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Participatory technology development for incorporating non-timber forest products into forest restoration in Yunnan, Southwest China

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ABSTRACT

Indigenous knowledge has become a topic of considerable interest within the research and development environment. Incorporating indigenous knowledge into state-led 'top-down' conservation and development programmes, however, is still a great challenge. This paper presents a case from Yunnan, Southwest China, in which indigenous knowledge has been integrated into the development of an agroforestry model with non-timber forest products for the Sloping Land Conservation Programme (SLCP) by using a participatory technology development (PTD) approach. This approach was adopted to increase the likelihood that technologies developed would be suitable for resource-poor households. It is expected that integrating indigenous and scientific knowledge, will lead to positive ecological and economic outcomes. Finally, the paper argues that the integration of indigenous knowledge in both forestry policy formulation and implementation is important in the context of sustainable forest management in mountain areas.

1. Introduction

Indigenous knowledge is being used increasingly in traditional healing (Cox, 1999), biodiversity conservation (Xu et al., 2005a), forest management (Ramakrishnan, 2007), maintaining resilience of social–ecological systems (Berkes et al., 2000), and sustainable land use (Thapa et al., 1995) and livelihoods (Flavier et al., 1995). Its significance is widely recognized at the international level, for example in the Convention on Biological Diversity (Posey and Dutfield, 1996). A current challenge is the development of strategies to incorporate indigenous knowledge into state-driven conservation and development programmes. In developing countries, where rural communities are shifting from subsistence livelihoods to market-oriented economies, the role of indigenous knowledge in poverty alleviation is much debated (Ellen et al., 2000). While there are advocates for increased use, recognition, and preservation of traditional knowledge at national level, there are many questions about how to develop and adapt indigenous knowledge in the context of rapid technical, political, and economic change.

Rich in cultural and biological diversity, Yunnan Province, known as the 'the roof of Southeast Asia', is home to 45 million people from 25 distinct ethnic minorities, most of them living between 1000 and 3000 masl. The Chinese government has a strong interest in political security in this mountain region and is also concerned about environmental impact on the economies of Yunnan and the surrounding provinces, all of which are affected by the headwaters of the Yangtze, Salween, Irrawaddy, Mekong, Black, Red, and Pearl rivers. A nationwide project, the Sloping Land Conversion Programme (SLCP) or 'Grain for Green' programme, was recently introduced to encourage on-farm afforestation on a large scale. By providing grain and cash subsidies to encourage farmers to plant trees on their croplands, the programme's main objective is to convert vast areas of steeply sloped agricultural land to forest or grassland, specifically targeting areas with slopes greater than 25°. Although this initiative was originally in response to the hydrological instability of the Yangtze and Yellow rivers, the project has spread beyond their immediate watersheds. The potential impact of the SLCP on indigenous people is great as it affects over 750,000 ha of cropland and more than 10 million mountain inhabitants (Xu and Wilkes, 2005). The programme has several other goals, ranging from erosion control and improvement of hydrological stability to poverty alleviation (Bennet, 2008). The government, however, has not incorporated indigenous forest-related knowledge into species' selection, tree planting, and forest management in this programme (Xu and Ribot, 2004). Forest restoration and conservation policies are implemented from the top-down and often fail to recognize the diversity of indigenous

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species valued for their non-timber forest products, indigenous knowledge and practices, or the capacity of local farmers to adapt their land management and livelihood tactics to changing circumstances. One particular challenge is that of developing a 'sustainability' strategy to maintain the positive benefits of SLCP following the end of subsidies.

This paper discusses a pilot project, carried out in Baoshan Prefecture in Yunnan Province, to find species of non-timber forest products that can be cultivated with trees on agricultural land, which are not only economically viable for farmers, but also ecologically acceptable from a government perspective in the context of the SLCP. The project used a participatory technology development (PTD) approach, based on the findings of social, ecological, and policy studies which have indicated that reciprocal, functional links between biodiversity, indigenous knowledge, and livelihoods provide long-term resilience and incentives for conservation (Berkes, 2006). The present paper examines the potential for incorporating indigenous knowledge into biodiversity conservation and development of livelihoods, as well as building local capacities for watershed restoration.

