the interviewee's perceptions, and livelihood assets targeted by the projects as mentioned in the interviews or in the project documents. We did not further monitor or evaluate the projects' livelihood outcomes. Interviewees were also asked to list constraints on agroforestry implementation from their point of view.

Data Analysis

Interviews were transcribed, then coded and analyzed using qualitative content analysis following Patton (2002). We grouped agroforestry projects according to whether they were initiated by local people or by an external actor, and according to the knowledge base they were working with (mostly local, mostly external, or a combination of both). We also recorded the total number of specific livelihood assets which each agroforestry project targeted, based on the project goal and activities described in project documents, as well as on direct observation and the interviews with project staff and farmers. We used the five categories defined by DFID (1999)—financial capital (e.g., earnings, savings, debts), human capital (education and agroforestry knowledge), physical capital (e.g., equipment, seedlings and tree nurseries), social capital (e.g., networks, cooperatives, and reciprocal arrangements) and natural capital (soil, watershed and biodiversity protection and productivity)—plus a sixth: production of food for the households and for sale. In addition, we recorded the number of tree and crop species used in the project, and gave each project a diversity score ranging from 1 to 5 (1 for only one tree and one crop species, 2 for three to five combined species, 3 for six to ten species, 4 for eleven to fifteen species, and 5 for more than fifteen species). The species count was estimated based on the interviews and on direct observation, but an exhaustive inventory was not carried out.

Results

Table S1 summarizes the contribution of 42 agroforestry projects to local livelihoods (the five livelihood assets plus food security) and to agrobiodiversity. More than half of the projects investigated (22) were exogenous initiatives. Nevertheless, the majority of projects and organizations (34) relied at least in part on local knowledge ("knowledge base" in Table S1). The National Agricultural and Forestry Innovation Institute (INIAF), for example, has a mandate to preserve agrobiodiversity and "ancestral" agricultural knowledge, and

