Rehabilitation of Degraded Forests to Improve Livelihoods of Poor Farmers in South China

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Foreword

Degradation of forests and forest lands is a problem in many parts of the world and is particularly serious in south China where 70 per cent of the population lives in rural areas. Many natural disasters, such as catastrophic flooding in the Yangtze River basin, have been attributed to deforestation and there is real poverty in areas that have severe soil erosion and degraded forests. Forest policy reforms in the last 20 years have enabled rural households to generate income from forests, to own the trees they have planted, and have offered new opportunities to manage forests sustainably. Rehabilitation of degraded forests and forest lands is one of the possible pathways to improvement of livelihoods of poor farmers and others in the rural communities.

In China, where individual farmers own much of the forest, management of the forest is just one component of the farming system and activities must be integrated with other agricultural tasks. Opportunities to improve management and livelihoods are dependent on overcoming biophysical, socioeconomic and political constraints. There has been increasing recognition among foresters and other natural resource managers that to address the problems of rehabilitating degraded forests and lands requires a holistic approach. A multidisciplinary effort involving all stakeholders, in particular the landholders, is required to analyse problems and formulate options for their solution.

Between 1990 and 1994 the Chinese Academy of Forestry (CAF), with financial support from the International Development Research Centre (IDRC) of Canada, designed and implemented a Farm Forestry Program that took a multidisciplinary and integrated approach to solving on-farm forestry problems. The results of this work were reported in a book - *Integrated Research in Farm Forestry* (ed. Cai Mantang and Hu Shaofang, Chinese Science and Technology Press, Beijing, 1995). Building on this experience, a new project was initiated in 1995 to develop strategies to assist in the rehabilitation of the degraded forests and forest lands in southern China, to improve local livelihoods and to provide inputs into policy deliberations. A multidisciplinary, participatory approach with action-orientated research was designed and carried out at selected sites in four provinces. The new project was managed by the Chinese Academy of Forestry and implemented in partnership with the Center for International Forestry Research (CIFOR), CAF Research Institute of Resource Insects, CAF Research Institute of Tropical Forestry; Central South Forestry University, Zhejiang Forestry College, Lin'an County Forestry Bureau with cooperation of local and regional institutions and communities. IDRC again provided financial support.

The analysis of the CAF/CIFOR/IDRC project reported here should enable a better understanding of the constraints and opportunities for improving the livelihoods of poor rural communities and rehabilitating degraded forests and forest lands. Some of the participants have already contributed to deliberations at a symposium entitled "Policy reform and forestry in China: lessons for China and the world" held at Dujiangyan, Sichuan in June 2001. I hope that this report will provide inspiration for researchers, resource managers and government officials, both in China and elsewhere, to address poverty and environmental concerns through a multidisciplinary, participatory and holistic approach.

David Kaimowitz
Director General, CIFOR.

Chapter One

Rehabilitation of Degraded Forests to Improve the Livelihoods of Poor Farmers: A Synthesis of Four Case Studies in South China

Cai Mantang[1], Liu Dachang[2] and J.W. Turnbull[3]

Introduction

Deforestation in the tropics is high with an annual loss of 14.2 million ha converted to other land uses (FAO 2001). Deforestation and forest degradation are closely linked and are sometimes referred to as 'forest decline' (Contreras-Hermosilla 2000) which can be taken to include losses of forest productivity in terms of wood and non-wood products and environmental services. It directly threatens the livelihoods of millions of forest-dependent people.

The underlying causes of forest decline include: market failures, mistaken policy interventions, governance weaknesses, and broader socioeconomic and political causes such as population growth and distribution of economic and political power (Kaimowitz and Angelsen 1998, Contreras-Hermosilla 2000). Clearly forest decline is a complex phenomenon with many socioeconomic, political and cultural causes. Pressures to exploit forests, especially natural forests, have not stopped and several factors suggest forests will continue to decline and have less capacity to provide both timber and non-timber forest products. It follows that more efforts will have to be made to rehabilitate and sustainably manage degraded natural forests and develop productive plantations if the predicted increases in consumption of forest products are correct.

Degradation of forests and lands is a common phenomenon all over the world and is a very serious problem in China. Much of China's extensive area to the south of Yangtze River, referred to as 'south China' in this account, has a subtropical climate in which the typical vegetation is evergreen broadleaf forest. Due largely to human actions, nearly all primary evergreen broadleaf forest has disappeared and only a few areas exist, usually in isolated mountainous locations. Secondary forests and man-made plantations have replaced the original

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evergreen broadleaf forest but most of these forests are degraded to some extent. There has been a significant loss of biodiversity, with a reduced number of species and a standing biomass much lower than in primary forest. In some cases, the vegetative cover of forest land has been reduced to sparse shrubs or even bare land.

While there has been an overall improvement in China's living standards, the gap between the supply and demand for forest products has been widening partly due to low productivity of degraded forests. Numerous natural disasters have been attributed to deforestation and the loss of environmental functions provided by forests (Yang 2001). At the local level, the lower productivity of degraded forests and forest lands has a direct impact on rural communities which are often partially dependent of forests for their livelihoods.

In the early 1990s, about 70% of population in south China lived in rural areas (China Statistical Bureau 1993). These people rely on forests for livelihood support in many ways. They depend on forests for energy (fuelwood), for timber used on their farms, and for timber and non-wood forest products (NWFPs) to sell to generate cash income. As a consequence of forest degradation, they are now able to collect less variety and quantity of products from forests and so generate less income than formerly. This means a decline in their livelihoods unless they can generate income in other ways.

Forest degradation has on-site and off-site ecological and environmental effects, including deteriorating agro-ecological conditions, increased flooding, lower water quality and siltation of dams. The deterioration of agro-ecological conditions results in decline in agricultural productivity, which in turn has considerable impact on the welfare of farmers and their families. Moreover, if the local supply of timber and other forest products is curtailed, people will either suffer from the shortage or have to rely more on expensive imports.

Some of the principles set out in the Rio Declaration of the United Nations Conference on Environment and Development in 1992 to guide states and peoples in global environment and development matters relate to forestry, e.g. for environmental protection to be an integral part of development. Agenda 21 provided an action plan and there was an appeal for countries to formulate and implement national forestry programmes. The link between integrated forestry development in mountainous areas, where the majority of the 65 million poverty-stricken people in China reside, and the process of poverty alleviation is recognized (Jiang 1997). A forestry action plan has been prepared for China's Agenda 21 which includes comprehensive forestry development and poverty alleviation in mountainous areas as a specific goal (Zhao 1997).

Effective implementation of such a plan requires a good understanding of the extent and causes of forest degradation and the actions required to rehabilitate and manage degraded forests sustainably. There has been research on causes and prevention of forest degradation in south China since the late 1960s (Institute of Forestry and Pedology 1980, Research Team of Intensive Cultivation of Chinese Fir 1992, Chen 1992, Xu 1992). Zhu (1991) examined human impacts on changes in biodiversity and soil fertility in secondary broadleaf forest. Research has also been carried out to identify tree species and develop tree-planting technologies for those areas with harsh ecological conditions (Yu 1997, Yang *et al.* 1999). However, experience shows that forest degradation largely is a result of human intervention and so understanding its causes and rehabilitating it needs more than a biological perspective.

Political change and social transition are features of modern China and numerous changes in government policies have impacted on forestry. Several changes of policies related to land tenure and management of non-state forests have sometimes resulted in severe deforestation (Liu 2001). After 1950 there was a situation of collective ownership and compulsory low price wood delivery system under the totally government-controlled planned economy

Table 1.1 Evolution of tree tenure and marketing systems in south China

Period	System	Ownership	Timber marketing
Before 1950	Historical	Bureaucrats, landlords, timber merchants and self-sustaining farmers	Free market
1950-1955	Land reform	All farmers, including self-sustaining farmers and former landlords	Free market
1956-1958	Socialist transformation and agricultural collectivisation	Collective ownership and production	Quotas and prices determined by the State
1958-1980	People's communes	Collective ownership and production	Quotas and prices determined by the State
1979-1983	Household-based agriculture (Contract responsibility) and people's communes	Family forest plots (*ziliushan*); responsibility forest land (*zerenshan*); collective forest	Self-determined production: compulsory delivery system
1984 to present	Household-based agriculture	Family forest plots, responsibility forest land collective forest; shareholding system	Price controls lifted, but taxes and fees increased; government monopoly on procurement
1999 to present	Logging ban in natural forest	Same as above	No timber harvesting is allowed from collective and private natural forests

Source: Sun (1992) and Liu (2001).

