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Source: Mountain Research and Development, 35(4) : 318-327

Published By: International Mountain Society

URL: https://doi.org/10.1659/MRD-JOURNAL-D-15-00046.1

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

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Participatory Selection of Tree Species for Agroforestry on Sloping Land in North Korea

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The action research project reported in this article used a participatory approach to select trees for sloping-land agroforestry as a key strategy for forest ecosystem restoration and local livelihood development. It was the first such project in the Democratic People's Republic of Korea (North Korea) to use a participatory approach, empowering local user groups to develop their preferences for agroforestry species. Local knowledge of the multiple functions of agroforestry species ensured that the tree selection criteria included the value of timber, fruit, fodder, oil, medicines, fuelwood, and erosion control. Involving 67 farmers from 3 counties, this participatory selection process resulted in Prunus armeniaca, Castanea crenata, *and* Ziziphus jujuba *being selected as the top 3 species for the development of sloping-land agroforestry in North Hwanghae Province. These trees embody what the region's farmers value most: erosion control, production of fruit, and economic value. The participatory approach in agroforestry could help to meet both local needs for food security and the national objective of environmental conservation and has great potential for wide adaptation in North Korea and beyond.*

Keywords: *Agroforestry tree species; sloping-land management; participatory species selection; user groups; Democratic People's Republic of Korea.*

Peer-reviewed: *August 2015* ***Accepted:*** *September 2015*

Introduction

Since the mid-1990s, natural disasters and economic difficulties have plunged the Democratic People's Republic of Korea (North Korea) into a state of prolonged food insecurity (Noland 2004). Food and energy shortages have forced people to cut trees on sloping land, which has led to serious deforestation and environmental degradation, which in turn caused soil erosion and a loss of biodiversity and livelihood options (Pang et al 2013; Kang and Choi 2014) (Figure 1). To address this problem, the North Korean government established a new policy in 2000 to stimulate reforestation and promote agroforestry to meet both environmental protection and food security needs.

Key to this policy is planting the most beneficial tree species. However, in North Korea, not a lot of attention was paid to the selection process. Species were usually selected according to a single criterion—economic or environmental benefit—which led to a focus on fast-growing timber species including larch and pine (Xu et al 2012). Moreover, the selection process has been dominated by state forest agencies, which have given little attention to local desires. This centralized model of tree species selection has failed to address both the national target for conservation and local interests in livelihood development (Xu et al 2012).

In agroforestry for sloping-land management, the choice of species is highly complex in both biological and socioeconomic terms (Roshetko and Evans 1999; Gunasena and Roshetko 2000; Simons and Leakey 2004; Leakey et al 2012) (Figure 2). From an ecological perspective, the erosion and runoff control provided by a mix of appropriately selected and placed trees can help achieve watershed and biodiversity conservation objectives (Leakey 2012). At the same time, for socioeconomic reasons, successful selection of tree species in mountain areas can increase agricultural productivity and supplement farmers' incomes through the sale of fruits, nuts, fuelwood, and timber, while mitigating fuelwood and timber shortfalls (Weyerhaeuser and Kahrl 2006).

However, there is no simple and practical way to identify the social and environmental trade-offs in tree species selection (German et al 2006). Stakeholders include many individual resource users with differing interests that are difficult to generalize across an ecological zone. They cannot actively take part in land-use management if the plan fails to fulfill their livelihood requirements. In the past, too, researchers' own interests and views on species importance have regrettably

FIGURE 1 Extensive farming on steep slopes after famine in the 1990s. (Photo by Jianchu Xu, taken in North Hwanghae Province in 2008)

constituted the most important criteria (Franzel et al 1995). Therefore, the principle of "right species for right place" requires that the preferences of local stakeholders and ecological suitability both be considered, paying particular attention to local ecological knowledge (Reubens et al 2011; Suárez et al 2012). There is an urgent need to develop ways to manage sloping land that strengthen the multifunctionality of the forest ecosystem and focus on multipurpose species selection.

A participatory approach to natural resource management has been advocated as a means to improve relevance and the swift adoption of technology. It has helped scientists to understand how farmers experiment on their own and to seek partnerships with them to develop technology (Chambers et al 1989). In development studies, the participatory approach has been widely applied for integrating scientific knowledge and local knowledge (He et al 2009), serving as a means of capacity building (Muro and Jeffrey 2008) and also, more importantly, as a tool to empower local people in natural resource management and decision-making, from which they have been largely excluded by the centralized system (Ribot et al 2010). Thus, participatory natural resource management is a means of decentralization (Blomquist et al 2010). It now has been widely accepted that a participatory approach helps meet both local needs and national objectives for sustainable development (Campbell and Vainio-Mattila 2003).