2. Methods

2.1. Study site

Longyang District, in Baoshan Prefecture of Yunnan Province, is situated between the upper reaches of the Salween and Mekong rivers. It is one of the areas targeted for both the National Forest Protection Programme (NFPP) and the SLCP in a national effort to conserve watersheds. The pilot study was carried out from 2002 to 2007 in a small watershed that feeds into the Nu River (Salween), located in Yangliu Township, Baoshan Prefecture, Yunnan Province (25°13′01″N: 99°01′38″E) (Fig. 1). The watershed is situated on mostly steeply sloping land covering an area of 42.35 km^2. It has one administrative village, Pingzhang, which includes five natural villages with a total population of 7300. The inhabitants of these villages are from the Yi and Bai ethnic groups whose per capita annual income in 2002 was 106 USD, according to Yangliu Township Government's records.

The watershed has a subtropical climate influenced by the Indian monsoon. Mean annual temperatures range from 11 to 14 °C with rainfall from 1600 to 1800 mm, 80% of which is concentrated in the months of May through October. Elevations range from 1100 to 3000 masl, and the watershed's complex topography and elevation provide opportunities for a variety of agricultural management practices. Farmers grow paddy in the lower areas (below 1600 masl) near the river and corn and potatoes at higher elevations (>1600 masl). The natural forest vegetation is dominated by pines (*Pinus yunnanensis* and *Pinus armandii*) and alder (*Alnus nepalensis* D. Don); these forests provide a favourable important non-timber forest products. The local community collects mushrooms, pine nuts, and a wide range of medicinal plants from the forest and, in addition, cultivates walnut trees (*Juglans regia*) to earn additional cash income.

Fig. 1. Location map showing Yangliu Watershed in Longyang district of Yunnan Province, China.

2.2. SLCP

With the implementation of the Sloping Land Conversion Program, 235 ha of cropland at the study site were afforested between 2002 and 2003. Approximately 25% of the total area within the watershed (1059 ha) is targeted for further conversion. Two fruit tree species, pear (*Pyrus pyrifolia*) and walnut (*J. regia*), were accepted as tree cover by forestry agencies for this program and over 200 households participated in their planting. In 2002, the Baoshan Forestry Bureau invited the World Agroforestry Centre (ICRAF) to help improve the implementation of the SLCP and promote conservation with development. Farmers, foresters, and ICRAF facilitators jointly agreed upon a participatory approach for this effort, and participatory mapping was undertaken for targeted areas within the watershed to characterize local land use and land cover. A policy analysis of the SLCP was also carried out by the project team.

2.3. The participatory technology development process

PTD emerged from the 'Farmer First' (Chambers et al., 1989) concept which was first introduced in the late 1980s. In contrast to conventional top-down approaches, it is an innovative method to promote farmers' participation in agricultural research and extension. It is based on the realization that farmers and professional researchers have different knowledge and skills which may be complementary and that by working together the two groups may achieve better results than by working alone (Hoffmann et al., 2007). Participatory technology development in the context of the SLCP refers to the selection of and development of management practices for locally adapted species for farm-specific agroforestry systems by and with local farmers. Local people combine their indigenous knowledge with the scientific knowledge of extension workers and research specialists with the goal of establishing balanced, multifunctional mountain landscapes that can provide local people with satisfactory livelihoods and deliver environmental services downstream. The PTD process has six main steps (Jiggins and De Zeeuw, 1992): 'Getting Started', 'Looking for Things to Try', 'Designing Experiments', 'Trying Things Out', 'Sharing Results', and 'Keeping up the Process'. Participatory monitoring and evaluation are carried out in each step of this process (Fig. 2).