(Table 1.1). Subsequently the government introduced market-orientated reforms changing property rights and marketing arrangements. In rural areas, poverty makes many farmers adverse to taking even small economic risks and they have become very cautious about accepting policy changes (Yin 1994). In these circumstances, technology-oriented options and interventions alone are not sufficient to successfully rehabilitate the degraded forest and lands and improve livelihoods. Zhu (1997) describes several case studies showing the need for the participation and cooperative interaction of leaders, scientists, extension technicians and farmers. It is clear that factors that cause forest degradation or inhibit rehabilitation need to be examined from multidisciplinary perspective, including socioeconomics and government policies, and with participation of all stakeholders. Only this way will it be possible to develop effective options and strategies.

In 1995 our research project was initiated to develop strategies to assist in rehabilitation of the degraded forests and forest lands, improve local livelihoods, and provide input to policy deliberations. It was implemented by the Chinese Academy of Forestry and the Center for International Forestry Research, with support from Canada's International Development Research Centre, in partnership with local and regional institutions and communities in the provinces of Yunnan, Hunan, Guangxi and Zhejiang in south China. A multidisciplinary, participatory approach was used and action-oriented research was carried out in the field over the period 1996-1998. The project included several complementary small technology research activities in different locations and these are reported elsewhere.

This chapter synthesises the outcomes of the case studies in Yunnan, Hunan, Guangxi and Zhejiang. Research methods and biophysical and socioeconomic settings are described. The causes of forest degradation are analysed and, based on the case studies, strategies necessary for rehabilitating degraded forest in south China are suggested. Chapters 2 to 5 provide more details of the research and outcomes of each case study.

Research Methods

Conventional scientific approaches in forestry and agroforestry have often seen technologies developed independently of the social dimensions in which they must be adopted. Farmers on the other hand consider the management of woodlots, and trees grown in association with crops and livestock as part of their integrated farming system. To meet their economic needs they manage their land in a holistic manner aware of the interactions of the several biological components and the complexity of the social and economic environment that provides both constraints and opportunities. Integrated farming systems combine agriculture, forestry, horticulture, animal husbandry, aquaculture, as well as other biological production, into an interconnected system (Li 2001).

As the aim of this research was to seek to improve the livelihoods of farmers by addressing the problems of degraded forests and forest lands it was necessary to apply methods that could encompass the complex biological-social-economic system in which farmers managed their forests as part of an integrated farming system. Rocheleau (1999) has reviewed the many methods that have emerged in recent years to address the complexities of conducting agroforestry research and especially the need to apply the methods of social science. She particularly refers to the use of participatory processes and practices and the need to bridge social, economic and ecological sciences.

We drew heavily on social science methodologies especially in the diagnosis of problems and the design of options to address them. It would have been desirable to include social scientists directly in the research but institutional difficulties precluded this option. The compromise was that the forest researchers in the project received training in social science methods from the Ford Foundation in China at the start of the project. A logical procedure consisting of three stages: diagnosis, design and delivery, called 'Tri-D' in this research, was used.

Diagnosis, Design and Delivery

Diagnosis and Design adapts farming system approaches and Rapid Rural Appraisal (RRA) or Participatory Rural Appraisal (PRA) to identify problems and to design and test forestry and agroforestry options (Raintree 1987, Nair 1993). This procedure has been used commonly in community-based agroforestry research outside China but was a new approach in forestry in China. Participatory rural appraisal or participatory rapid rural appraisal has been described by Chambers (1994 a, b, c) and Chambers and Guijt (1995).

Diagnosis aimed at achieving a good understanding of local biophysical and socioeconomic settings, problems (extent and causes of forest degradation and effects of forest degradation on livelihoods), and constraints to forest rehabilitation. Design, the second stage of the research process, aimed to identify effective strategies or options and form policy recommendations for rehabilitation and sustainable management of degraded forests based on the results of diagnosis. In the delivery stage new options that had been identified were tested for their appropriateness and effectiveness and policy recommendations were made.

The approaches and methods used within the Tri-D process included:

- participatory approach
- multidisciplinary approach
- triangulation
- attention to indigenous knowledge
- conventional forestry research methods, and
- action research.

Participatory Approach

In recent years there have been notable examples of successful collaboration between scientific research organisations and rural communities which have been assisted by a greater emphasis on participation, partnership and negotiation in the research process (Zhu 1997, Rocheleau

1999). Participation is now widely advocated and accepted as a strategy for rural development and natural resource management. Participation can be interpreted in various ways but mobilisation and empowerment of the local communities are two basic elements (Oakley 1987).

This project emphasised the participatory approach with mobilisation, empowerment and interaction as key elements of the research process. Participation took place at all the stages of diagnosis, design and delivery. We involved farmers and their families, researchers and extension staff, and government officials and facilitated interaction between them to develop and test options and strategies to address forest degradation and improve livelihoods.

Farmer participation was emphasised as farmers have good knowledge of their circumstances, problems and constraints. They are also holders and beneficiaries of forests that need rehabilitating, and hence are able to make a very significant contribution to the development of effective strategies. During the research process nearly 400 households were consulted and 43 groups interviewed as part of the diagnosis. A subset of households participated in identification and testing of rehabilitation options.

More than 50 researchers and extension staff had some level of involvement in the research. Their participation was on the basis that they could play an important role in developing appropriate strategies, providing information and extension services, and facilitating communication between participating government officials and farmers. This is extremely important in mountainous areas where farmer access to information and extension services is poor. About 130 local government officials were involved to some extent. Their involvement was encouraged because they can facilitate implementation of options identified by helping to raise investment funds and resolving administrative conflicts that often appear in resource management.

Diagnosis

The diagnosis phase involved detailed planning of the research, intensive data collection, analysis of data and specification of the potential interventions. PRA tools used at this stage included:

- secondary data collection
- participatory observation
- household survey (semi-structured interview, complemented by questionnaire survey)
- key informant interview (semi-structured interview)
- group interview/meetings.

A large amount of secondary data was collected from relevant government agencies at county level such as the Forestry Bureau, Agricultural Bureau, Statistical Bureau, Meteorological Bureau, County Archives; township governments; and village offices. Data were collected on climate, soil, land uses, forest resources, the role of forest in local livelihoods, forest products, forest tenure and management, marketing and taxation of forest products, tree planting policy, demography (population, labour force, their education), wealth/income, village social organisations and infrastructure.

Participatory field observation was carried out immediately after secondary data collection. It was undertaken jointly by researchers, several senior villagers and village leaders who were familiar with village circumstances and history. The field visits observed and discussed land uses, types and cultivation patterns of crops, types of forest, historical changes in the forest, extent of forest degradation, and village infrastructure.

Household survey aimed to identify problems and constraints to forest rehabilitation at household level. Sample households were selected through random sampling from all households in the research villages. Household survey was conducted mainly in the form of semi-structured interviews plus a questionnaire survey. Each household interview lasted 1.5-2 hours. Topics discussed during household interviews usually included family population and its age distribution, number of family members at labour age, major livelihood means including sources of family income, family expenditure by activity, land uses, forest area and volume, forest degradation, and constraints to forest rehabilitation.

Key informant interviews were semi-structured, aiming to analyse problems at village level. Topics covered population, labour force and gender distribution of labour, education, land uses, crop calendar, village social organisations and governance institutions, forest resources and tenure, village regulations on forest management, timber prices, household collaboration mechanism for forest production (e.g., shareholding system for forest management), and extension and credit services.