As for agroforestry, participatory methods hold the greatest potential to involve farmers in the design of agroforestry systems (Haggar et al 2001; Suárez et al 2012). Participatory agroforestry is therefore one of a number of strategies currently being promoted to enhance watershed function and local livelihood development (eg Weyerhaeuser and Kahrl 2006; He et al 2009). For this strategy to succeed, tree species for sloping-land agroforestry must be chosen carefully in order to address local people's perceived needs. Generally, the selection involves identifying and prioritizing farmers' needs and preferences in forest tree management and utilization. Furthermore, by taking local environmental knowledge into consideration, a participatory approach helps to identify tree species for selection that can meet both social and environmental needs (German et al 2006). Priority setting and characterization based on users' perceptions is an essential element in tree species selection, and, more importantly, the rapid adoption of selected species and agroforestry technology (Kumtashula and Mafongoya 2005).

FIGURE 2 Selecting the right species not only helps to restore the ecosystem but can also contribute to local livelihoods. (Photo by Jianchu Xu, taken in Suan County in 2012)

Currently, however, there is limited information on the selection of indigenous tree species for sloping-land agroforestry, in particular on participatory experiences in a highly centralized country like North Korea. Drawing on empirical data, this research highlights the importance of such an approach. It may produce valuable insights for participatory research and practice in 3 aspects:

1. Data generated from qualitative research were enhanced using a quantitative method, a combination that has received little attention in research on participatory methods.
2. It elaborates on the process of empowering local user groups to develop their species preferences, whereas other research has been more focused on results.
3. It highlights local knowledge about the multiple functions of agroforestry species, including the value of their timber, fruit, fodder, oil, medicinal products, fuelwood, and ability to control erosion.

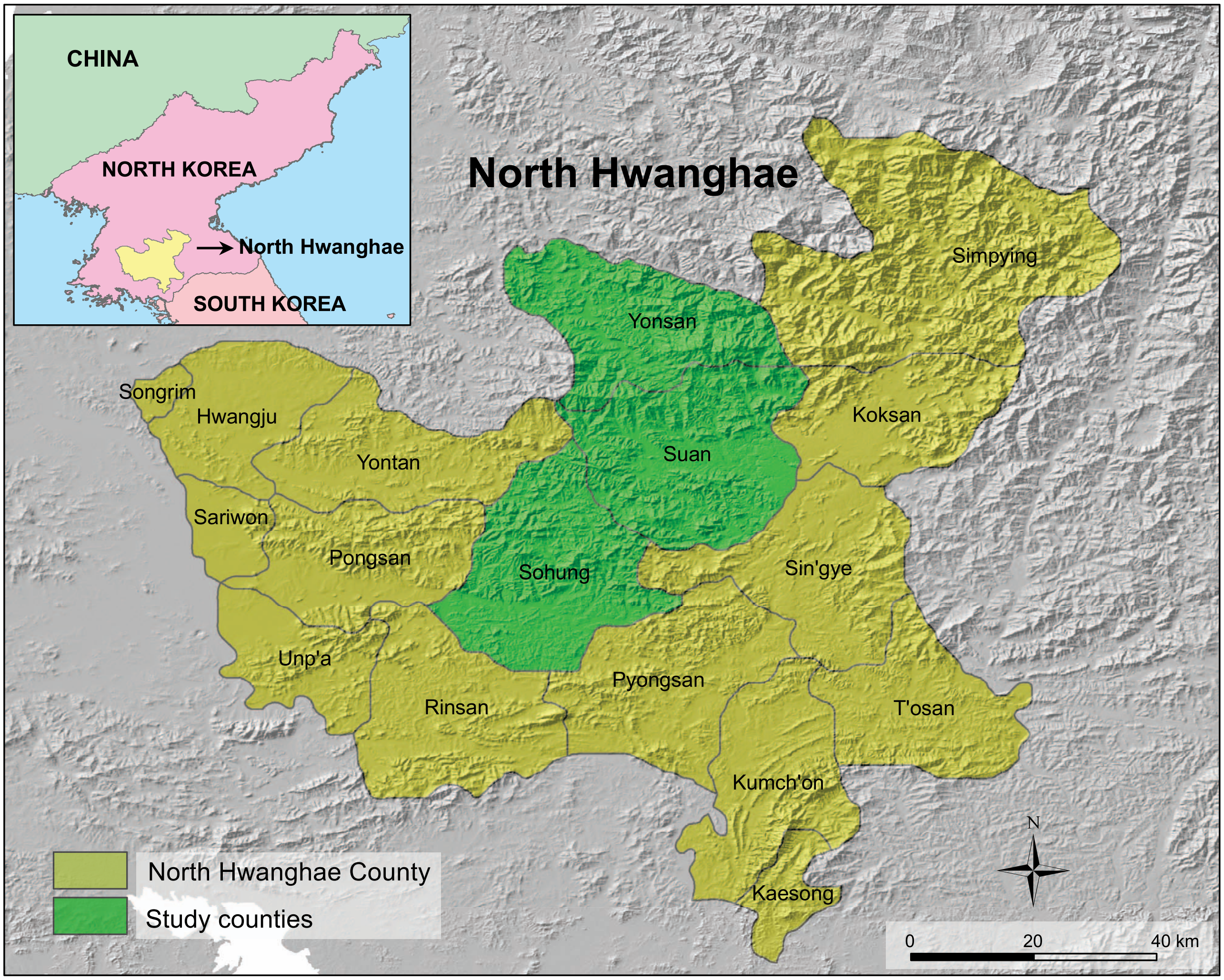
As such, this research has empirical implications for other places in the world on how to select tree species for environmental protection and livelihood development using a participatory approach.