2.3.1. Getting started

This stage involved discussions with all stakeholders on the current situation and the potential ecological, socioeconomic, and

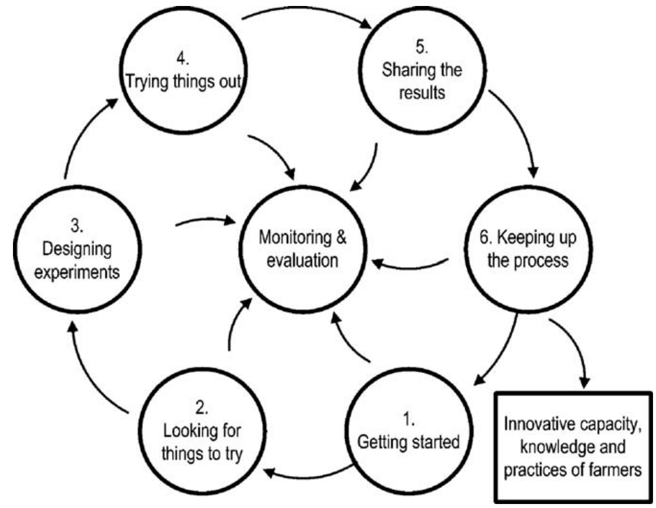

Fig. 2. The participatory technology development cycle showing the steps taken to process and capture the innovative capacity, knowledge, and practices of farmers.

political consequences of SLCP implementation. It was agreed that the goal of participatory technology development was to promote innovative and adaptive implementation of SLCP as a means of benefiting local farmers and providing them with sustainable livelihoods. The principle of farmers' participation and was accepted by the project team.

2.3.2. Looking for things to try

The PTD team of local foresters and researchers worked with village 'experts' (sensu Davis and Wagner, 2003) to put together an inventory of indigenous knowledge which involved a listing of useful plants (native trees and non-tree species), mapping biological resources and land use at the landscape level, and collecting voucher plant specimen (Salas et al., 2003). After scientific identification and joint analysis of plant specimens, scoring and ranking for these species were carried out using a participatory rural appraisal toolkit (Chambers, 1994) to identify the most promising medicinal plants for cultivation in the SLCP area.

2.3.3. Designing experiments

A participatory research plan was drawn up by voluntary farmer innovators, local foresters, and the project team. A total of 10 households participated in experiments using over 10 species.

Table 1
Participatory scoring values indicating villagers' preferences for different species.

Scores Species	Market aspect Subtotal	Ecological aspect Subtotal	Social aspect Subtotal	Technique aspect Subtotal	Total score
Aralia chinensis L. (Araliaceae)	9	14	10	8	41
Gentiana rhodantha Franch (Gentianaceae)	11	16	11	9	47
Paris polyphylla var. yunnanensis (Franch.) Hand-Mazz (Trilliaceae)	11	13	12	9	45
Scutellaria baicalensis Georgi (Labiatae)	10	13	11	9	43
Dipsacus daliensis T.M. Ai (Dipsacaceae)	10	14	10	9	43
Acanthopanax senticosus (Rupr. et Maxim.) Harms (Araliaceae)	9	12	9	8	38
Codonopsis pilosula (Franch.) Nannf. (Campanulaceae)	9	13	10	10	42
Plantago major L. (Plantaginaceae)	9	12	7	8	36
Senecio scandens Buch.-Ham. ex D. Don (Compositae)	9	10	7	8	34
Pollia japonica Thunb. (Commelinaceae)	9	12	9	8	38
Adenophora tetraphylla (Thunb.) Fisch. (Campanulaceae)	9	13	10	10	42

Note: Selection of species took place in a participatory workshop with stakeholders. Selection was based on four broad criteria (aspects): (a) market, which is further divided into four criteria, i.e., market potential, market competition, knowledge and capital needs for cultivation, and profitability; (b) ecological aspects, i.e., resource availability, multiple use, period of cultivation needed before harvest, harvest period, harvest impact on wild resources, and renewability; (c) social aspects, i.e., benefit sharing, income generation, indigenous knowledge about plants and products, potential for employment, and gender division; (d) techniques needed – technology required, existing technology, processing needs, and capacity for processing. Scoring for each criterion was on three levels: 3 being the highest, 2 medium, and 1 the lowest. The subtotal is the sum of the value based on different criteria under the respective aspects.

The purpose was to identify superior species based on clear selection criteria (see Table 1).

2.3.4. Trying things out

Farmer innovators carried out on-farm experiments in SLCP areas, documenting and monitoring species' performance under different treatments with technical support from the project team, thus enabling a mutual learning process (Vernooy et al., 2006). Farmers were therefore involved in generating economically and environmentally sound technologies for sustainable and equitable management of natural resources (Van de Fliert and Braun, 2002).