Group meetings examined questions of relevance to the whole village. In each research village, representatives of five or seven groups were interviewed. In the case of five groups, they were village leaders, women, elders, middle-aged people and youths. In the case of seven groups, they were village leaders, elders of 60 years old or over, married middle-aged and young people, unmarried young people, women, the poor and the relatively wealthy. Interviews were semi-structured, each lasting 2-3 hours. Each interview involved 4-12 people; most of them had not been involved in the household surveys.

Design (Planning)

Participating researchers, farmers and government officials worked together in an interactive manner to identify options and strategies for forest rehabilitation and evaluate the role of existing technologies and indigenous knowledge. After a number of intensive discussions, in which technical, economic and social factors were considered, several options were identified for each type of degraded forest. Farmers then chose the option or options best suited to their specific conditions and circumstances.

Delivery (Testing)

This phase involved planning the on-farm testing, refining the technologies and approaches, dissemination of results, and feedback from users. Researchers and government officials played a part in this implementation phase, but farmers had the most important role. They tested options in their forests, fields, home gardens and workshops. Participating farmer households represented those who had different forest resource holdings, types of degraded forests and lands, and wealth levels.

Species' identification is a good example of participatory implementation. The PRA surveys revealed that villagers had not sufficient choice of well-adapted species for profitable tree planting. Based on this information, tree species not previously grown in the area were selected from both outside China and other parts of China and tested their suitability for local ecological conditions and potential profitability. This was undertaken at all the sites but was extremely important at one site (Yuanmou, Yunnan) where the availability of a well-adapted and profitable species is key to degraded land reclamation. The process was participatory and collaborative, with local communities providing land for field experiments and being responsible for tending seedlings.

Multidisciplinary Approach

Forest degradation is related to both socioeconomic and biophysical factors and rehabilitation needs an integrated solution. Achieving a good understanding of causes of forest degradation and developing effective options or solutions often require a multidisciplinary approach. Each of the research teams consisted of specialists from different disciplines. For example, the Hunan research team consisted of experts in forest economics, forest resource management, forest ecology, silviculture, and botany. Social scientists and agricultural experts were consulted as required.

Triangulation

Triangulation was used as a research tool in data analysis to check the reliability of the data collected. Supplementary survey or further observations were made to validate data if inconsistencies appeared in information from secondary sources, field observation, household survey, key informant interview, group meeting or conventional forestry methods.

Indigenous Knowledge

Indigenous knowledge was used in developing some options for rehabilitating degraded forests and lands. Local people often had existing knowledge that was just as useful and effective as more recently developed techniques. For example, in Hunan, villagers developed a sustainable system of establishment and management of Chinese fir plantations several hundred years ago (Menzies 1988, Yu 1994) but this technology was abandoned for many years as government officials dictated planting practices.

Conventional Forestry Research Methods

While innovative approaches such as PRA were emphasised, conventional forestry methods and techniques such as forest vegetation survey, soil survey and expert consultancy were also used.

Forest Vegetation Survey

Forest vegetation survey and forest inventory were undertaken in sample plots of varying size at all research sites. Information was gathered on forest types, species composition and forest productivity (inventory), the extent of forest degradation including historical changes in biodiversity and forest biomass, and causes of forest degradation. Researchers and knowledgeable farmers together made surveys of historical changes to forests.

Soil Survey

Soil survey was made in different forest types and at different levels of degradation to understand relation between forest degradation and changes in soil properties and fertility. Type, texture, depth, fertility of soil and its capacity for holding water and fertility were observed and measured by routine methods.

Expert Consultancy

Expert consultancy was used to help with the identification of causes of forest degradation and options for reclamation. Consultation took place with those specialists with expertise in related fields or who had research activities in the research locations. The specialists were not members of the research teams of this project but they expanded the range of expertise and contributed to developing options to address particular problems.

Action Research

Options identified to rehabilitate forests and forest lands and improve livelihoods were tested through an action research approach which involved farmer participation as part of the communities' own research and development effort. Researchers and local government officials facilitated this research in various ways.

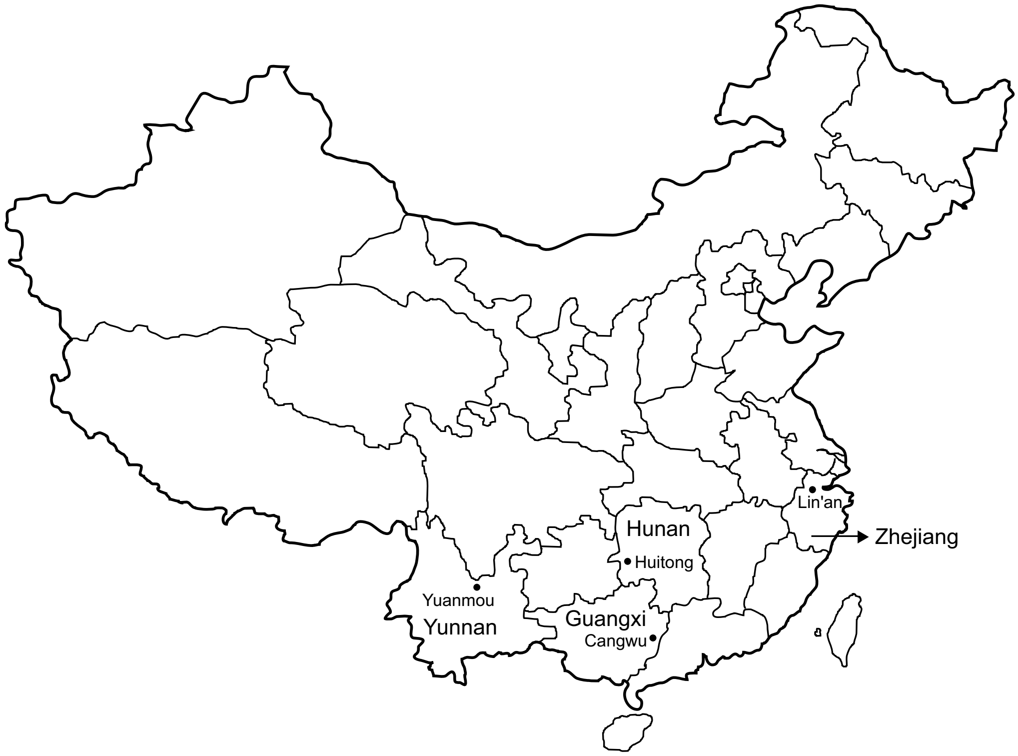
Location of Research Sites

The main factors considered when selecting sites for the case studies were:

- types and extent of degraded forest/land and potential to address the causes of forest degradation
- economic development level and the extent of dependence of local people on the forest and the forest products used and traded. This was necessary to determine how people at different levels of development market their forest products and their attitude towards forest rehabilitation, and
- environmental conditions, e.g., rainfall and humidity vary east to west and different technical interventions need to be developed for areas with different climatic conditions. Tree species must be selected carefully for adaptation to site conditions.

Case studies were carried out in one county in each of four provinces (Map 1.1). They extend

Map 1.1 Location of the four provinces where study sites were located



from the eastern seaboard (Zhejiang) to the upper catchment area of the Yangtze River on the high altitude plateau in the southwest (Yunnan) and together they represent a reasonable sample of south China in the aspects included in this study. Initially eight sites were selected for study to provide a better sample but this number had to be reduced due to cost factors. The sites selected were in:

- Cangwu County, Guangxi
- Huitong County, Hunan
- Lin'an County, Zhejiang
- Yuanmou County, Yunnan.

All the counties were in hilly or mountainous areas. Cangwu County is situated in east Guangxi; Huitong County in the west of Hunan; Lin'an County in northwestern Zhejiang; and Yuanmou County in central Yunnan in the upper catchment area of the Yangtze River.

Research in Yuanmou was undertaken at both county level and village level, while the studies in the counties of Cangwu, Huitong and Lin'an were largely at village level, though some countywide issues were addressed to provide a good understanding of context. Village-level studies were carried out in:

- Shanxin village in Cangwu County
- Dongxi and Xiangjian villages in Huitong County
- Chenjiakan, Hongqiao and Sahngfeng villages under the jurisdiction of Gaohong Township in Lin'an County
- Laofan, Xiaocun, Moke, Bingyue villages in Yuanmou County.

