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This article analyzes a project concerned with the conversion of agricultural land into forests and the impact on local communities in the upper Min River Basin in China. The aim of the project, called "Grain for Green" (Tui Geng Huan Lin)*, is to improve watershed conditions, enhance biodiversity, and conserve natural resources. Results from a participatory socioeconomic survey showed that the basic living standards of farmers were guaranteed by government subsidies because some of their cultivated land was converted into protected forest. The common perception is that although farmers were happy to participate in the project because they became less dependent on agriculture and were able to diversify their income, they were worried about their future after 8 years of government subsidies and preferred to plant forests for economic rather than ecological reasons. There is also a fear that if subsidies end, farmers may turn forestland into sloping cultivation land. To guarantee sustainable implementation of the Grain for Green Project, farmers discussed options with local government officials. In face-to-face interviews, they discussed issues such as basic cropland protection, educational investment, out-migration of the workforce, hydroelectricity exploitation, and tourism development.*

Keywords: *Grain for Green; afforestation; conversion of cultivated land; geographic information system; socioeconomic data; China.*

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FIGURE 1 Cultivation on steep slopes in Long Dong-gou Valley. (Photo by Ye Yan-qiong)

Introduction

Land use changes in mountain regions have both on-site and off-site effects on the environment and the people in river basins. The upper Min River Basin is an important water tower for the downstream population in the Chengdu Basin. The river provides irrigation water for crop production and supplies water to many downstream cities through the ancient Dujiangyan irrigation system that has been in use for more than 1000 years. The basin is an important ecological defense for the upper Yangtze River Basin and is also a major water supply source for the Chengdu Basin. It is known as "the Land of Abundance" (Pu 2000) in China. Forest clearance in the upper Min River Basin has had significant negative impacts on the quality and quantity of water flow in the Chengdu Basin (Liu 1994).

In 1998, after the devastating floods along the Yangtze River, considerable attention was focused on the possible causes (He and Song 1999; Li 1999; Chen 2001). Upstream deforestation was blamed, but this was not completely supported by scientific evidence (Bruijnzeel 1990; Hamilton and King 1993; Gade 1996; Wunder 1996; Winkler 1999). However, the crisis clearly prompted action to advance nature conservation and environmental protection in China. The central government announced the establishment of the Nature Forest Protection Project (NFPP) in an effort to halt the destruction of natural forests, whereas the "Grain for Green" (*Tui Geng Huan Lin*) Project was initiated to return cultivated land on slopes of 25° or more to forestland in the upper Yangtze River Basin and the middle and upper Yellow River Basin. The aim was to halt the deterioration of the natural environment and to safeguard water resources (Zhang et al 2000; Yang 2001). Natural forests were to be protected in the Sichuan province; the provincial government selected the upper Min River Basin as an experimental area for the Grain for Green Project because of its importance as a major water supply source for the Chengdu Basin.

The upper Min River Basin is well known for its forest resources and timber industry. The basin contains numerous ethnic groups such as the Han, Tibetans, and Qiang, and the area has been inhabited for hundreds of years. Agricultural land resources are very limited, and most cultivation is on sloping land (Figure 1). The goal