2.3.5. Sharing the results

The farmers' 'field school' supported by forest extension workers became an important focal point for exchanging experiences and results with other experimenters, neighbours, farmers from different ethnic groups, and the project team. New ideas for experiments and training were developed during annual meetings of farmer innovators, project staff, and forestry officials.

2.3.6. Keeping up the process

Since annual food crops were not allowed in SLCP areas, the project team negotiated with local government officials for favourable conditions to enable ongoing experimentation to incorporate medicinal plants into tree plantations at both pilot and extension levels. In this way, the originally top-down SLCP project was transformed into a bottom-up approach for integrated conservation and development in mountain regions.

3. Results

3.1. Policy environment for participatory technology development

The SLCP is the largest afforestation programme in China. Its purpose is to protect watershed functions through forest plantation on marginal croplands. It is welcomed by most farmers because of the high compensation rates and incentives provided. Its simplified top-down approach, however, presents significant challenges during its implementation in ecologically complex and culturally rich provinces such as Yunnan. The policy and practice of SLCP has prevented intercropping of trees with annual food crops even in the early stages of conversion. Farmers and foresters have often had different species preferences. While farmers were interested in the compensation they received through participation in the program, the programme provided compensation only during the first 5 years after planting economic species and 8 years for ecological tree species. Farmers were at risk of having to find alternative livelihoods in the short term and of having to find markets for new tree products in the long term. The technical capacity for tree and land management in the context of a market economy was inadequate.

The SLCP was not designed for decentralized, flexible planning and implementation, and problems in its implementation reflected fundamental issues in the transition from subsistence agriculture to market-based production through which farmers were expected to make long-term investments towards an eventual increase in income (Weyerhaeuser and Kahrl, 2007).

To provide support for this transition, extensive discussions were held between farmers and line agencies to introduce promising alternatives in agroforestry into the SLCP. The aim was to establish a mix of ecological and economic and multistoreyed and multistructured species that give farmers the option of earning some income from forest lands while trees are still growing. Despite the ban on intercropping with annual crops, other species, such as shrubs, were permitted. Identifying land-cover or forest understory species became the first step in 'getting started'. All parties involved (farmers, foresters, and the ICRAF team) opted for domestication and cultivation of medicinal plants under pear and walnut trees in SLCP areas.

3.2. Adaptive knowledge systems

An inventory of indigenous knowledge of medicinal plants was compiled and local herbalists, plant collectors, and the project team carried out a mapping exercise on medicinal plant resources in which over 30 medicinal plants collected from local habitats were identified. Groups of local 'experts' and farmers from 10 village households were formed for nursery development. Their tasks included: (i) development of a plan for on-farm experimentation which included species' selection, plot design, and monitoring of species' performance; (ii) identification of technical support needed from forest extension workers and ICRAF staff; and (iii) sharing their results with other farmers. Farmers were encouraged to share their indigenous knowledge and innovations were encouraged. Field research on propagation and nursery development was supported by forest extension workers and ICRAF staff.

The integration of indigenous and scientific knowledge systems began with species' selection. The basic criteria for selection were that plants selected were native, naturally occurring species that could be domesticated, were economically valuable, and could be used for extension. Eleven species were identified at this stage. Local experts were invited to score and rank them based on the agreed selection criteria, as described in Table 1. It was decided that species with a total score greater than 40 would be selected and, on this basis, 11 species were chosen for further experimentation.

Of these 11 species, seven were selected for on-farm trials and five households undertook the first round of experiments using these species on an SLCP pilot site covering 0.8 ha. Although the project team encouraged seed collection and germination, the farmers preferred either direct seeding under fruit trees or transplantation of young seedlings from the wild to accelerate the process and produce the maximum amount of seeds possible for the following season. The seeds harvested from transplanted plants were found to have better germination rates.

Table 2
Selection of species for extension activities.