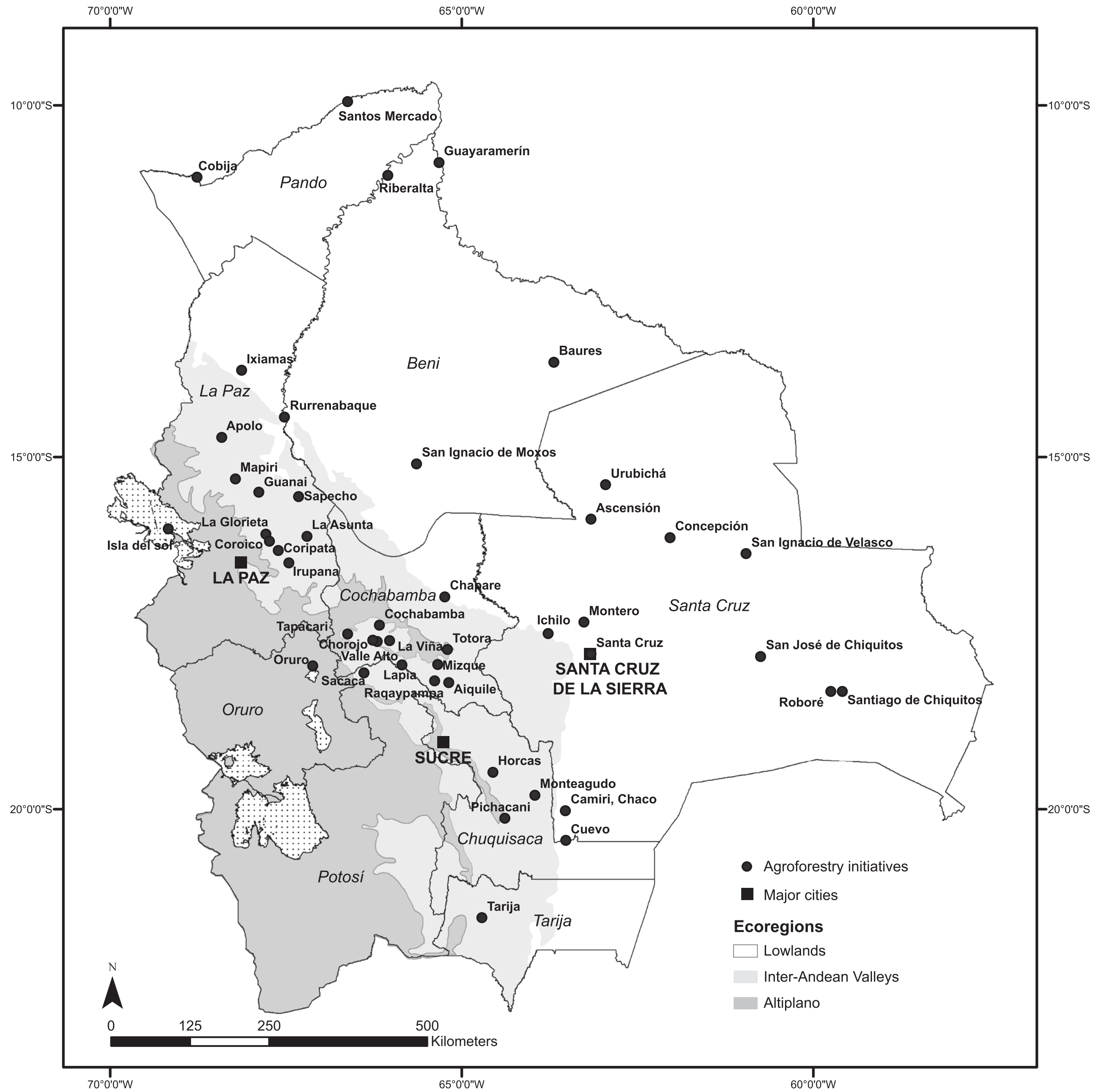

Fig. 1 Agroforestry projects in Bolivia included in this study

to contribute to food security and sovereignty by fostering a "dialogue of wisdom" (Law No. 144 of Productive, Communal, and Agricultural Revolution).

An organization more directly related to agroforestry and local knowledge is the Institute for Man, Agriculture and Ecology (IPHAE), which originated from the suggestion of farmers in the Pando and Beni Departments, and was then supported by the Bolivian government and Bolivian universities. Their initial purpose was to combine different forms of knowledge of local actors to jointly develop projects. Their agroforestry projects with copoazú (*Theobroma grandiflorum*), combined with a local copoazú pulp factory and marketing channels to the major Bolivian cities, have had positive impacts on local livelihoods and the environment (UNDP 2008; Vos et al. 2015).

The majority of the agroforestry projects (31) used a mixed knowledge base, meaning in most cases that they used local tree species as well as introduced species and varieties (e.g., cocoa hybrids) and relied on local knowledge of tree management (e.g., pruning) and tree-crop interactions. Exogenous projects tended to target single livelihood benefits to increase financial capital (e.g. agroforestry with coffee as a cash crop, as in the Caranavi project described in Table S1). The eight projects predominantly based on external knowledge targeted on average 2.0 different livelihood assets and had an average tree and crop diversity score of 2.13. Projects with a local or mixed knowledge base tended to focus on food security and increased natural capital (e.g., building soil fertility): The projects with a local or mixed knowledge base targeted similar numbers of livelihood assets (3.5 on average for mixed-knowledge-base projects and 3.7 for local-knowledge-base projects), and had similar tree and crop diversity scores (3.75 and 4.00, respectively). Whereas financial and natural capital were enhanced by most projects, endogenous projects focused much more on social networks and leadership, which contribute to social and human capital. Projects that integrated different forms of knowledge contributed to a diversity of livelihood assets—for example, homegardens with fruit trees and vegetables for a diversified diet—focusing on gender, sale and bartering, and knowledge exchange. In terms of agrobiodiversity, projects using a local or mixed knowledge base involved a higher number of tree species and crops than those with an external knowledge base, which tended to promote a single combination of tree and crop species, such as coffee with leguminous shade trees from the *Inga* genus (as in the Coroico project described in Table S1).