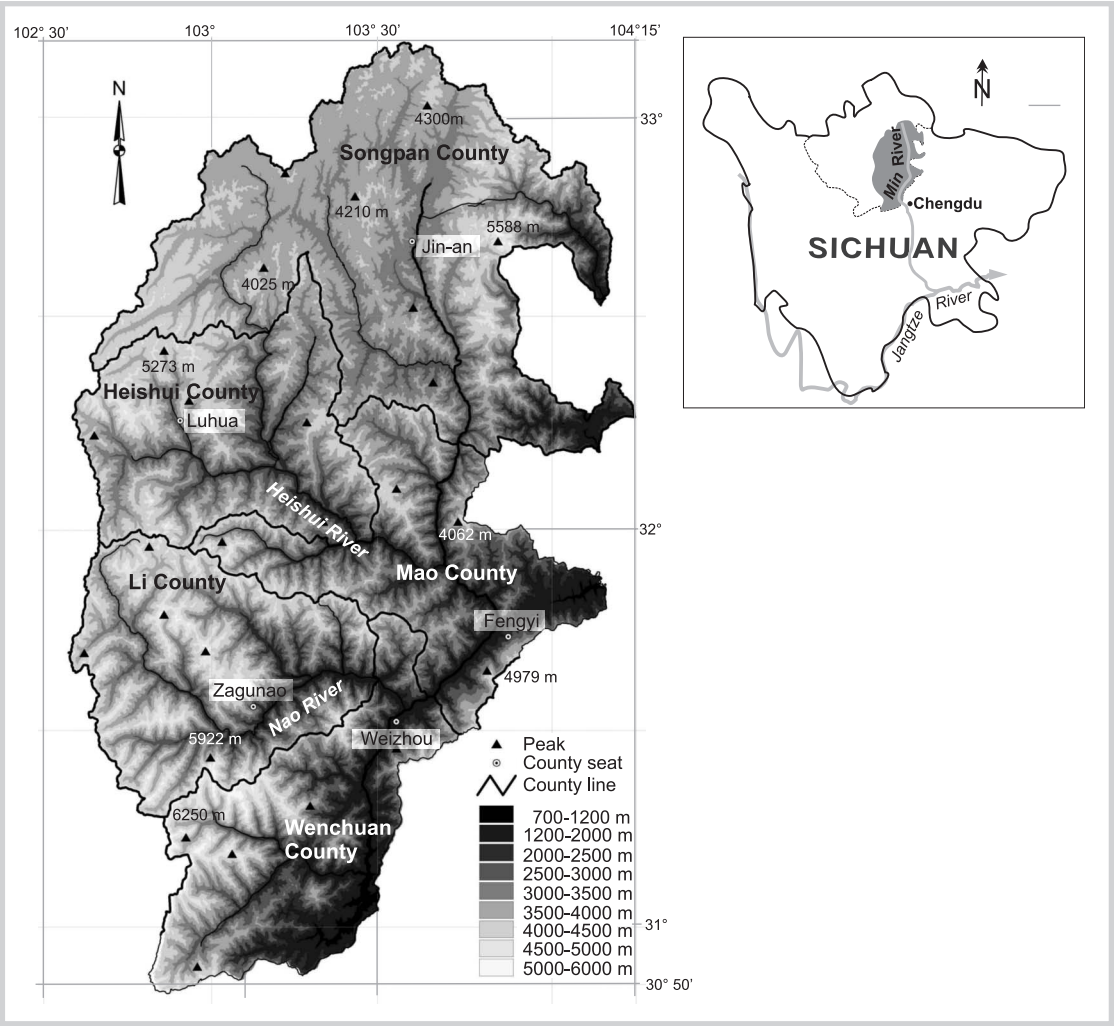


FIGURE 2 Location of the upper Min River Basin. (Map by Ye Yan-qiong)

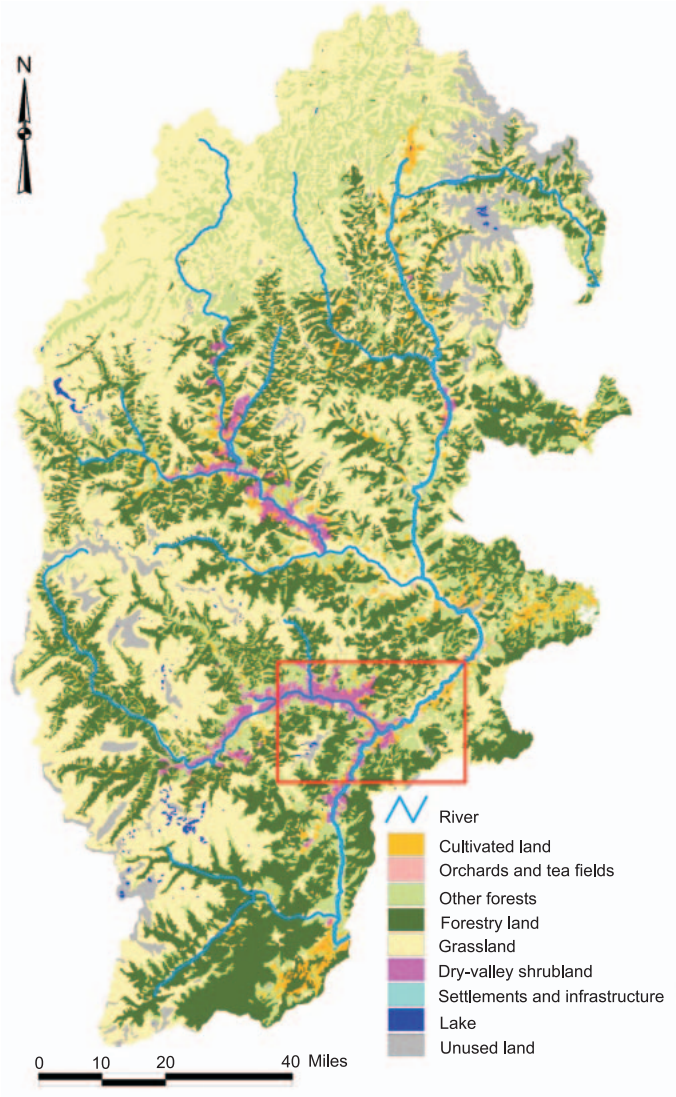
of the Grain for Green Project is to convert most of the cultivated land into forest for watershed protection and biodiversity enhancement. This article documents the impact of this project on economic conditions and the livelihoods of farmers.