Species	Results of trials	Reasons
Aralia chinensis	Dropped	Problem of seed availability for extension; low germination rate
Gentiana rhodantha	Dropped	Small market niche in locality; not farmers' preference
Paris polyphylla var. *yunnanensis*	Dropped	Technique barriers to management; high investment in greenhouses needed; long period of waiting for harvest; considerable labour input
Scutellaria baicalensis	Dropped	Lacking market access; problem of seed availability
Dipsacus daliensis	Kept	Good market; cultivable with little technique needed; short period for harvest
Codonopsis pilosula	Dropped	Very low survival rate; uncultivable on the project site
Adenophora tetraphylla	Dropped	Problem of seed availability; very low survival rate

Note: The reasons for extension of selected species are based on participatory monitoring, scientific assessment, and farmers' knowledge.

Table 3
Economic benefits to households from *Dipsacus daliensis* cultivation in 2005 and 2007.

Households	2005				2007			
	Area (ha)	Production (kg)	Net income (USD)	Net income/ha (USD)	Area (ha)	Production (kg)	Net income (USD)	Net income/ha (USD)
Household A	0.2	350	90	450	0.07	150	98.57	1478.57
Household B	0.05	100	28.57	535.71	0.1	300	171.43	1714.29
Household C	0.2	280	68.57	342.86	0.2	200	114.29	571.43
Household D	0.13	275	157.14	1178.57	0.17	600	342.56	2057.14
Household E	–	–	–	–	0.07	175	110	1650
Household F	–	–	–	–	0.03	50	35.71	1071.43
Household G	–	–	–	–	0.07	150	85.71	1285.71
Household H	–	–	–	–	0.4	1200	857.14	2142.86
Household I	–	–	–	–	0.2	600	428.57	2142.86
Household G	–	–	–	–	0.47	1150	821.43	1760.2
Average	626.79				1587.45			

Note: Net income stands for the income minus labour inputs and other agricultural materials (seeds and fertilizer). Only four of five households benefited in 2005. We sampled 10 out of 40 for the economic survey in 2007.

Table 4
Pyrus pyrifolia growth and production in different SLCP systems.

	n	With intercropping of medical plants Mean ± S.E.	Without intercropping Mean ± S.E.	T	P-value (t-testing)
Crown width (m)	30	1.70 ± 0.05	1.26 ± 0.05	5.80	0.000
Tree height (m)	30	3.80 ± 0.15	3.08 ± 0.13	3.56	0.001
Fruit production (kg/tree)	30	3.73 ± 0.25	2.30 ± 0.22	4.31	0.000

Note: S.E. indicates standard error of mean ($n = 30$); based on student's t-test, the significant difference between means for each parameter indicated by P-value ≤ 0.001.

In 2005, farmers' interest groups evaluated the species' selection and the participatory technology development process. The results were mixed (Table 2). Even though several species were found to be both amenable to cultivation and marketable, farmers preferred species that were easy to manage and quick to harvest. As a result, only one species (*Dipsacus daliensis*) was selected as a "super species" for extension purposes. This species was chosen because the root, believed to be a good tonic for the blood, can be harvested quickly (in one and a half years) and sold to manufacturers of Chinese medicines. Other key factors in its selection were that seeds were readily available and little labour was needed for its cultivation.

3.3. Participatory monitoring and evaluation

The first round, while modest in extent, led to widespread extension. The critical elements for participatory technology development include not only field experimentation but also learning through monitoring and evaluation. The integration of indigenous and scientific knowledge led to the sharing of in-depth and extensive experience and knowledge based on the results. As one species proved to be of high value and particularly suited to cultivation in the region, it was selected for subsequent plantation: in the second round, the project was scaled up to 40 households and the project currently covers four natural villages, with more than 5.3 ha of land is intercropped with medicinal plants and trees. Expanding acreage to more than 20 ha led to the establishment of a producers' association for medicinal plants. An additional five suitable species were identified as back-up species through a new cycle of participatory technology development with other farmers. This process of extension was the result of monitoring and evaluation which gave a clear picture of the immediate economic returns that could accrue from this new type of SLCP. The extension process also provided valuable learning experiences for all those involved: farmers learned to domesticate, cultivate, process, and market medicinal plants; the ICRAF research group gained new knowledge about tree and plant interactions in these agroforestry systems; and forestry officials learned about the ecological benefits of tree cover with fruit trees and land cover with medicinal plants.