Integration of Local and External Knowledge

This section describes cases from three regions in Bolivia where local (often traditional) knowledge has been successfully integrated with external and scientific knowledge.

Silvopastoral Systems in the Bolivian Chaco

In the semi-arid region of the Gran Chaco, with a dry season of about seven months, temperatures that often exceed 40 °C, and a total annual rainfall between 400 and 800 mm, trees that bear fruit in the dry season are crucial to the survival of livestock, a major livelihood and income source. Interviewees (two CSO members and two farmers) said that more than 120 fodder plant species (trees, shrubs and herbs) have traditionally been used in silvopastoral systems in the Chaco, such as quebracho blanco (*Aspidosperma quebracho-blanco*), algarrobo blanco (*Prosopis alba*), and algarrobo negro (*Prosopis nigra*).

Today, land degradation as a consequence of overgrazing is a major problem, and silvopastoral systems can only be maintained by means of an integrative approach promoted by local organizations called *monte diferido* (Fig. 2, right). This technique includes fallow phases, fencing, hay and silage production, and limited livestock numbers. It uses a wide variety of native tree and shrub species, including fodder trees that bear nutritious fruit in the dry season, as well as newly introduced grass varieties of the *Panicum* genus. The technique makes use of the rich traditional knowledge, particularly on fodder trees. According to the two CSO representatives, annual dry biomass production in the Chaco can be as low as 140 kg/ha without such management practices, compared to more than 1000 kg/ha in a well-managed system (see also Joaquín 2014). They estimated that cattle ideally needed 4000 kg of dry biomass per head per year, and could not gain weight in an ecosystem with less than 500 kg of dry biomass production per hectare per year.

Fig. 2 Two nearby locations in the municipality of Cuevo, Santa Cruz Department. *Left*: soil erosion and low plant diversity due to overgrazing. *Right*: silvopastoral system with native fodder trees (algarrobito negro/*Prosopis sp.*) that bear fruit for livestock twice a year and produce leaves that are used as fodder

The interviewees said that only a combination of the *monte diferido* land management practices with storage of hay and silage and water harvested in the rainy season made it possible to maintain productivity in the dry season. The project thus contributed to food security (meat and milk), financial capital (income), natural capital (soil and biodiversity conservation, biomass production), physical capital (fencing and planting material), and human capital (capacity building).

Cocoa, Coffee, and Coca in the Yungas of La Paz

Many agroforestry farms in the Yungas, the eastern slope of the Andes, have a mix of subsistence and local-market orientation with some export orientation. The most important agroforestry crop in economic terms is coffee. We found combinations of high-yielding cultivars of coffee and cocoa in diversified agroforestry systems, which draw on a combination of local and external knowledge provided by farmers, their organizations, and agricultural consultants. Three of the nine coffee agroforestry projects (two of them endogenous) also used local tree species such as achachairú (*Garcinia humilis*) and subsistence crops such as walusa (*Xanthosoma sagittifolium*), along with the associated local knowledge about their cultivation and use. Exogenous projects focused on export crops (cocoa/coffee), but used locally adapted N-fixing *Inga* species to improve soils and provide biomass and shade.

Overall cocoa yields around the town of Rurrenabaque were reported to be rather low, as one interviewee indicated, ranging from 150–370 kg/ha/year for hybrid varieties to 180–290 kg/ha/year for local varieties. A previous study in the adjacent Alto Beni region (Jacobi et al. 2013) showed that, with knowledge integration activities such as knowledge exchange platforms and technical assistance among local farmers and their organizations, focusing on local experimental knowledge, cocoa yields were higher than those reported by our interviewee, and higher under agroforestry than in cocoa monocultures (466.5 kg/ha/year under agroforestry and 350 kg/ha/year in monocultures). Farmers cultivating organic cocoa in agroforestry systems had higher incomes than farmers with cocoa monocultures, due to organic certification and additional income from agroforestry products, which increased their resilience to economic and ecological stress (Jacobi et al. 2015). Cocoa agroforestry in the Yungas contributed to financial (export of certified organic cocoa), natural (soil and biodiversity conservation), human (capacity building), social (cooperatives), and physical (planting material) capital, as well as food security (fruit trees in cocoa agroforestry systems).