History and land use

The Min River is a tributary of the Yangtze River and enters the Yangtze upstream of the Chengdu Basin, located southeast of the Aba Tibetan and Qiang Autonomous Prefecture, Sichuan, in a high mountain region with an altitudinal range between 600 m and over 6000 m (Figure 2). The basin is located on the eastern edge of the Tibetan Plateau and has an area of 24,657 km^2. It is a deeply dissected landscape with local relief between 2000 and 4000 m. Precipitation increases as temperature decreases with elevation. The average annual precipitation on the valley floor in Mao County is 500 mm, and the mean annual temperature is 13°C. Rainfall increases to 850 mm and the average temperature decreases to 5°C in Songpan on the basin plateau at 2885 m (Bao and Wang 2000).

The 3000–3800 m elevation zone consists of mixed conifer and broadleaf forests (*Pinus tabulaeformis*, *Quercus liaotungensis*). The 2200–3000 m elevation zone is dominated by mixed evergreen and deciduous natural forest consisting of subalpine spruce–fir (*Abies ernestii*, *Picea asperata*), and broadleaf forest occurs below 2200 m. The valley bottom is too dry to support forests and is dominated by grasses (Zhang 1992), whereas wet grassland occurs in the plateau region above 3800 m.

Clearance of natural forest stands began 4000 years ago when the Qiang tribes moved into the basin from northwest China (Wu 2000), but most natural forests remained undisturbed until 600 years ago. Since then, deforestation has accelerated as a result of timber extraction and conversion to agricultural land. Modern commercial logging began at the beginning of the last century, and the first logging company was founded in 1921 along the upper Min River Basin (Winkler 1996). Large-scale logging reached its peak between 1950 and 1980 and then declined during the 1990s because most of the valuable timber was exhausted. Forest cover was estimated at 50% in the 14th century, declining to 30% by 1950 and 18.8% by the 1980s. As the forests diminished, evaporation increased in the dry valley and water use for agriculture was increased; runoff in the upper Min River Basin declined. The average annual discharge between