Biophysical and Socioeconomic Settings of South China

Topography and Extent of Forest Lands

China's land area is 9.6 million km^2 of which 6.6 million km^2 (69%) is mountainous. As the proportion of mountainous and hilly topography in the south is higher than in the north, forestry is the primary land use and 'forest land' makes up most of the land area of south China. More than half of the 70% of people in rural areas in south China live in mountainous areas and they rely heavily on forests for timber, NWFPs and fuelwood for their livelihoods.

Mountainous and hilly areas comprise between 80% and 90% of the counties in the research project and the proportion of forest land is from 66% in Yuanmou County to 83% in Shanxin village, Cangwu County.

Climate

Most of south China typically has a subtropical climate but rainfall and humidity vary markedly within the zone. Three research sites are humid or subhumid with a mean annual rainfall of 1516 mm (Guangxi), 1415 mm (Zhejiang) and 1264 mm (Hunan). In contrast, the climate of Yuanmou (Yunnan) is dry and hot and is classified as semiarid. Its mean annual rainfall is 629 mm, and potential evaporation is six times the rainfall. Moreover, almost 90% of rainfall comes during a short wet season (June to October). The temperature is as high as or higher than in other research areas.

The climatic variation has implications for the identification of technical solutions for forest rehabilitation. The humid or subhumid environment is good for tree growth and for natural regeneration of secondary forest but the harsh dry climate of Yuanmou makes successful tree growing a significant challenge.

Diversified Forests and Plantations

Primary forest vegetation in most of south China has been replaced by naturally regenerated, secondary forests and man-made plantations (Table 1.2). Secondary natural forests include evergreen broadleaf forest, mixed coniferous and broadleaf forest, and various coniferous forests. There are major plantations of Chinese fir (*Cunninghamia lanceolata*), bamboo (e.g. *Phyllostachys pubescens*), and a range of tree species for NWFPs (e.g. *Cinnamomum cassia* and *Camellia oleifera*).

Evergreen broadleaf forest occurs at all the study sites, including Yuanmou. It is the dominant vegetation type in Shanxin village in Cangwu county, but makes up a small proportion of forest area in the other three sites. All the broadleaf forests at these sites are secondary in origin.

Masson pine (*Pinus massoniana*) forest occurs naturally in most provinces of south China, and is present in Lin'an, Huitong and

Table 1.2 Woody vegetative cover on designated forest land (% of total land area)

Vegetative cover	Yuanmou Yunnan	Shanxin, Cangwu Guangxi	Dongxi, Huitong Hunan	Lin'an Zhejiang
Evergreen broadleaf forest		56	10	7
Mixed forest		25		
Forest* and plantation	6			
Masson pine forest				33
Chinese fir plantation			44	10
Bamboo forest/plantation				20
Tea plantation				4
Other tree species for NWFPs		2	22	
Sparse bushes	46			
No woody vegetation	14			2
Forest land (%)	66	83	76	76

* Mixed forest, pine forest and evergreen broadleaf forest.

Cangwu counties but is considered absent in Dongxi village, Huitong and Shanxin villages (Table 1.2) because they have individual trees but not stands of this pine.

Chinese fir has been planted in many areas of south China where Masson pine occurs although its best growth is observed on the more fertile and deeper soils of lower slopes and valley bottoms. It has been planted in Lin'an, Huitong and Cangwu counties but there are only scattered trees on the land of Shanxin village, Cangwu.

Plantations designated 'NWFP' are established for tree products other than wood. Although bamboo produces many non-wood forest products, it is treated separately because of its relative importance. These plantations are a major source of cash income for villagers. Many tree and shrub species are used with the species and extent of NWFP plantations varying between localities. For example, NWFP plantations accounted for only 2% of total land area in Shanxin village, and major species were *Cinnamomum cassia*, *Illicium micranthum* and bamboo. *Cinnamomum cassia* is a medicinal plant, and fruits of *Illicium micranthum* (star anise) are a common spice in Chinese food. Bamboo is planted for both shoots and timber. The proportion of NWFP plantations was much higher in the two villages of Huitong, and comprised about 25% of land area, mostly in home gardens. Species used are *Camellia oleifera* (tea oil), *Vernicia fordii*, *Castanea* sp. (chestnut), and fruits (orange, plum and pear). Bamboo is planted for both shoots and timber. In the Lin'an villages NWFP plantations made up 24% of total land area, with tea and bamboo as the main species. Bamboo is largely managed to produce shoots for export and local consumption.

In Yuanmou, the majority of forest land is covered with sparse bushes, 6% of forest land by poor quality mixed forest and tree plantations, and 14% has no tree cover at all. Forest cover is the lowest of the four sites and degradation of forest land is more serious than at the other sites.

The variation of forest types between sites is mainly a result of differences in the degree of human intervention and it has implications for rehabilitation. Rehabilitation of existing, degraded forests in areas such as Cangwu, Huitong and Lin'an is possibly more economically feasible and socially desirable than reclaiming forest land without tree cover. However, where most of the tree cover has already been removed, as in Yuanmou, efforts have to focus on planting trees, shrubs and grasses to restore the seriously deteriorating environment.

Role of Forest in Local Livelihoods

Rural people in south China rely on forest products for income generation and on-farm consumption and benefit from ecological services of forests. Natural forests and plantations are managed for timber, NWFPs and fuelwood. The extent of local people's dependence on forest and types of forest products they collect vary between communities. This variation in dependence on forests inevitably results in differences in community attitudes to tree planting and forest management. In Cangwu, Huitong, and Lin'an, there is heavy reliance on forests for income generation as well as for timber and fuelwood for on-farm use. If villagers in these areas are not interested in tree planting and sustainable forest management, it suggests that there is some problem that needs to be resolved. In contrast, villagers in Laofan village, Yuanmou have other sources of income and domestic energy and may have little interest in tree planting.

Shanxin Village, Cangwu County, Guangxi

Forests are very important to the villagers in Shanxin for generating cash income. The evergreen broadleaf forest provides wood for farm tools and is the source of many NWFPs and local fuelwood needs. Timber is harvested in mixed forest for various on-farm uses. Before the late 1970s, they managed evergreen broadleaf forest mainly for fuelwood and for wood for making charcoal. These products were exported to cities in the Pearl River Delta and

Hong Kong. Subsequently, market demand for these products diminished greatly due to the availability of alternative energy sources, such as electricity and natural gas. However, new markets appeared when many wood-processing enterprises requiring small-diameter wood were established locally. Villagers also generate income from NWFP species such as *Cinnamomum cassia*, *Illicium micranthum* and bamboo. Now small-diameter wood, NWFPs and fuelwood are important sources of cash income for local farmers. It was estimated that the contribution of forestry sub-sector to Shanxin's agricultural income was about 20% in the mid-1990s.

Huitong County, Hunan

Villagers manage Chinese fir and NWFP plantations to provide products for trade and these are a major source of cash income for them. Chinese fir timber is also harvested for on-farm consumption. Villagers also collect NWFPs and fuelwood from evergreen broadleaf forest. It was estimated that forestry activities contributed about 30% of farmer income in the villages of Dongxi and Xiangjian in 1993.

Lin'an County, Zhejiang

Forests in Lin'an play a greater role in employment and income generation than in the other counties in the research project. Villagers manage Chinese fir plantations, Masson pine forest, and evergreen broadleaf forest for timber for trade and on-farm consumption. They manage bamboo and tea plantations as cash crops. There has been a boom in developing bamboo plantations and bamboo shoots are the major source of cash income for local farmers. They are so profitable that many farmers have extended the planting to unsuitable sites, resulting in poor productivity and site degradation through soil erosion. Villagers also collect fuelwood from evergreen broadleaf forest.