Coca (*Erythroxylum coca*) is a traditional crop of the Yungas and used to be cultivated in diversified systems before the demand from the international drug market and the associated increase in producer prices led many families to opt for input-intensive coca monocultures, as three coca-agroforestry farmers explained in the interviews. They described aromatic plants that were traditionally associated with coca to control pests and diseases, such as quirquiña (*Porophyllum ruderale*). More than 200 farming families had sought and received organic certification for diversified coca plantations without the use of agrochemicals in recent years, as according to them, there was an increasing demand for organic coca leaves for tea and for chewing. One local organization recommended and implemented agroforestry systems with coca as a cash crop together with local trees, shrubs, and herbs. They promoted "dynamic" agroforestry systems (also known as "successional" agroforestry), which are based on high plant diversity and density following a successional process over the years from diversified plantations dominated by pioneer plant species to secondary species to primary species. The concept is based on different stages of succession towards increasing complexity. A colonizing stage is followed by a stage of accumulation, where plant biomass and soil organic matter are accumulated, and this finally leads to a stage of abundance with high biodiversity and biomass. Most crops are understood to be part of the abundance stage, which, in order to remain productive, requires interventions such as pruning and selective weeding. The concept of successional agroforestry systems is based on the traditional forest gardens used in southern Mexico, which have a high share of native vegetation, as well as on the technique of using plants from secondary and primary forests in cultivation systems to accelerate succession, which is practiced by the Kayapo people in the Amazon Basin (Schulz et al. 1994). Three farmers who managed such a system explained in interviews that they had obtained their knowledge through direct observation, trial and error, exchange with other farmers, and trainings by local and foreign CSOs. A representative of the local organization explained that successional agroforestry systems needed intensive management and close observation of natural processes, which posed an obstacle for its implementation. Recognizing that earlier designs were rather complex, they were working to simplify the systems without compromising the principles of increasing biomass and biodiversity. They did so by planting trees at lower densities, e.g., high-value timber trees every 20 m instead of every 12 m or less, as previously recommended. They also opted for more fast-growing species to accumulate biomass, and only grew them to a diameter of 10–15 cm before cutting them down and incorporating them into the system as mulch, an alteration intended to increase light and growth in the system. This innovative management of dynamic agroforestry was developed together with farming families in the Yungas based on the above-mentioned traditional systems, but in an adapted form that met needs identified by the families. For instance, cocoa trees require an increased amount of light in order to flower. The resulting adapted system produces not only food, but also income.

Quinoa-Quishuara System in the Altiplano

Although we could not find agroforestry projects implemented by CSOs in the Altiplano, we found an example of quinoa production diversified with local trees and vegetables in the community of Cantasi Utiri, 105 km southeast of the city of Oruro, at almost 4000 m above sea level. The agroforestry farmer, originally from the community, had worked with a local organization as an agronomist in the field of quinoa production. Inspired by the organization's agroecological approach, he started experimenting on his own land and combined quinoa with a native tree from the Altiplano, quishuara (*Buddleja coriacea),* to increase soil fertility and humidity, and garlic as a pest repellent. He also planted fava beans, peas, oats, and potatoes with quinoa. With this intercropping technique, he said that he was cultivating quinoa for the sixth year in a row without the need of shifting to another plot or using mineral fertilizer. Hedgerows of native grasses and shrubs helped to prevent soil erosion. He explained that he was trying to conserve knowledge about how his family cultivated quinoa in earlier times. His knowledge on how to combine and manage the crops came from his family, his own experiments, and his work experience with the local organization. His activities contributed to natural capital (soil fertility and agrobiodiversity), food security, financial capital (quinoa sales), and human capital (his own knowledge).