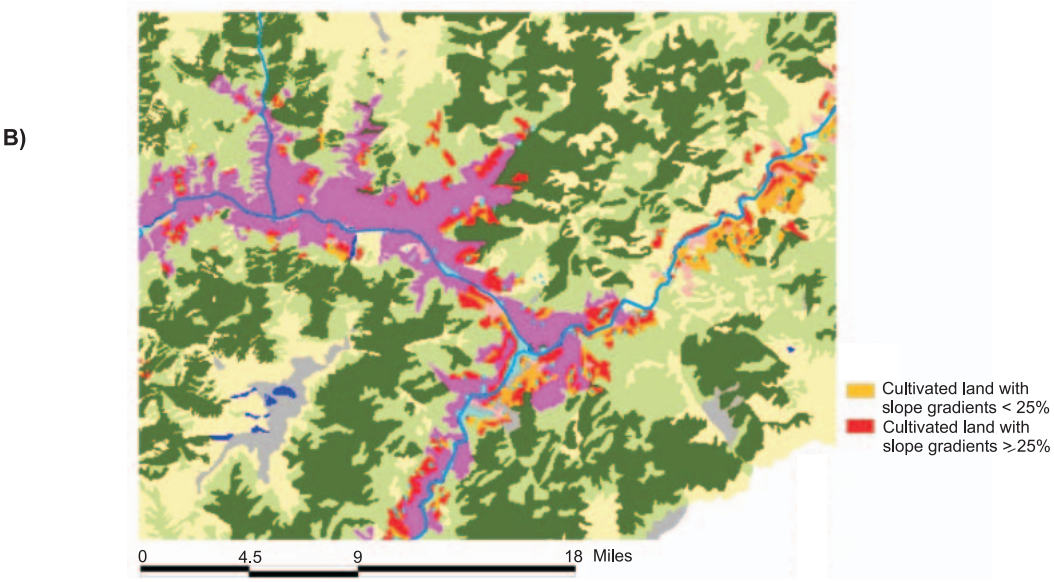


FIGURE 3, A AND B Land use in the upper Min River Basin (A), with blow-up of an area (B) showing cultivated land with slope gradients <25° and ≥25°. (Map by authors)

1950 and 1980 was 9.8 m^3/s, whereas the storm runoff increased by 6.9 m^3/s, and low water runoff decreased by 5.89 m^3/s (Wu 1997). Although logging for timber and exploitation for agricultural land stopped in 1998, when the NFPP and the Grain for Green Project were undertaken, environmental problems induced by forest clearance remain serious and are clearly evident. For example, the area affected by severe soil erosion was 10,265 km^2 in 1989 and 11,913 km^2 in 1999. Annual soil erosion increased from 2615 to 4040 tons, and the average annual rate increased from 25.5 to 33.7 tons/hectare (Ye 2002).

The upper Min River Basin had a population of 379,420 in 2000, of which Tibetans accounted for 29%, Qiang 37%, Han 28%, and Hui 6%. The rural population of 300,940 (79% of the total population) derived most of their income from agriculture before the implementation of the Grain for Green Project. According to the land use map (1:250,000), in 1994 (Figure 3a), the cultivated land area was 528.4 km^2, which accounted for 2% of the total land area in the basin (Table 1). This amounts to only 0.18 hectares of farmland per capita. Using geographic information system analysis, the land use map was superimposed on the slope map derived from the digital terrain model data for the Min River Basin (Table 2). Figure 3b shows that only a small portion of the cultivated land occurs in the warm dry valleys and sloping areas (>6°), but very steep sloping land (≥25°) accounted for 78.1% and 27.3% of the total cultivated land area, respectively (Fan 2002). Orchards dominate the low dry area, and the quality of apples and pears is excellent. The area under orchards has increased rapidly since the 1970s and now occupies 67 km^2 of the basin.

The total gross domestic product (GDP) was estimated at 186 million Yuan (US$ 22.5 million in 2000). Agriculture contributed 16.5% of the GDP, forestry 33.9%, and animal husbandry 7.6%. The average annual net income of farmers was 1458 Yuan (US$ 176.1).

TABLE 1 Land use in the Upper Min River Basin

Total population	379,420
Rural population	300,940
Total land area (km^2)	24,656.9
Cultivated land (km^2)	528.4
Orchards (km^2)	66.7
Forest (km^2)	12,304.8
Grassland (km^2)	10,068.5
Settlements (km^2)	39.5
Water (km^2)	158
Unused land (km^2)	1491
Average cultivated land per capita (hectares)	0.18

The Grain for Green Project

The state policy for implementing the Grain for Green Project states that farmers' income should not decrease when cultivated land is converted into forest. To accomplish this, state subsidies for husked grain and fees for education and health care are being provided. The government also provides 225 tons/km^2/y of grain to the regions of the Yangtze River and 150 tons/km^2/y to the upper and middle regions of the Yellow River. The subsidy is provided for 8 years if land is converted into ecological forest and for 5 years if planted for economic purposes. The government also provides a fee of 30,000 Yuan (US$ 3623) for education and health care and 75,000 Yuan (US$ 9058) as a seedling fee per square kilometer of afforested cultivated land.