Laofan Village, Yuanmou County, Yunnan

Most people in Yuanmou generate income by cultivating vegetables in winter. It is less profitable to plant trees and income cannot be generated in short period of time. Little natural forest remains in the area and there are few plantations. Previously some trees were grown for fuelwood but now there are other energy sources such as electricity and gas available. Tree management is therefore relatively unimportant and currently makes little contribution to local livelihoods.

Forest Tenure and Management

Timber forests in China are controlled by government agencies or enterprises, collectives, share-holding groups and individual households. Before the nationwide forestry reform, launched in the early 1980s, most forests in China were owned and managed by the collective (commune, production brigade and production team), and they hence were called 'collective forests' (Table 1.1). The reform allocated use rights to denuded or non-forested collective land to individual households as their family plots (*ziliushan* in Chinese) in an attempt to encourage them to plant trees and develop plantations. The collective also 'allocated' most of existing collective forests to households (or a group of households) to manage. As a result, often both collective management and household-based management of forest exist in one village, with the latter being dominant form in terms of managed forest area. In some cases, household management is only form of management as all forests and forest lands were allocated to individual households (Yin 1994, Liu 2001).

Throughout China the state directly controls about 40% of forest land, and the collective 60% during the early 1980s when the forest reform began. In the ten provinces of south China, however, 90% of forests were collective owned, and the other two provinces (Sichuan and Yunnan) had about 65%. After the forest reform, most of these collective forests were under household management. For example, farmer households in Xiangjian village and Dongxi village of Huitong manage 92% and 66% of forest land respectively, while households in the three villages of Lin'an manage 85% of forest land.

Demography and Infrastructure

Demography

Three common features of demography in south China were evident in the study villages.

- Villages are agricultural communities and rely heavily on agriculture (food cropping, forestry, and animal husbandry).
- A high proportion of the population has reached labour age (women 16-54 years old, and men 16-59 years old), which means in many families labour is available for forest rehabilitation from the underemployed.
- Most villagers have only primary and junior middle school education, which is a constraint for securing off-farm employment and external income generation.

Laofan village, Yuanmou has a small population. In 1995 there were 441 persons in 108 households, with 73% of the population in labour force of which 93% was engaged in agriculture.

Shanxin village, Cangwu had a population 2570 in 521 households (1995). About 64% of the population had primary school level education, 32% junior middle school education and about 3% was illiterate and very few villagers had senior school education. In this village 43% of the population was of labour age, the majority of whom were involved in agriculture. Only those with senior middle school education and a proportion of those with junior middle school education have sought part time or full time off-farm employment.

Xiangjian village, Huitong had a population of 1170 in 335 households (1995). About 40% of people had primary education, 40% attended junior school and about 4% went to senior middle school. The remainder was illiterate. Of the 75% of villagers at labour age, most were involved in agriculture, and less than 10% had off-farm employment. Demography of Dongxi village in Huitong was similar to that of Xiangjian.

The population of Gaohong township, Lin'an was 10 513 in 1995. The education levels and employment opportunities differ from the other research sites. A large proportion of the population had primary or junior middle school education, but about 8% of villagers completed senior high school. People of labour age comprised 65% of the population. Only 45% of the labour force in Gaohong was working in agriculture, with 28% in secondary industry and 27% in tertiary industry.

Communications

Laofan village is only 7 km from the Yuanmou County town. A sealed road links it to the county town that in turn has good road and railway connections with provincial capital cities (Kunming in Yunnan, and Chengdu in Sichuan). This provides villagers with ready access to markets for vegetables and other agricultural produce.

Shanxin village has relatively ready access to transport. Six of its village household groups reside along the highway passing through the village and 11 are connected by unsealed road to the highway. However, the village is rather isolated in terms of telecommunication, for example, the village office had no telephone connection when this research was conducted.

The villages of Xiangjian and Dongxi are about 25 km from Huitong County town. Both villages have ready access to both road and rail transport.

Gaohong is near Lin'an county town that has a high standard highway to Hangzhou, capital of Zhejiang province. Telecommunications are good and many households have television. This enables farmers to obtain information and market signals more easily than farmers at the other sites.

Although generally mountainous and hilly areas have poor transport infrastructure compared to those in the plains, in this study almost all the sites have relatively good access to transport, which suggests this is not a constraint to forest rehabilitation. Communities in mountainous areas do however vary in their ease of access to marketing and technology information.

Economic Status

Among the four sites, Lin'an was most advanced in economic development. Cangwu and Huitong were less developed and Yuanmou farmers had the lowest income. For example, average per capita annual income of the three study villages in Lin'an was about 1800 Yuan in 1995, compared to about 1540 Yuan in the villages of Xianhjian and Dongxi in Huitong. Average per capita annual income of villagers in Shanxin village, Cangwu was 980 Yuan in 1994, with 80% of households unable to produce sufficient food for themselves.

Extent of Forest Degradation

Forest degradation was interpreted as decline in productive capacity, reduced biodiversity, and in some cases deterioration of plantation health. The indicators used to assess degradation differed from one type of forest to another, and in a few cases, indicators for same type of forest are different across sites. Existing indicators were used as the aim was to concentrate on identifying causes of forest degradation and intervention options for rehabilitation.

This research examined the level of degradation in the following types of forests and forest lands:

- Evergreen broadleaf forest
- Masson pine forest
- Chinese fir plantation
- Eucalypt plantation
- NWFP plantations, and
- Non-forested forest land.

The majority of forests was assessed as degraded or seriously degraded. This is indicative of the situation in much of south China. As a result, those rural people who rely largely on forest are now able to harvest less timber and non-wood forest products, which means a decline in their income from forest and accordingly a decline in their quality of life if they cannot find alternative sources of employment and income. The agro-ecological environment has become poor with potential negative off-site effects such as local flooding and siltation. Forest degradation also means loss of biodiversity in natural forest. The situation in the different forest types is summarized below and more details are provided in the case studies in Chapters 2-5.

Evergreen Broadleaf Forest

Three indicators were used to assess the state of degradation of evergreen broadleaf forest:

- forest composition, or tree species diversity indices (Simpson Index and Shannon-Wiener Index)
- biomass (standing timber volume/stock and fuelwood output)
- mean stem diameter at breast height.

The assessments showed most evergreen broadleaf forests (70-85%) are degraded or seriously degraded. For example, 85% of this forest type at Shanxin village was degraded, 10% seriously (Chapter 3). Degraded and seriously degraded forest comprised 79% and 69% of forest area of Xiangjian and Dongxi villages respectively in Huitong County (Chapter 4). Nearly 80% of this forest in the three villages of Lin'an County was degraded (Chapter 5).

The degradation of evergreen broadleaf forest is reflected in the decreasing number of tree species and families, simpler forest structure, and reduced standing biomass (wood volume), compared with its previous state and with normal, undegraded forest. Degraded evergreen broadleaf forest often comprises impoverished and ecologically unstable stands. The cases of the villages of Cangwu, Huitong and Lin'an clearly show that the number of species in the forests has been significantly reduced. High value timber species for house building and furniture are greatly diminished in number and fast-growing, lower-value species, such as *Castanopsis fissa* and *Quercus griffithii*, have become dominant species in degraded forest. In seriously degraded forest few tree species remain and many trees have been reduced to a shrubby form. Seriously degraded forest of Shanxin village has become shrub land and bare land. In the three villages of Lin'an, evergreen broadleaf forests were in good condition in the 1960s and 1970s, with a dense canopy (80-90%), but now they are in poor condition with a more open canopy (30-50%).

In Shanxin, standing biomass of the degraded evergreen broadleaf forest declined from about 100 t ha^{-1} in the early 1950s to 65-100 t ha^{-1} in the early 1980s to 30 t ha^{-1} in the late 1990s. The biomass is much lower than the 280 t ha^{-1} of forest with the same dominant species in a nearby reserve.

Fuelwood output of Shanxin's evergreen broadleaf forest is now consistently less than 20 t ha^{-1} (on about a 7 year cutting cycle), compared to the 30 t ha^{-1} or more from slightly degraded forest. In the villages of Lin'an, mean diameter at breast height of evergreen broadleaf forest declined from 10-12 cm in the 1960s and 1970s to 6 cm currently.