In contrast to the currently dominant quinoa monoculture resulting from the quinoa export boom which leads to soil degradation and desertification in the Altiplano, traditional quinoa production used to take place with living fences and windbreaks of local trees and shrubs (Sorgedrager et al. 1991; Aguilar et al. 2008). Kerssen (2015) described how communities in the southern Altiplano have started to hold workshops that bring together quinoa farmers who live in the communities and producers who have migrated and are now based in the major cities, enabling them to jointly develop ecologically and culturally acceptable ways of producing quinoa. An important aspect of these workshops is the collective recovery of traditional knowledge, norms, and practices, such as the traditional fallow phases called *mantos* (Kerssen 2015).

Constraints on the Integration of Local Knowledge

The examples above show how local and external knowledge can be integrated successfully in agroforestry projects. They also indicate that this integration can create culturally appropriate and ecologically sustainable farming systems that enable the continued existence of local farming communities while producing goods both for subsistence and for national and export markets. However, such activities tended to be rather isolated, and usually involved only a limited number of agroforestry farmers in each farming community. If such positive examples are to have a greater impact, it is important to understand why local agroforestry knowledge does not currently receive more attention and support. Agroforestry as well as local and traditional knowledge are prioritized in Bolivian laws and national development plans, such as Law 300 on Mother Earth and Integral Development for Living Well, Law 3525 on Ecological Production, Law 337 on Support of Agricultural Production and Restitution of Forests, and the Agricultural Sector Development Plan (MDRyT 2014). We identified two government-supported agroforestry programs (the aforementioned project around Riberalta and Guayaramerín with copoazú agroforestry in the Pando and Beni Departments, and diversified coffee agroforests in the Yungas of La Paz). However, our interviewees indicated that agroforestry projects implemented by national CSOs and international development agencies tended to apply externally developed approaches without taking sufficient account of local knowledge. The interviews pointed to five main reasons for this, which we summarize below.

Preference for Ready-Made Solutions

As two interviewees from CSOs explained, decision makers and project designers favored ready-made technological solutions. The resulting project activities did not correspond to the farmers' reality:

> Every community has their own form of agroforestry, a diversity which is very often not compatible with projects and associated technology packages. (CSO representative, Santa Cruz)

Two CSO representatives stated that projects should be oriented toward what already exists, rather than imposing an external solution. They pointed out that many solutions of this kind were already in place locally, but that planners and policymakers were reluctant to take them into account, because they considered local and traditional practices difficult to mechanize and therefore regarded them as backward. As an example, one of the CSO representatives described *zanjas*, ditches along the crops filled with cow dung mixed with leaves, a technique based on local experimental knowledge. According to her, improved soil water retention capacity was shown after 3–4 years, and the growth and health of crops were considerably improved due to higher soil fertility. Although increased water retention capacity and soil fertility are highly desirable for improved productivity and livelihoods, policymakers showed little interest in *zanjas*, and there was thus no feedback from practice to policy. One politician expressed in the interview that diversified agroforestry systems were not suited for large-scale production, which is why he considered diversified farming based on traditional concepts to be a niche approach. Hoch et al. (2012) showed that local low-input, low-risk approaches are often more adapted to local realities than expensive, high-risk external technologies, but suggested that overestimation of the potential of externally promoted techniques and underestimation of local approaches is common in development work.

Skepticism About Local Knowledge

Interviewees from CSOs stated that their own staff members were not necessarily convinced of agroecological principles guiding the implementation of diversified agroforestry systems that take into account local approaches. For example, one organization described irrigation technology as their priority, but their projects did not apply any local soil conservation techniques such as cover crops, or techniques to increase soil organic matter and retain water in the soil, which might have enhanced agricultural systems' resilience to drought. CSO representatives reported that politicians did not visit successful farmers and their plots, and that they showed little interest in agricultural approaches based on local knowledge, although Article 1 of the Framework Law on the Rights of Mother Earth and Integral Development for Living Well explicitly refers to the need for "restoring and strengthening local and ancestral knowledge".

Four interviewees emphasized the role of INIAF, which is in charge of technical assistance and preservation of traditional agricultural knowledge and agrobiodiversity in line with the Framework Law on the Rights of Mother Earth and Law No. 144 of Productive, Communal, and Agricultural Revolution. However, two of them said that the prevailing perspective in INIAF and other agricultural organizations underestimated the productive capacity of diversified farming systems and any meaning of 'living well' beyond increased agricultural productivity. One interviewee said that INIAF should use information on locally adapted agroforestry systems and regretted that there was no feedback mechanism between agroforestry farmers and the organization.