TABLE 2 Cultivated land by gradient and cultivated land returned to forest by counties (km^2)

County	Total area per slope gradient				Total area of cultivated land	Cultivated land returned to forests
	0–6°	6–15°	15–25°	≥25°		
Sonpan	33	28.4	54.8	8.6	124.8	67.0
Heishui	5.7	44.4	57.5	53.6	121.2	91.5
Mao County	1.33	24.6	83.1	29.6	138.7	84.9
Li County	11.3	10.3	12.8	30.9	34.7	14.0
Wenchuan	11.4	28.8	47.4	21.3	109	78.7
Total	62.7	136.5	255.6	144	528.4	336.1

TABLE 3 Changes in total forest industry output and the main products in Mao and Li Counties, expressed as million Yuan and (million US$)

Output in million Yuan (million US$) (%)	Total output	Output from forestry activities	Output from orchards	Output from timber
Mao County				
1995	8.64 (1.04)	1.52 (0.18) [18%]	3.70 (0.44) [42%]	3.42 (0.41) [40%]
1999	6.62 (0.79)	1.15 (0.13) [17.4]	4.54 (0.54) [68.6]	0.93 (0.11) [14.0]
2000	8.36 (1.00)	3.76 (0.45) [45.0]	3.76 (0.45) [45.0]	0.84 (0.10) [10.0]
Li County				
1995	3.16 (0.38)	0.66 (0.08) [20.9]	1.79 (0.21) [56.6]	0.71 (0.08) [22.5]
1999	6.60 (0.79)	3.99 (0.48) [60.4]	2.31 (0.27) [35.00]	0.30 (0.03) [4.6]
2000	4.78 (0.57)	2.81 (0.33) [58.8]	1.80 (0.21) [37.6]	0.17 (0.02) [3.6]

The project started in the upper Min River Basin in 1998. On the basis of official statistics for the year 2000, 336.1 km^2 of previously cultivated sloping land has been planted with trees. This means that 63.6% of all cultivated land was converted into forests, with 27.3% (or 143.9 km^2) on land with slopes ≥25°. By 2000, the government had provided 75,629 tons of husked grain, 10.08 million Yuan (US$ 1.22 million) for education and health care, and 25.2 million Yuan (US$ 3.05 million) for seedlings. Most of the land conversion occurred in the warm and dry valley region and resulted in a decline in cultivated land of 0.12 hectares per capita and a reduction of 66.7%. The results show that the government has paid great attention to the restoration of the environment and has made great efforts to return sloping lands to forests. However, the livelihoods of farmers in the region will be affected by the Grain for Green Project.

Methodology

A socioeconomic questionnaire was used to investigate the impacts of the Grain for Green Project on farmers' livelihoods in the rural community. Questionnaires were sent to local officials, village leaders, and farmers, and detailed follow-up interviews were carried out in March 2002. Fifty questionnaires were sent out, and 30 replies were received. During the face-to-face interviews, questions were asked about farm practices, types of trees preferred by the farmers, subsidies received from the government, and impacts on income.