Masson Pine Forest

Two indicators were used to assess the degradation of Masson pine forests:

- standing timber volume
- mean diameter at breast height (dbh) and mean tree height

Most Masson pine forest is degraded. In Lin'an, pine forest was dense in the 1960s and 1970s, with an average dbh of 26-28 cm, a mean tree height of 11-12 m, and a timber volume of 105-120 m^3 ha^{-1}. In contrast, by the mid-1990s, average dbh decreased to 8-10 cm; tree height, to 6-7 m; and timber volume to 20-30 m^3 ha^{-1}.

Chinese Fir Plantation

Indicators used for Chinese fir plantations were similar to those for Masson pine forest. They were:

- standing timber volume
- mean diameter at breast height and mean tree height
- mean annual increment

Although probably in the best condition among all timber forests and plantations, many Chinese fir plantations are also degraded. The Ministry of Forestry indicator for a fast-growing Chinese fir plantation is 12-15 m^3 ha^{-1} mean annual increment (MAI) depending on the area of cultivation (Department for Reforestation, Ministry of Forestry 1982). Most Chinese fir stands now are young and middle-aged and their productivity is lower than that of a normal Chinese fir stand. For example, in Lin'an, 20-year-old plantations have a mean dbh of 10 cm, a mean tree height of 7 m and a mean annual increment of 2.7 m^3 ha^{-1}, well below the national standard.

Eucalypt Plantation

The only eucalypt plantation assessed was of *Eucalyptus exserta* in Laofan village, Yuanmou. The main indicator was growth rate.

Although this eucalypt is one of the most tolerant species of poor soil conditions, the stand is irregular and lacks vigour. Apart from the slow growth rate, there are almost no understorey plants and there is continuing development of numerous soil erosion gullies. Both the plantation and the land are severely degraded. It is recognised that most species of *Eucalyptus* are not effective in controlling soil erosion in dry areas, because their open crowns provide very little shading of the soil and their roots compete very effectively with understorey plants for the small amount of water available. This suggests that a species with a dense spreading crown that is either deep rooting or has a low water requirement would have been a better choice on this eroded soil and in this dry climate.

NWFP Plantations

Indicators for NWFP plantations were decided based on the purpose of plantation establishment and included:

- productivity
- uniformity of the plantation (bamboos)
- plantation health.

Table 1.3 Causes of forest degradation

Policy and socioeconomic factors	Forest practices
Development policy Breakdown of forest management system Tenure insecurity Over-harvesting Market environment and external conditions	Poor harvesting methods Suboptimal silvicultural practices (species-site matching, multiple cropping, monoculture, burning).

The extent of degradation in NWFP plantations was variable. Tea plantations in Lin'an and some bamboo plantations planted off-site were seriously degraded. In the study villages of Lin'an about 20% of Lei bamboo plantations was degraded, with lower productivity, uneven mother bamboo individuals at different ages and higher incidence of diseases, compared to those of a normal plantation. Nearly half of bamboo forest used for producing dry shoots was also degraded.

Non-Forested Forest Land

Two indicators were used to assess the extent of degradation of this type of forest land by examining how much forest left, how poor they are, and how serious soil erosion is in the site. The indicators were:

- per cent of land with vegetative cover, and
- extent of soil erosion.

Yuanmou, Yunnan, was the site with the greatest area of this type of land. While about 66% of the land area of the county is designated as forest land, only 6% was covered with forests, the majority had bushes, grass or no vegetative cover at all. Bush vegetation was characterised by few species and with individuals sparsely distributed. Heavy rains in the short wet season result in severe erosion of the unprotected soil. Degradation is a serious problem in Yuanmou and significant efforts are required for ecological and environmental restoration. Chapter 2 describes this situation in greater detail. Other sites had relatively small areas of non-forested forest land, e.g. 2% in Lin'an.

Causes of Forest Degradation in South China

The four case studies provided insights into the causes of forest degradation in south China. In most instances several interacting factors are responsible. Factors change over time and dominant factor(s) in a given period may be replaced by other factors as context changes. These factors can be grouped into two broad categories. One group includes aspects of forest policy, development policy and other socioeconomic factors; the other mainly inappropriate forest practices (Table 1.3).

Policy and Socioeconomic Factors

Political and socioeconomic factors affect forestry development and some of the effects have been highlighted in reviews by Li *et al.* (1988), Richardson (1990), Sun (1992), Yin (1994) and Zhu (1997). Of the several government policies that have been linked to deforestation and forest degradation perhaps the most devastating was the 'Great Leap Forward' development policy in the late 1950s. However policies such as the forestry tenure reform of the early 1980s also had the unintended outcome of deforestation.

Radical Development Policy

In 1958, the government launched the 'Great Leap Forward' campaign and one of the campaign's objectives was to realise industrialization in China with steel output as the major indicator. It was planned that China's steel output would surpass that of Great Britain in 15 years. To achieve the goal, people were mobilised to make iron and steel using backyard furnaces throughout China. The furnaces failed to produce usable iron and steel and wastefully consumed a very large amount of fuelwood and charcoal. Another aspect of the policy was the call for self-sufficiency in grain and this led to forested land being cleared and cultivated (Richardson 1990). As this was a countrywide campaign it impacted massively on forests and caused a significant forest decline that can be considered as the first disastrous deforestation in modern China.

Examples from our research sites lend support to this conclusion. In Shanxin, Cangwu County, a large number of people from the neighbouring town came to the village to cut trees and make iron and steel. Together with local villagers they established about 190 charcoal making sites. Consequently, patches of high quality evergreen broadleaf forests were cleared and many other dense forests became poor quality secondary forest with low stocking. This also occurred at our sites in Yunnan, Hunan and Zhejiang.

Breakdown of Forest Management System

When the forest management system breaks down, deforestation is very often a consequence. This happened in many places in China especially during two periods: during the 'Great Proletarian Cultural Revolution' and after the forest reform in the early 1980s. The Cultural Revolution, initiated in 1966 and lasting a decade, paralysed almost the whole governance system from national to village level. It resulted in the breakdown of the management system of collective forests in many areas. The collapse of forest management was not a failure of the system itself but was the result of the abnormal political and policy environment.

The effects were reported from the Shanxin village in Guangxi where the leadership of the village lost control over forest management and illegal logging increased considerably. From 1966-1968, fuelwood and charcoal output in Shanxin and neighbouring villages experienced a peak reflecting uncontrolled harvesting of forest products.

Significant deforestation during the forest reform in the early 1980s was also related to collapse of the forest management system, through tenure insecurity and risk aversion by villagers (as discussed below). Management breakdown explains why numerous trees and stands that remained under collective management at that time were cleared, while tenure insecurity accounts for the harvesting of forest designated for household management. At the beginning of the forest reform, Laofan village retained its eucalypt plantation as collective property but nobody was given authority to manage it. Consequently, villagers cut down almost all the trees that were planted in the mid-1960s.

Tenure Insecurity

In modern China, government interventions through a series of policies and decrees sought to implement farm forestry and encourage farmers to participate in developing forest resources. There were frequent, radical changes in forest tenure during the period from the early 1950s to the early 1980s. A majority of forests was the private property of rural households in the first half of the 1950s. These private forests were collectivised between 1955-1957, and became the property of communes in 1958. They were then owned and managed exclusively collectively until the early 1980s.

Late in 1978, China began its agricultural reform. The primary feature of this reform was the abolition of collective agriculture and the introduction of household-based agriculture. Before the reform, officials of the commune and production brigade made most decisions concerning land use and management, and agricultural production on the collectively managed lands. Farmers usually did not participate in the decision-making process. Through the reform, use rights to agricultural lands were distributed to individual farm households, while the village collective remained the owner of land. Along with the transfer of land use rights, households gained increased authority to make decisions about land use and management and agricultural production and marketing. Village collectives reserved some rights as the owners of land. As a result, farmers' motivation to increase agricultural production improved considerably.