Lack of Communication

The interviewed agroforestry farmers mentioned that there was a lack of communication and knowledge exchange on an equal basis between CSOs and farmers, which they interpreted as most agricultural and development organizations' lack of interest in their knowledge and practices. This echoes the statement by Powell (2006, 518) that "most current practice consistently militates against the type of relationship and the type of communication that are essential if development policy and practice are to be anything other than an imposition of external ideas". Another aspect was that few organizations used information on social issues (e.g., gender aspects) in their programs and projects. One agroforestry farmer near Cochabamba explained, for example, that she had never seen an agroforestry project focusing on women and their homegardens, which are traditionally highly diverse combinations of fruit trees, herbs, and vegetables. According to her, projects were usually dominated by men and focused on what she called "male agroecosystems", which were the plots designated for marketable crops instead of household consumption. She assigned this to a fragmented way of thinking in exogenous project designs:

> There is one project for fruit, and another one for vegetables, but no link between the two, no combination of both, [which is] how we have always done it. (agroforestry farmer, Cochabamba)

Insufficient Project Follow-Up

Five interviewees from CSOs said that the short project durations undermined the success of agroforestry. According to them, knowledge transmission and application depended to a large extent on CSOs, which were often unable to provide continuous support to project participants. They said that most projects distributed seedlings, but few of them supported their planting and maintenance. Agroforestry farmers also mentioned this point, along with the need for more integrated project designs focusing on plant knowledge and maintenance in addition to tree planting. For example, two interviewees had accidently mowed down small trees that a project had planted on their farms because they did not recognize them. A coca agroforestry consultant said:

> We organize courses on agroforestry, and the participants become intrigued, but as we cannot do that in continuity, there is no real progress. We, together with the government, are failing the farming families. (agroforestry farmer and consultant, La Asunta)

As a result, farmers who were at first highly interested were left without support when the project ended, and abandoned their agroforestry system when difficulties arose.

These failures had a multiplier effect on their neighbors, especially when demonstration plots were not well managed or were abandoned, as this was taken as proof that agroforestry did not work. The five CSO interviewees who mentioned this issue said that it was crucial not only to develop successful experiences of diversified agroforestry, but also to maintain them by providing ongoing support to farmers.

Lack of Validation in Formal Education

Most importantly, a consensus from the interviews was that the root causes for neglect of local and traditional agroforestry knowledge by agricultural organizations were to be found in the formal education system. Sixteen interviewees (14 CSO members and two agroforestry farmers) mentioned that the theoretical and practical emphasis in agronomy and related faculties was on the productivity of monocultures, and that agroforestry as polyculture was usually not taught. This approach was deeply rooted in the curriculum, in a system they described as highly centralized and hierarchic with little or no exchange with development organizations or farmers. According to them, this situation has led to a lack of human capital, and has been exacerbated by the fact that agricultural extension in many parts of Bolivia has been organized mainly by the private sector, fostering input-intensive, export-oriented monocultures.

Ways to Promote Integration of Local Knowledge

Our interviews indicated that there has not been enough interaction between agroforestry practitioners, extension service providers, and policymakers, and that there is a need for alternative ways of producing and distributing knowledge.

Four CSO representatives said that the decentralization of university facilities was crucial to agricultural education—a suggestion that is in part already being implemented, with an annex of the faculty of agronomy of the Universidad Mayor de San Andres La Paz in Alto Beni, and a satellite campus of the Catholic University of Bolivia in Carmen Pampa near Coroico in the Yungas. An agronomy lecturer from the Universidad Mayor de San Andres explained that agronomy students there came mainly from local farming families and continued to help their families, for example during the coca and coffee harvests, while studying. However, this decentralization of higher education is not sufficient if it does not include local agroforestry knowledge and practices in the curricula and establish institutionalized forms of knowledge exchange between the universities, consultants, and farmers.