Research methods

Study site

The study was conducted in Suan, Sohung, and Yonsan counties in North Hwanghae Province, North Korea (38°42′N to 38°47′N, 126°17′E to 126°24′E) (Figure 3). The highest point in the area is Kidae Peak (811 m), and the second highest is Mount Chonja (751 m). Over 81% of the counties are mountainous, which is a common landscape type in North Korea. The 3 counties also have lowland valley watersheds. The lowland valleys are mainly dominated by rice or maize cultivated by cooperative farms. Agricultural returns from the lowlands have been distributed by the centralized system (Xu et al 2012). Local people gained de facto access to sloping land during the famine in the 1990s, clearing vast swathes of forest to grow food (Xu et al 2012). Such practices have caused serious deforestation in North Korea (Pang et al 2013).

FIGURE 3 Location of the study area. (Map by Mingcheng Wang)



The climate in those counties is generally temperate continental. Annual mean temperature is 8.9°C, with a January average of −7.8°C and an August average of 23.6°C. Average annual rainfall is 1100 mm, which is a relatively large amount of rain. The first frost occurs around mid-October, and the last around mid-April. Mountains cover 81% of those counties and broad-leaved trees make up 55% of all tree species. Soil is mainly forest brown soil. These biophysical conditions limit the opportunities for double-cropping or massive agricultural production, which causes rural communities to continue clearing forest on sloping land. This has led to soil erosion, which will have to be countered by sustainable land use practices.

The Sloping Land Management Project was initiated in the 3 study counties by the Ministry of Land and Environmental Protection (MoLEP), with financial aid from the Swiss Agency of Development and Cooperation and technical support from the World Agroforestry Centre's East and Central Asia office. In 2003, the Sloping Land Management Project established 3 sloping-land user groups in Suan County. Two years later, in 2005, the project was expanded to Sohung and Yonsan, and by 2014, there were 14 sloping-land user groups in Sohung, 20 in Yonsan, and 22 in Suan, supporting the food security of participating households. These user groups were formed locally; their members were mainly disadvantaged farmers who now had use of sloping land to meet subsistence needs, while taking responsibility for restoring forests and minimizing soil erosion. MoLEP and the Swiss Agency of Development and Cooperation saw agroforestry as the key strategy to combat food shortage and deforestation. The World Agroforestry Centre has been involved since 2008 to support the development of participatory agroforestry.

Data collection

Data collection was done in 2 major steps between 2008 and 2011. First, participatory rural appraisal was employed to collect data—on criteria for tree ranking, tree species selection, and farmers' traditional knowledge of the trees' multiple functions—through semistructured interviews, focus group discussions, nonparticipant observations, and a transect walk. Semistructured interviews helped to identify indigenous species that people had used before, and the transect walk identified existing species. Focus group discussions were conducted with the sloping-land user groups' representatives and MoLEP officials to exchange their knowledge of and interest in tree species.