Nationwide forestry reform in the early 1980s followed the pattern of the agricultural reform. Use rights to denuded or non-forested collective land were distributed to individual households as their family plots in an attempt to encourage them to plant trees and develop plantations. The collective retained ownership of the land, but farmer households have land use rights and own any trees they plant on the land. At the same time, the collectives also 'allocated' existing collective forests to farmer households to manage. In this case, the collective owned the forest but transferred responsibility for forest management to individual households. Income from the forest is shared between the collective and households that manage the forest under a wide range of terms agreed by both parties.

The state of tree and land tenure and its influence on farmers' revenue directly influences farmers' attitudes to engaging in forestry as part of their farming operations (He 1995). It is arguable that tenure insecurity or frequent changes in policy for forest tenure in China over the three decades to the early 1980s was responsible for the deforestation that took place immediately during the forest reform in the 1980s and hence contributed considerably to forest degradation. Between 1977 and 1987 there was an overall reduction in standing volume of forests in south China from 49.6 m^3 ha^{-1} to 43.7 m^3 ha^{-1} (Yin 1994).

Significant deforestation took place immediately after the adoption of the household-based forest management system. The root cause of the deforestation was a complete lack of farmer confidence in tenure security, a sense developed from their experience in the period from the 1950s to the 1980s, rather than the household management system itself. With perceived insecurity farmers immediately harvested trees distributed to them to realise their value. They were not convinced that the government would not reverse its policy so risk aversion strongly influenced their decision to harvest the trees (Yin 1994). All the study sites in Yunnan, Hunan, Guangxi and Zhejiang experienced deforestation at this time. The premature harvesting led to a huge loss of forest and many of the remaining forests were severely degraded by over-logging.

The long period needed for timber to generate income for investors requires tenure security. If the security is not there then farmers will take a lower risk option. For example, farmers in Lin'an were very enthusiastic about bamboo, because they can obtain income from it in just two or three years. This behaviour conforms to that reported in studies on property rights and investment incentives in other parts of the world (e.g. Fortmann and Bruce 1988, Besley 1995). It follows that if there is doubt about tenure security, longer-term tree crops for timber production are likely to receive poor management and become degraded, and are unlikely to be replaced after harvesting.

Over-Harvesting

Although over-harvesting took place in the early 1980s due to tenure insecurity, generally it results from the excessive dependence on forest resources. Local villagers rely heavily on forests to generate cash income from timber and NWFPs, while timber and fuelwood are also harvested for on-farm and domestic use. Fuelwood is the main or only source of energy for cooking and space heating, in most communities, especially those living in mountainous areas where temperatures are lower.

Forestry contributed to about 30% of farmers' income in the villages of Dongxi and Xiangjian in Huitong County. In Cangwu, Guangxi, sales of fuelwood and charcoal to cities on the Pearl River and Hong Kong were a major source of cash income from the 1950s to the late 1970s until market demand disappeared as new other energy sources became available. Fuelwood still is the primary source of energy for local villagers and the small-diameter wood is in demand for new wood processing plants.

If over-harvesting is to be halted and forests allowed to recover, villagers need to have alternative sources of income. This can be achieved through either farm forestry development or non-farm and off-farm employment, or a combination of both.

Market Environment and External Conditions

The market environment includes government interventions to the market such as harvesting quotas, pricing and taxation policies and marketing services. External conditions relate to local constraints such as resource supply and the demand for the forest products.

Government regulations on wood harvest and trade impact negatively on timber forest establishment and management in China. A cutting permit is required to cut trees and quotas to control the quantity of timber harvested in a region are specified by the government. Timber harvesting must be carried out at a time and location, and in an amount specified by the cutting permit. To some extent, this limits farmers' authority and makes them unable to respond to market signals. For example, they may not be able to harvest and sell their wood when prices are high due to the inability to obtain a permit. In most cases, the forestry department, or other institutions to which it delegates authority to purchase timber from farmers and village collectives, monopolizes the timber market. Consequently, timber prices are skewed and farmers receive prices lower than those on the free market. Present wood marketing practice may encourage illegal logging and sales and discourage farmers from managing timber forests sustainably. The study in Huitong County, Hunan, concluded that restrictive regulations on timber harvesting and marketing and the high level of taxation and fees on timber sales were disincentives to farmer to invest in sustainable management of plantations of Chinese fir and other timber species (Chapter 4). In comparison, the market environment for NWFPs and bamboo shoots is much better as farmers are able to sell them freely.

Poorly designed mechanisms for benefit distribution can discourage investment in forest management and lead to forest decline. Data from our surveys show timber income is distributed between outside stakeholders (government and forest department) and local community/households. The outside stakeholders receive income in the form of taxes and fees. For example in Huitong, Hunan, the price for Chinese fir timber is about 600 Yuan m^{-3} from which 295 Yuan m^{-3} is deducted for government taxes and fees including the forest department's fee for the reforestation fund (Chapter 4). Returns to the farmer are low as it takes at least 20 years before Chinese fir is large enough to harvest. In contrast, tax on bamboo shoots is less than 1% of sale price. This is another reason why farmers have little enthusiasm for timber forest management.

Degradation or deforestation may also result from poor local socioeconomic conditions. Where there is reduced demand for a product farmers may respond by cutting down the trees (He 1995). In Yuanmou, Yunnan, forests were cut down and not replanted when the local demand for fuelwood disappeared and agricultural crops provided an alternative source of income (Chapter 2). In the case of tea plantations in Lin'an, Zhejiang (Chapter 5), when market demand and prices for tea declined, farmers neglected their tea plantations and consequently the productivity decreased. If indicators other than output are used, then strictly speaking it may not be appropriate to assess such a plantation of tea or other NWFP species as 'degraded'.

Forest Practices

Harvesting Methods

Inappropriate logging methods result from over-dependence of villagers on timber/wood for both farm-use and income generation. Over the past two decades most timber stands in south China have been young or middle-aged with a low timber volume. In the absence of mature forests, farmers logged the best quality, large-diameter trees from immature stands (*badamao* in Chinese) to meet their timber needs. This selective logging also occurred because sale prices for large-diameter logs are high. Farmers in Cangwu, Huitong and Lin'an counties all adopted the logging practice that resulted in a dysgenic selection in their forests. In Cangwu, increasing demand for wood for new local industries resulted in cutting cycle being reduced from 8 years to 5-6 years.

Poor harvesting occurred in bamboo forest for producing shoots. Farmers harvest early sprouting and vigorous shoots and leave late sprouting, weak or unhealthy shoots as mother bamboos. This is detrimental to healthy and productive bamboo forest. They also break shoots off by hand instead unearthing them with hoes or other tools, a practice believed to contribute to lower quality bamboo shoots. Demand and prices for low quality shoots are low and accordingly local farmers were not enthusiastic about investing their time and money in properly managing bamboo forest.

Silvicultural Practices

Traditional cultivation practice for Chinese fir was a sustainable system that included establishing modest-sized plantings on suitable sites, allowing land to lie fallow after two or three successive crops, and intercropping with food crops or cash tree crops. However, these traditional technologies were abandoned for various reasons after about 1960. From this time, extensive Chinese fir plantations were often developed on inappropriate sites, and fallows and mixtures were not used. This changed silvicultural practice has resulted in lower soil fertility and forest land degradation (Fang 1987, Sheng 1991, Yu *et al.* 1992), and plantation productivity of later rotations is low. A further factor in productivity decline in later rotations may be the destructive effects on soil fertility of burning and intensive site preparation practices prior to planting Chinese fir. Burning has been a common practice in Chinese fir plantations because it provides short-term benefits to soil fertility, prevents weed growth, and makes planting easier. There are however many records of loss of site productivity in tropical plantations due to the loss of soil organic matter due to burning (e.g. Goncalves *et al.* 1997). Observations at our research sites are consistent with these literature reports, e.g. in the Hunan villages average MAI of Chinese fir plantations has decreased from 10.5 m^3 ha^{-1} in the first crop to 9.2 m^3 ha^{-1} in the second crop and 6.0 m^3 ha^{-1} in the third crop. These figures suggest that the decline in tree productivity becomes very significant in the third crop.