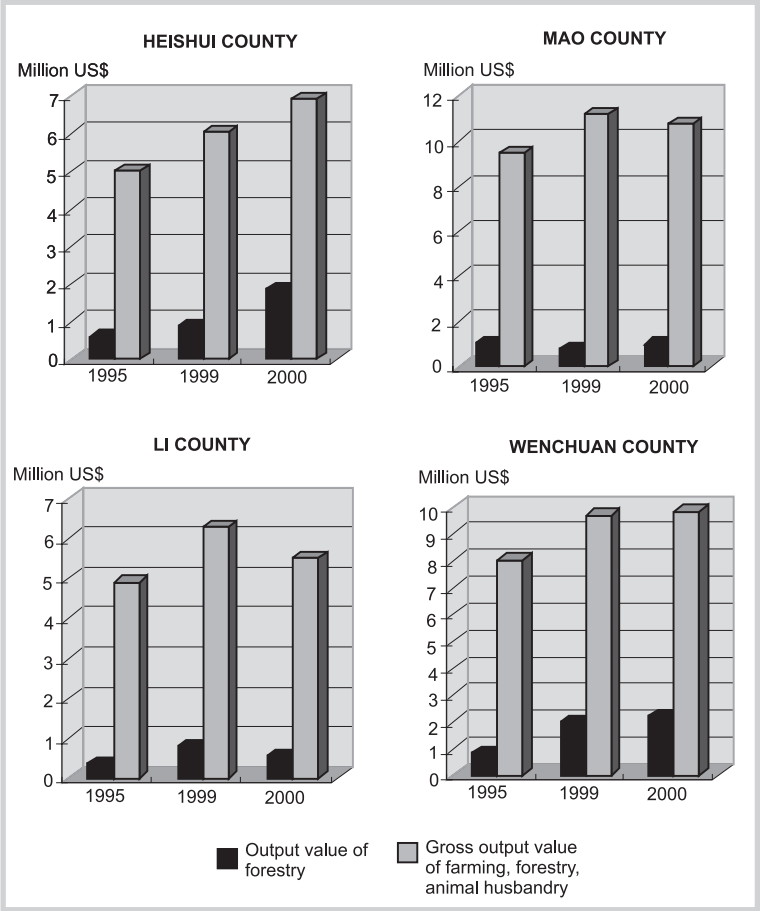
Results

The Grain for Green Project contributed greatly to improving the forest and restoring environmental conditions in the basin. Timber output was reduced from 3.42 million Yuan (US$ 413,044) in 1995 to 0.84 million Yuan (US$ 101,449) in 2000 in Mao County and from 0.71 million Yuan (US$ 85,749) to 0.17 million Yuan (US$ 20,531) in Li County, respectively (Table 3). Because of the Grain for Green Project, forest area started to increase by 1998, but returning cultivated land to forests had considerable effects on farmers and rural communities in the basin.

The results of the main impact of the Grain for Green Project in the upper Min River Basin were derived from official statistics, results from questionnaires, and face-to-face interviews. The results showed that the basic livelihood of farmers was guaranteed by government subsidies as compensation for returning their cultivated land to forests.

The average grain yield on sloping land in the basin was very low (202.5 tons/km^2). The government subsidy for husked grain was 225 tons/km^2 for land returned to forests under the Grain for Green Project. This means that farmers received 11% more grain through the subsidy than they would have obtained from average yields. This suggests that the basic livelihood of farmers was slightly better as a result of the subsidies. In those villages where large areas were converted, it was not uncommon for farmers to sell their grain subsidies. As a result, most farmers are willing to return their land to forests, particularly where the per

FIGURE 4 Output values for forestry and gross output values for farming, forestry, and animal husbandry in the upper Min River Basin.



capita land ownership is greater than 0.2 hectares. Local governments are also keen to remove more cultivated land and convert it into forests because they collect considerable administration fees for the subsidies.

The declining importance of agriculture

Figure 4 indicates that the gross output value from farming, forestry, and animal husbandry declined, whereas the output value from forestry increased from 1995 to 2000. Farmers have more time to do nonagricultural work than before because nearly two-thirds of cultivated land is now under forestry (Table 2). The results from the questionnaires and interviews with farmers showed that the farmers preferred doing temporary work in forest management (working in nurseries, planting trees, trimming), and 30% claimed that not having to leave their homes for outside work was the main reason for the preference.

The output from forestry (Table 3) increased from 0.66 million Yuan (US$ 79,710) in 1995 to 2.81 million Yuan (US$ 339,372) in 2000 in Li County and from 1.52 million Yuan (US$ 183,575) in 1995 to 3.76 million Yuan (US$ 454,106) in 2000 in Mao County, respectively. About two-thirds of the forest management output was paid wages for temporary work. This resulted in an overall increase in income from forest management from 1.45 million Yuan (US$ 175,121) in 1995 to 4.38 million Yuan (US$ 528,986) in 2000. The average annual family income from forest management increased by 472 Yuan (US$ 57). The highest annual family income, as determined by the interviews, was 3000 Yuan (US$ 362). In addition, farmers could supplement their income by constructing plastic greenhouses, planting and selling vegetables, and conducting business in the nearby town.

After 8 years of government subsidies, farmers are worried again about their livelihoods. They hope to safeguard and improve their household income from the Grain for Green Project, whereas the government's aim for the Project is to restore the degraded environment and control soil erosion by returning sloping cultivated land to forest. Project regulations call for 80% of the forest to be ecological forest, with only 20% used for economic gains in the future. According to regulations, subsidies for cultivating ecological forests are only for 8 years, and cash subsidies for commercial forests are only for 5 years. The regulations also state that farmers will have the right to collect subsidies and are responsible for managing forests but have no rights to use forests for timber production if they plant trees for ecological reasons. The farmers do have the right to use the fruits produced in the forest if they plant trees for commercial purposes; this will provide gains in income in 3–5 years. At the same time, the regulations do not indicate clearly whether government subsidies will continue after 8 years or how farmers' livelihoods will be guaranteed. Therefore, farmers prefer to plant, for commercial rather than ecological reasons, commercial trees, such as the Chinese prickly ash (*Zanthoxylum bungeanum*) (Figure 5), apple, grape, and pear on most of their returned cultivated land. This led to an increase in commercial tree planting from 204,900 trees in 1995 in Heishui County to 598,500 in 1999 and 1,135,100 in 2000 (a 5-year increase of 930,200 commercial trees).