Based on these experiences, in August 2008, a participatory agroforestry development workshop was organized by the World Agroforestry Centre in Suan County, with participation by sloping-land user-group representatives from all 3 counties (Figure 4). Workshop participants were asked to brainstorm to form a list of species for possible use in the sloping-land agroforestry project in their county (Xu et al 2011). A list of tree species for each county resulted from this brainstorming, which served as the basis for a ranking founded on economic and environmental benefits, as well as management benefits (Table 1); this material was then developed into a questionnaire to rank tree species.

In the second step, in 2010–2011, farmers were surveyed on their preferences regarding tree products and species in order to identify their needs and to determine the most useful species for landscape restoration, using the questionnaire developed in the first step to ask sloping-land user group members to rank the tree species based on their various benefits. Participants could score each species from 0 to 5 on each of the ranking criteria (Figure 5). Table 2 describes the demographic and educational characteristics of the 67 farmers, all sloping-land user group members, who participated in the tree ranking exercise.

Data analysis

The Statistical Package for Social Science version 15.0 (SPSS 15.0) was used to determine the mean scores of individual tree species that were ranked according to their benefits from the survey. Analysis of variance (ANOVA) tests were performed to identify how the mean scores of different tree species groups varied across each benefit (ANOVA is designed to test for a significant difference between 2 or more groups). The highest-ranked species based on benefit was then selected for discussion in a consultation workshop organized in each county, where the most appropriate tree species were determined.

Results

Farmers' perspectives on species' multiple functions were explored through a preliminary survey as well as during the workshop in 2008. Instead of focusing only on the economic aspect, farmers' perspectives were much more holistic and took environmental, social, and economic benefits into account (Table 1). Farmers' traditional knowledge (Table 3) was gauged by means of interviews. Apricot and chestnut trees were praised for their quick fruiting capacity, only 3 years after planting. Jujube was another well-liked tree because it is immune to pests and can be used as a food. Peach was mentioned as a good tree when planted by itself, but a poor choice for agroforestry because harvests from intercrops would be very low.

The best species for sloping-land agroforestry were identified using a questionnaire based on the preliminary species list and farmers' selection criteria for different uses. Species were ranked on how well they met the farmers' selection criteria; a 1-way ANOVA test showed a significant difference ($P < 0.0001$) across the 3 study counties.

- Fruit ($F = 72.091$): jujube, plum, and apricot, followed by peach, walnut, and chestnut, followed by shiny-leaf yellowhorn and persimmon;
- Fuelwood ($F = 17.708$): acacia, oak, and amorpha;
- Fodder ($F = 41.300$): mulberry, acacia, and oak;
- Timber ($F = 46.725$): larch, pine nut, and poplar;
- Medicinal use ($F = 29.764$): aronia, jujube, sea buckthorn, and prickly ash;
- Other income sources ($F = 18.067$): prickly ash, peach, walnut, chestnut, and apricot;
- Soil fertility ($F = 18.083$): acacia, followed by oak and mulberry;
- Soil protection (erosion control) ($F = 4.23$): amorpha, acacia, mulberry, walnut, poplar, and shiny-leaf yellowhorn;
- Carbon sequestration ($F = 8.227$): acacia, poplar, amorpha, mulberry, evodia, and peach;
- Horizontal influence (competition with crops) ($F = 8.227$) and sociability in plant community ($F = 8.672$): sea buckthorn, mulberry, aronia, and walnut (ranked highly for both attributes);
- Ease of breeding ($F = 6.797$) and ease of management ($F = 3.750$): acacia, mulberry, oak, amorpha, poplar, and peach (for both attributes); shiny-leaf yellowhorn, walnut, chestnut, and apricot (for ease of management).

The results from the 1-way ANOVA test indicated the significant differences in perceived species benefits within and between groups. Based on the farmers' preferences determined in the county workshops, agroforestry species and suitable locations were chosen for sloping-land restoration in the 3 counties of the North Hwanghae Province (Table 4).