Many projects used local knowledge, but we found few examples of ongoing agroforestry knowledge co-production, such as organizations inviting agroforestry farmers and consultants to knowledge exchange events in farming communities. We observed this practice in the field of cocoa cultivation in the departments of La Paz and Beni. Four members of CSOs working on cocoa agroforestry said they had positive experiences conducting such events on-farm, because many cocoa producers lived in remote areas, and because participants were much more interested in learning practices they could directly apply. Working with *peritos*, agricultural consultants who are also local farmers seemed the most promising approach, but it was only used by two CSOs in our sample. These interviewees stated that this scheme had proven successful in the field but faced resistance in higher levels of the hierarchy of governmental and non-governmental organizations.

One of our questions to agroforestry farmers was whether their neighbors were interested in doing something similar or had already done so. A consensus among interviewees was that most neighbors were interested, but that this interest was in many cases not enough for agroforestry practices to be adopted. Adoption only occurred where agroforestry knowledge was either already present because of widespread traditional use (e.g., in homegardens around Cochabamba), or made accessible by a facilitating organization (e.g., cocoa agroforestry in the Yungas). Projects that build up farmer leadership seem to be more successful, such as using *peritos* in Alto Beni, and *yapuchiris* in Tapacarí Province near Cochabamba (Ricaldi Arévalo and Aguilar 2014). Yapuchiris are traditional local farmer leaders who collect, produce, and share agroecological knowledge and risk management strategies. Using both ancestral and new techniques acquired from exogenous projects and organizations, their work can be regarded as an example of farmer-to-farmer knowledge transmission blending with scientific knowledge promoted and used by CSOs, and they can become effective promoters of agroecological practices.

One politician stated that 'recovering the relationship with Mother Earth' in the population would strongly influence the adoption of agroecological principles including agroforestry. He said that the government's discourse on the rights of Mother Earth was lively, but that financing for agricultural development and extension was more directed to what he called Western scientific knowledge-based agriculture (e.g. promoting highly productive cattle breeds and pasture varieties instead of traditional silvopastoral systems in the Bolivian Chaco). According to him, a more holistic view of development that acknowledges the potential sustainability and resilience of such systems was missing among decision-makers. This statement relates to a clash with the dominant Western scientific worldview that separates the social from the natural world, and where the laws of nature are disconnected from the social and spiritual domains of life (Rist and Dahdouh-Guebas 2006). This "monism of matter" (Mathez-Stiefel et al. 2007) leads to a vision of agricultural development in many organizations that overemphasizes the productivity of single crops or breeds. The traditional Andean worldview, on the other hand, is based on a "monism of the mind", in which the material and social worlds are regarded as connected and interrelated. In this view, material phenomena are expressions of social and spiritual phenomena, and the balance between these spheres has to be maintained through reciprocity (Mathez-Stiefel et al. 2007; Boillat et al. 2012; Gonzales 2012). Local and traditional knowledge on agroforestry in Bolivia often seems to be based on such a worldview of reciprocity, as shown by our interviews with several agroforestry farmers. One farmer, for example, expressed this as the imperative to give something back to Mother Earth or the forest—be it in the form of a ritual or by providing habitat for biodiversity in the landscapes—rather than only extracting goods. Such a critical view on predominant resource extractivism was also expressed in seven other interviews. These different worldviews shape the way the concept of development itself is perceived. While Western development discourses often focus on economic well-being, Amerindian perspectives often aim at a balance between human, ecological, and spiritual environments (Rist and Dahdouh-Guebas 2006; Albó 2011). One widely-known example is the indigenous concept of *Vivir bien,* which has been discussed as an alternative to classical Western development theory (Kerssen 2015). However, the Western scientific view tends to undervalue other worldviews by making a hegemonic claim to truth (Rist and Dahdouh-Guebas 2006). In line with this perception, our interviewees indicated a devaluation of agroforestry in general and local knowledge in particular in formal educational and scientific structures. The Bolivian educational system has been designed according to a Western science-based "monism of matter," neglecting local and indigenous knowledge and traditional agricultural systems. This can be considered a global phenomenon, as scientists worldwide have usually supported exogenous over endogenous approaches. Nyong et al. (2007) argue, for example, that scientists have tended to limit plant trials for forestry and agroforestry to known species that have performed well in other parts of the world. In doing so, they neglect to take into account those local practices that have passed the test of time and sustainability by evolving over hundreds or thousands of years while remaining culturally anchored (Altieri and Nicholls 2013).