3.4. Economic benefits developing livelihoods

The economic benefit of growing *D. daliensis* was a significant incentive to expand cultivation of medicinal plants into other SCLP areas. Table 3 gives the economic benefits from PTD. In 2005, the average production per ha was 1733 kg which yielded 626RMB (79 USD) net income per ha. In the second round of on-farm demonstrations, the average production increased to 2570 kg/ha and the net income to 1587 USD/ha. This increase was a result of improvements in management practices (e.g. pruning leaves to improve roots) and a rise in market prices.

Although plots were small, much higher returns per land unit were achieved than with any other crop. In cases where the crops were well managed, individual farmers' financial returns reached approximately 4000 USD/ha. In a poor mountain community where the average annual per capita income is 100 USD, the incentive of such high returns motivated farmers to join in and become members of farmer associations. Market growth also encouraged them to continue with participatory technology development.

3.5. Ecological sustainability

The project also monitored the ecological consequences of incorporating medicinal plants into forest restoration in the SLCP in terms of improving tree growth and performance. Table 4 compares the growth of *P. pyrifolia* in the SLCP with and without intercropping. Thirty trees were selected randomly for this evaluation. Mean tree growth rates and fruit yields were greater in the intercropping system, with an average of 1.7 m of crown cover, 3.8 m in tree height, and 3.7 kg of fruit yield, versus 1.3 m mean crown cover, 3.1 m tree height and 2.3 kg fruit yields for trees that were not intercropped. These differences were significant (based on Student's t-test) for crown cover ($t = 5.80$, $P < 0.001$,), height ($t = 3.56$, $P = 0.001$), and fruit production ($t = 4.31$, $P < 0.001$).

Trees intercropped with medicinal plants replicate conditions found in natural forests. The canopy of deciduous fruit trees provides adequate shade, sunlight, and humidity for medicinal plants. No chemical fertilizers are needed because the tree litter recycles nutrients and natural predators control insects. It was noted that a dense cover of medicinal plants provides good protection and organic matter for the soil, thus controlling erosion, improving fertility and ultimately increasing production of medicinal plants and fruit, as well as farmers' incomes. Cultivating medicinal plants contributes to in situ biodiversity conservation and can help to prevent overharvesting of wild plant resources.

4. Discussion

Many studies have focused on ethnobotanical approaches to the documentation of indigenous knowledge (c.f. Pei, 2001); incorporating non-timber forest products into improved swidden-fallow management (Xu et al., 1999; Xu, 2007); and traditional agroforestry practices (Sharma et al., 2007). While other studies have examined conflicts between rural livelihoods and implementation of the Sloping Land Conversion Programme (Xu et al., 2005b; Weyerhaesuer et al., 2005), few have explored innovate alternatives to implementation of the SLCP, and one rarely finds research linking indigenous knowledge to policy planning and implementation. The present case study demonstrates that implementation of a participatory technology development process involving local farmers, native species, and indigenous knowledge, supported from external facilitators including the government forestry agency can benefit all parties concerned.

The PTD approach provides a useful framework not only for participatory research, but also for farmers' empowerment. Its utilization of a participatory approach throughout the full cycle – from planning to action and change – facilitates the attainment of both qualitative and quantitative impacts (Van de Fliert and Braun, 2002). In our pilot project, farmers from the local community, foresters from the government agency, and facilitators from the project were all closely involved in identifying problems in forest policy, seeking solutions to them, experimenting with local species, and monitoring and evaluating the results. The process enabled the stakeholders, particularly farmers, to become involved in, have control over, and make decisions about the on-farm research process (Vernooy et al., 2006) and, as a result, they took on ownership of the research which was farmer-led and location-specific. This, in turn, informed practice and promoted consensual decision making and adaptive management (Van de Fliert and Braun, 2002).

The team was able to demonstrate that participatory research could be both a means and an end to strengthening people's capacity to make decisions and their ability to create an environment for change (Vernooy et al., 2006). In the case of Yangliu watershed, capacity building for farmers, foresters, and researchers was embedded in the PTD process for improving forest management in the SLCP. This was associated not only with the technical aspect of species selection and field experimentation, but also with the social aspects of how to organize and motivate farmers. It enabled rural people to analyse and reflect on their livelihoods in a way that was empowering and transforming.