Discussion

Agroforestry tree species for ecosystem restoration and livelihood development should be chosen based on their ability to perform under site-specific biophysical conditions

10.1659/MRD-JOURNAL-D-15-00046.1

FIGURE 4 The participatory approach empowers local people to become involved in decisions about tree species selection for agroforestry on sloping land. (Photo by Jianchu Xu)

and land-use types (eg agroforestry or timber system), and should yield the products and services (eg fruit, timber, firewood, other income-yielding products, and erosion control) prioritized by the land managers, in this case the local community (German et al 2006; Reubens et al 2011; Suárez et al 2012). In North Korea, this is particularly true, as tree selection needs to serve both environmental and food security purposes. When selecting trees for sloping-land

TABLE 1 Criteria used by farmers to rank trees for inclusion in agroforestry projects.[a)]

Benefit type	Criterion	Specific benefits
Economic	Fruit	Fruit production, marketability, resistance to pests
	Firewood	Sprout regenerating ability, hardness of wood, low moisture retention, quick drying, fast growth
	Fodder	Leaf production, softness, nutrient content, quick drying (for storage)
	Wood	Fast growth, hardness of wood, marketability, color of wood
	Medicine	Effectiveness, wide application, production of medicinal elements
	Other income	Honey production, other food production, commercial value of seeds and seedlings, oil production
Environmental	Soil fertility	Amount of litter, root nitrogen-fixing ability, fast biodegradation of leaves
	Erosion control	Widely spread roots, water retention ability (wide leaves, many branches), large crown area
	Growth	Fast growth
	Horizontal influence	Light penetration, horizontal spread of branches, horizontal spread of roots
	Sociability	Lack of negative effects on other plants, presence of positive effects on other plants
Management	Breeding ease	Ease of using seeds, roots, cuttings
	Manageability	Resistance to disease and pests, less requirement for weeding and fertilizer

[a)]All listed factors were considered by farmers.

agroforestry, a participatory approach is crucial, as also observed by other scholars (Weber et al 2001; Narendra et al 2013).

"Participation" includes various types and degrees of involvement in, and control over, the selection of species. It encompasses a wide range of approaches, methods, and tools, and debates about it abound (Chambers 1997). Participation strengthens people's capacity to make decisions and their ability to create an environment for change (He et al 2009). As farmers and communities know their needs and local site conditions best (Roshetko et al 2008; Suárez et al 2012), a participatory approach involves farmers in processes that generate economically and environmentally sound technologies and manage natural resources more sustainably and more equitably (eg van de Fliert and Braun 2002; German et al 2006).

In the present case, we clearly show how the participatory approach enabled the local communities to select multipurpose species, in contradiction to government-dominated tree species selection, which only focuses on timber and fast growing species. The social and environmental trade-offs in tree species selection require not only the contribution of local knowledge, but also greater participation by local communities in the entire process (German et al 2006). As a result of such participation, this study was able to select multipurpose tree species for agroforestry in sloping-land management in the 3 counties under study. For the context of North Korea, a highly centralized country, it is a novelty that a bottom-up participatory approach was applied in forestry and enabled local decision-making.

This pilot project with its participatory approach was welcomed by government officials during a review workshop organized in 2012 (Xu et al 2012), during which participants expressed their appreciation of this participatory approach, as it advanced agroforestry development in 5 practical respects:

1. Responding to problems, needs, and opportunities identified by users;
2. Identifying and evaluating technology options that build on local knowledge and resources;
3. Ensuring that technical innovations are appropriate for local socioeconomic, cultural, and political contexts;
4. Promoting wider sharing and use of agroforestry innovations;
5. Building capacity and promoting knowledge exchange.

Additionally, the integration of quantitative analysis in the participatory approach (Figure 5) makes the results much more powerful and convincing to officials and donor agencies (Kumtashula and Mafongoya 2005). As a result, in 2013, the national government launched the National Agroforestry Policy, and in 2014, it formulated

FIGURE 5 Quantitative results from participatory exercises can be especially convincing. (Photo by Jianchu Xu)

the National Agroforestry Strategy, which aims to scale up the pilot project to the entire country. The launch of the National Agroforestry Policy is a landmark for North Korea. However, large-scale implementation of participatory agroforestry still requires additional international aid and capacity building.

Conclusion

This study adopted a participatory approach to selecting tree species for sloping-land management, agroforestry, and landscape restoration, which has implications beyond North Korea. It reveals the importance of the

TABLE 2 Characteristics of respondents who participated in the tree-ranking exercise.