Johannsson et al. (2013) show that in cases where collaboration among the project staff, government counterparts and other stakeholders had been established at multiple levels, more agroforestry trees survived and a larger proportion of households practiced agroforestry. According to Hoch et al. (2012), farmers in the Amazon Basin tend to favor low-risk approaches based on locally available inputs.

The example from the Yungas of highly diversified and knowledge-intensive successional agroforestry systems based on traditional homegardens and adapted to some market strategies indicates that there is no one-fits-all solution for agroforestry systems. Altieri (2004) argues that traditional agricultural knowledge is place-specific, evolving in time in a particular habitat and culture, and that the transfer of specific technologies to other places may fail if social, ecological or cultural aspects differ. Therefore, agroecology science and practice focus not so much on specific technologies but rather on underlying principles used in techniques to meet the environmental requirements of specific places (Altieri 2004). Coe and colleagues also recognize this challenge and the need for a co-learning paradigm embedded in development for the design of locally adapted agroforestry options (Coe et al. 2014).

In Bolivia, a legal-political framework supporting local knowledge and agroecological forms of family farming was established under the Morales administration (Sager 2014; McKay et al. 2014). This study indicates that the enforcement of this framework is limited in the field of agroforestry. We conclude from our study that more collaboration and exchange among decision makers and practitioners is needed before projects are designed, making it possible to communicate a message that is coherent and focuses on principles rather than techniques.

An important role for development-oriented research may be that of promoting collaborative learning among stakeholders in complex natural resource governance situations (Johansson et al. 2013). In this view, the role of research goes beyond the production and transmission of knowledge to practitioners, to focus on enhancing the integration of different forms of knowledge (Rist et al. 2007). Pohl et al. (2010) describe three basic roles of researchers in knowledge co-production for sustainable resource management: (1) that of a reflective scientist, providing expertise based on scientific knowledge validated according to the norms of the natural or social sciences; (2) that of an intermediary, making different forms of knowledge visible and linking them around common interests; and (3) the role of a facilitator, enhancing communication among different groups of actors, and promoting joint reflection aimed at a common understanding and collective action, as part of a learning process. Based on our findings, we consider all three roles crucial to integrating different forms of knowledge in agroforestry research.

Conclusions

Although there were encouraging examples of integration of local agroforestry knowledge, exogenous agroforestry projects were described by farmers we interviewed as insufficiently adapted to local realities because they were structured according to a fragmented understanding of natural resources and livelihood activities, whereas in local and traditional knowledge systems in Bolivia the environmental, social, and spiritual spheres of life are often connected. We interpret this as an expression of conflicting perceptions regarding the meaning of "development". Furthermore, our results indicate that local agroforestry knowledge tends to be undervalued because of a dominant epistemological model based on Western scientific knowledge and values, which is institutionalized in extension services and educational structures.

Agricultural and development projects that effectively integrate external and local forms of knowledge can only be maintained and scaled up if they are embedded in supportive networks and backed by an integrative epistemological framework that takes into account the various dimensions of sustainability. Moreover, truly participatory approaches are needed that not only include local actors in project activities but also embrace their knowledge systems and worldviews by means of social learning and dialogue. In line with Johansson et al. (2013), we believe that collaborative learning among stakeholders built on respect, equity, and empowerment forms the basis for identifying barriers and developing solutions. As such, it is a critical success factor for policies and projects aiming to contribute to a culturally, socially, and environmentally acceptable understanding of development.

We suggest that an increasingly important role for scientists, beyond knowledge production and transfer, will be to facilitate a dialogue between different forms of knowledge to create such synergies. This can be achieved by identifying ways to enhance knowledge co-production, strengthening local organizations and their networks, reforming agricultural educational institutions, and informing policymakers.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

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