Finally, the participatory technology development process strengthens the communication among different stakeholders and the interface of their different types of knowledge, i.e., scientific and indigenous. The process was developed in response to the complex, changing, and risk-prone environment of farmers in mountain regions of Southwest China who can no longer rely on their local knowledge alone and on farming as it was practised in the past. The participatory technology development approach provides a platform for interaction among stakeholders through which scientific knowledge can be integrated with indigenous knowledge, which can both farmers and scientists. Rather than focusing on the dichotomy between scientific and indigenous knowledge (Agrawal, 1995), this approach promotes knowledge integration and innovation at grass roots' level for locally sustainable upland development, and serves as a tool for knowledge innovation, capacity building, multi-stakeholder interaction and policy reform.

In the process of sustainable forest management, social capital is not simply restricted to 'bonding', or relationships with groups, but also consists of 'bridging' and 'linking' social relations between groups and stakeholders (Woolcock and Narayan, 2000). While forest policy reform and the SLCP weakened the institutional arrangements and practices of indigenous forest management, social capital was developed in this project through participatory action research among farmers, extension workers, and researchers. The project went beyond the village level in dealing with internal arrangements for forest management, and engaged with a wider circle of stakeholders to 'bridge' and 'link' with externalities, in which other party such as local forestry bureau has potential external benefits from those activities also. These externalities, on the other hand, are supported by social capital enhancement at village level—e.g., discovery of local 'experts' and forming farmers' interest groups and farmers' associations which enable the community to act, respond, and adapt to the changing environment. The knowledge derived from this pilot project was shared by farmer-to-farmer training through the new institutions established within the community. Social capital, therefore, has played a significant role in knowledge exchange, in sharing, and in innovations in community forestry.

The policy implications for sustainable forest management drawn from this research project have two aspects. First, the research was participatory—households were involved in almost all stages of planning and implementation. This is a departure from past practice, as forestry authorities have traditionally paid more attention to finishing tasks assigned to it from higher levels of government than in working jointly with farmers on research, whose knowledge and capacities were generally under-valued. Since the research began, there has been a shift in their thinking from 'what we know' to 'what farmers know', from 'tree planting' to 'livelihood development', and from 'top-down' to 'bottom-up'. A critical understanding of the value of participation and of the importance of indigenous knowledge for research and sustainable development has been acknowledged by the local forest bureau, but more investment is required to scale up this impact.

Second, the formulation of the SLCP did not fully consider the complexity and diversity of mountain regions. Indigenous knowledge and its practices provide an important window through which policy makers can get a holistic perspective on the local natural and cultural landscape, and also can provide more appropriate and viable alternative practices for sustainable forest management in upland watersheds. Indigenous knowledge can increase the capacity of local communities to adapt to changing ecological situations, as well contributing in positive ways towards the transformation of landscapes and livelihoods. In addition to considering indigenous knowledge while implementing policies, it should also be taken into consideration in formulating policies for forest management.

5. Conclusion

For farmers, a participatory technology development approach linking development with conservation creates an opportunity for incorporation of indigenous knowledge, innovations, and practices. Such a process requires support through a decentralized and flexible approach to policy planning, implementation, monitoring, and evaluation and a mechanism to integrate scientific knowledge into decisions about disseminating knowledge to and through local communities. Forestry agencies need to integrate the needs and aspirations of local farmers into plans for conservation and development. The key to increasing local participation in forest restoration is to develop a 'sustainability strategy' at the onset so that the positive benefits of the SLCP programme will endure after subsidies cease (Calder, 2007). The example of successful SLCP implementation discussed in this paper demonstrates the potential for hybrid, tailored knowledge for technology development and for institutions to improve livelihoods and maintain functions of the forest ecosystem associated with biodiversity and knowledge systems (Xu et al., 2005a). The challenge is finding ways to upscale these promising innovations. Institutional reform and mandatory transformation towards pro-poor and pro-farmer programmes are the keys to sustainable forest management. Current development and conservation policies can be improved by considering specific local environments, knowledge systems, and institutional arrangements through participatory approaches.

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