Variable		Suan	Sohung	Yonsan	Counties combined
Sex	Female	32 (82.1%)	16 (88.9%)	10 (100%)	58 (86.6%)
	Male	7 (17.9%)	2 (11.1%)	0 (0%)	9 (13.4%)
Age	Mean ± SE	54.6 ± 1.96	48.2 ± 1.81	37.4 ± 2.38	50.3 ± 1.48
	Range	36–76	38–63	26–52	26–76
Formal education	High school	10 (25.6%)	7 (38.9%)	1 (10.0%)	20 (29.9%)
	Middle school	28 (71.8%)	11 (61.1%)	9 (90.0%)	46 (68.7%)
	Primary school	1 (2.6%)	0 (0%)	0 (0%)	1 (1.4%)

TABLE 3 Farmers' knowledge of key tree species.

Common name	Scientific name	Farmers' knowledge
Acacia	*Robinia pseudoacacia*	Good for fuelwood.
Alder	*Alnus japonica*	Grows quickly; grows well on north-facing slopes.
Apricot	*Prunus armeniaca*	Produces high-value fruit with first yields in 3 years; often suffers from pests; must be planted in sunny area for fruit production.
Aronia	*Aronia melanocarpa*	Has strong adaptability; grows best on drained soil; grows in rocky areas.
Chestnut	*Castanea crenata*	Bears fruit in 3 years; is adaptable to clay-loamy soil.
Jujube	*Ziziphus jujuba*	Is free of pests and can be used as a food
Larch	*Larix leptolepis*	Grows poorly in rocky areas.
Mulberry	*Morus alba*	Has high income potential; is good for soil erosion control.
Peach	*Prunus persica*	Provides fruit in 3 years, but intercrops have poor yields.
Pear	*Pyrus ussuriensis*	Grows well in the sun and in the shade.
Plum	*Prunus salicina*	Must be planted in a sunny area for fruit production; vulnerable to pests.
Poplar	*Populus davidiana*	Suitable for gently sloping land.
Walnut	*Juglans regia*	Must be planted in a sunny area for fruit production.

participatory approach as a key strategy for forest ecosystem restoration and local livelihood development. The results show the many good attributes ascribed to trees by local farmers, such as erosion control, fruit for food security, and economic benefits. Practically, the participatory approach plays a crucial role in understanding local preferences and knowledge of the multiple functions of agroforestry species (German et al 2006; Reubens et al 2011; Suárez et al 2012; Xu et al 2012). The policy implication is that selecting agroforestry species requires local participation in order to achieve both economic and ecological benefits in sloping-land management. Although the current participatory techniques are limited to the project level, there is great

TABLE 4 County-specific choices of species for agroforestry in different locations.

Main benefit	Suitable location	Preferred species	Counties
Fruit	Agroforestry near villages	*Prunus armeniaca, Castanea crenata, Ziziphus jujuba, Pyrus ussuriensis*	Suan
		Hippophae rhamnoides	Sohung, Yonsan
Erosion control, fuelwood	Forest and agroforestry on sloping land	*Alnus japonica, Salix gracilistyla, Juglans mandshurica*	Suan
		Ulmus pumila	Suan, stony area
		Morus alba	Suan, Sohung
Timber	Forest on mountain top	*Larix olgensis* var. *koreana*, *Larix leptolepis, Kalopanax pictum, Tilia amurensis*	Suan
Other income	Agroforestry on sloping land	*Pinus koraiensis, Evodia daniellii, Xanthoceras sorbifolia*	Sohung
		Quercus acutissima, Aronia melanocarpa	Suan, Yonsan

10.1659/MRD-JOURNAL-D-15-00046.1

potential in the national agroforestry policy, which will scale the project up to the national level. Furthermore, it bears significance for further studies elsewhere, and can help improve policy and agroforestry technology for the sustainable use of sloping land, in particular to protect watershed functions and improve food security.

ACKNOWLEDGMENTS

This study was supported by the Swiss Agency for Development and Cooperation and the CGIAR Research Programs on Forests, Trees and Agroforestry (CRP6). The authors thank Professor Gwangju Kim and Songryong Jo from the Ministry of Land and Environmental Protection; Munsong Kim and Sungil Choe from the Botanical Institute at the Branch Academy of Biology, State Academy of Science; and Songchol Ho, the local expert who helped collect data during the field survey. We also acknowledge English assistance from Juliet Lu and Sander Van de Moortel and mapping by Mingcheng Wang. We also highly appreciate insightful comments from 2 anonymous reviewers and support from the editorial team.

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