Recommendations

In general, the Grain for Green Project has been very beneficial in terms of environmental restoration and has been successfully carried out in the upper Min River Basin. However, the question of how to guarantee farmers a basic living after 8 years of government subsidies is still in question. The established ecological forests may be once again converted to agricultural lands if this question is not resolved. In a face-to-face discussion between local governmental officials, village

FIGURE 5 Chinese prickly ash (*Z. bungeanum*) planted on steeply sloping land. Vegetation around *Z. bungeanum* is sparse because farmers need to eliminate surrounding vegetation to improve yield. (Photo by Ye Yan-qiong)

leaders, and farmers, the following suggestions were made to resolve the problem.

Basic cropland protection: To guarantee that farmers have sufficient grain, sloping land between 10° and 25° should be converted into terraces. This will limit erosion, preserve soil fertility, and result in higher yields if management is improved.

Strengthening educational investment and outmigration of the workforce: The upper Min River Basin is a depressed mountain area with a multiethnic population. With the decrease of arable land due to afforestation, there will be a rapid increase in the labor force as a result of the Grain for Green Project. To alleviate the problem, people should be encouraged to consider migration to more economically developed areas. However, most of the workforce is unskilled, and there are language barriers. As a result, the government should strengthen its education program to improve the skills of the workforce.

Hydroelectricity exploitation: Hydroelectricity is regarded as a key industry for the development of mountainous areas. The generation of electricity is supposed to guarantee a steady increase in regional income. The potential of hydropower development is extremely high in the upper Min River Basin. The estimated potential is 30,000 MW, only 20% of which is currently being exploited. However, hydropower development faces great logistical problems. The area is remote and lacking in basic infrastructure; an extensive road network needs to be constructed before hydropower can be developed. The central and local governments need to increase investment in infrastructure. Results from the questionnaire and the interviews showed that the consumption and cost of electricity is low (0.32 Yuan or US$ 0.039/kWh as compared with east Sichuan (0.60 Yuan or US$ 0.072/kWh) and that one third of all fuel used in rural households comes from firewood. With an increase in hydropower development, firewood consumption would decrease and flooding problems could also be mitigated.

Tourism development: Winkler (1999) is convinced that the tourism industry in its initial phase is too small to be able to replace the contribution from the timber sector. However, the area has abundant natural beauty and benefits from fascinating local traditions and customs that attract many domestic and foreign tourists. Tourism development should be encouraged because Tao Ping Qiang Zhai in Li County is famous for its traditional building style, and Qiang's indigenous cultural events are an additional source of attraction.

Conclusions

Forest degradation has been widespread on sloping cultivation in the upper Min River Basin, resulting in many problems with soil erosion that affected dry and warm lowland valleys. The central government initiated the Grain for Green Project 3 years ago by converting sloping agricultural land into forest. This resulted in significant environmental improvement and a large reduction in soil erosion.

Farmers' livelihoods were guaranteed through a subsidy for husked grain, a cash subsidy for education and medicine, and employment opportunities in forest planting and management. This central government policy was well received by the farmers because there were sufficient economic incentives for improving their income. However, satisfaction will only continue if advantages to farmers continue. Farmers are worried about their livelihood in the future because the project does not clearly indicate whether government subsidies will continue after 8 years. Once the subsidies end and there are no other benefits, farmers may return to growing crops on sloping land and using the forest for firewood.

The Grain for Green Project will only be successful if a compromise can be worked out between the central government's agenda and the farmers' needs. The government wants to restore the degraded environment, and farmers want to increase their income. To guarantee sustainable implementation of the project and farmers' livelihoods, it is suggested that resources should be made available to protect the remaining cropland, strengthen the educational program, encourage outmigration of surplus workforce, increase the development of hydroelectricity, and encourage the development of tourism.

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