There has been considerable government pressure for farmers to plant Chinese fir without the necessary attention to situating the plantations on more fertile, deeper soils occurring on lower slopes and valley bottoms which this species is known to require for satisfactory growth. In Huitong (and other areas), Chinese fir plantations were often developed on shallow, infertile soils on upper slopes. The majority had low productivity and about half were classified as degraded (MAI = 6-10.5 m^3 ha^{-1}) or seriously degraded (MAI <6 m^3 ha^{-1}) (Chapter 4).

Species-site matching is also a problem in bamboo plantations. In Lin'an, Zhejiang, farmers have established extensive Lei bamboo plantations on steep slopes and ridges with infertile, shallow soil and other lands not suitable for the species. Bamboos planted on these sites grow slowly and plantation productivity is low. Planting Lei bamboo on steep slopes and ridges has caused serious soil erosion, and some extent biodiversity loss where natural forests have been cleared for the plantations.

A mulch cultivation technology for bamboos developed in the late 1980s to stimulate shoots to sprout earlier than normal has also caused problems. Lei bamboo usually sprouts after Chinese New Year but mulching increased soil temperature and shoots sprout before and during Chinese New Year when prices are much higher. This technology is profitable but unsustainable as it results in several bamboo diseases and unhealthy bamboo plantation including smaller stem diameters, a higher proportion of old mother bamboos and increased flowering. Both the application of the mulch technology and poor siting of plantations are motivational factors because high profitability is a great incentive for farmers to plant bamboo.

The underlying causes of these methods and practices leading to forest decline are over-dependence on forest products for livelihoods, farmer motivation, inappropriate guidelines of from government agencies on plantation development and limited availability of information on appropriate technologies and methods.

Forest Rehabilitation in South China

The above analysis indicates that successful rehabilitation of degraded forests and forest land needs to address several issues. While some issues are site-specific, others will apply to much of south China. They will require action to: 1) reduce dependence on forest resources; 2) overcome constraints to rehabilitation; 3) improve the motivation of farmers by removing disincentives; 4) improve technical guidelines for plantation development; 5) build and raise environmental awareness of farmers and other groups; and 6) identify and develop effective interventions for rehabilitating degraded forests using innovative approaches.

Reduce Dependence on Forest Products

An important cause of forest degradation in China is over-harvesting of forest products driven by over-dependence on forests. Many farmers rely heavily on timber/wood for both farm-use and income generation. Over-exploitation explains much of the degradation of timber forest, especially that observed in evergreen broadleaf forest in Cangwu, Huitong and Lin'an. Both over-harvesting and selective logging immature stands have contributed to forest decline.

Ways must be found to reduce dependence on forest products to support livelihoods if the present degraded forests are to be rehabilitated. These can include developing fast-growing plantations and intensifying or developing new farm, non-farm and off-farm activities and employment. Some possibilities were demonstrated at the research sites e.g. neem plantations in Yuanmou, and pig raising and orchard development in Cangwu. In Lin'an, where education levels were higher, there were greater opportunities for employment in non-farm and off-farm industries.

Overcome Constraints to Forest Rehabilitation

There are many site-specific constraints to successful rehabilitation of degraded forests, but some constraints are more general. Experience at the research sites highlighted the importance of size of forest holdings, current access to forest, access to technical information and advice, and capital for investment.

Fragmentation of Forest Holdings

Fragmentation resulted from inappropriate implementation of policy for the forest reform in the early 1980s. When forest land and forest were distributed to individual households, to ensure equal distribution they were divided into many tiny plots based on tree species and age, land quality, distance of forest/land from village etc., and matched to family size. As a result, a household was allocated several very small plots in different locations and so use rights to forest/land in one location are owned by a number of households. For example, in Shangfeng village of Lin'an County, several households each have 10 or more plots of forest, while the average holding is only 2.3

ha per household (Chapter 5). This situation is very common in south China.

Land fragmentation makes it difficult to develop an integrated plan to rehabilitate a degraded forest. For example, mountain closure for natural regeneration of secondary forest and plantation establishment in small catchment is cost-effective and technically easy to adopt, but it needs common action of many households. Mountain closure was adopted in three of our research sites. In Lin'an, household forest farms and a shareholding system were emerging as ways to solve the fragmentation problem. In the former case, a household expands its forest land area through leasing land use rights from, or in partnership with, other farmers. In the latter, all parties involved pool their land, funds and/or technology to manage forest and establish plantations. They subsequently share benefits generated from the forest based on the shares they hold through their resource input. A shareholding system was also adopted by villagers in Huitong but was not acceptable in Shanxin village. In Shanxin farmers were more comfortable with an option that did not change the form of forest tenure or involve redistribution of forest benefits. Each household with forest land in the closed area retained control of their trees and will harvest products only from their own plot(s) of land when the mountain is reopened.

A point that must be made regarding common action in forest rehabilitation is the form of common management. It is households who should decide what forms (e.g. shareholding system, household forest farm or other models) to be adopted based on their socioeconomic circumstances. At our sites decisions on this seemed to be related to the communities' level of social and economic development and the extent of their exposure to market forces. In Lin'an, farmers have achieved considerable economic advances and were more amenable to a shareholding system or household forest farm that involves leasing of land use rights. A shareholding system was not acceptable in Shanxin village, Cangwu, which is much less developed, more isolated and the farmers more conservative. In Huitong, which is more developed economically than Shanxin, the shareholding system as an option for common management of forest often was also rejected by local communities and farmers, though the government made great efforts to promote it.

Observations from these sites and elsewhere demonstrated that common management is not only is able to solve the problems of forest holding fragmentation but also is more cost effective than individual household management where, for example, each household must allocate a person to look after its scattered plots. It is necessary to pool resources or to transfer land use rights between households to realise common management for natural regeneration of forest but it must be achieved through negotiation and in response to market forces rather than externally imposed by the administration.

Access to Forests

Villagers in mountainous areas rely heavily on forests for their welfare and so need some access to forest resources when mountain closure is identified as an option for natural regeneration of forest. If all their forest is closed, they will be unable to collect fuelwood and NWFPs, harvest timber, or graze their animals. If this occurs they may have no cash income to buy manufactured goods or to pay school fees and medical expenses. Full closure of a mountain area for regeneration is therefore not acceptable and will not be successful.

Recognising the problems for full mountain closure, partial closure was proposed for the study villages of Huitong and Shanxin village when this strategy was identified for forest rehabilitation. Half of a mountain area was closed during a given time, while the other half was open for use. When the closed half reopens after a specified period (several years), the other half of mountain will be closed for rehabilitation. In Shanxin village, several households had all or the majority of their forests in the designated closed area so an exchange of forest land was arranged with those households with majority of their forest outside the closed area. The arrangement made it possible for all households to have access to forest resources.

Implementation of partial mountain closure was effective in the study villages in Cangwu, Huitong and Lin'an, which suggests it could be applied in the context of small scale forestry in south China.

Lack of Technical Information

It was evident from our research that village communities did not have ready access to information about alternative technologies that could help them diversify their sources of income. In Lin'an, farmers left tea plantations untended when market demand for general tea declined and they were not able to identify opportunities for alternative, profitable forest products. In Huitong, there was a need for agroforestry technologies and to identify new species or varieties with market potential that were adapted to local ecological conditions. These are beyond farmers. The situation was similar in Shanxin village when villagers tried to develop other sub-sectors of agriculture and non-farm activities to reduce pressure on existing forests. In Yuanmou, lack of a species that was adapted to local conditions and that could be grown profitably was one reason villagers were not enthusiastic about planting trees.

These problems were identified and resolved in the research sites by tapping into the broader experience and knowledge of project researchers and local research and development institutions. In Lin'an, there was a government extension organisation at township level and farmer demonstration households with primary responsibility to demonstrate successful technologies to their fellow farmers but poor communication between them. The project helped to improve the agricultural extension services by establishing village technical groups to assist the flow of information.

Villagers have good understanding of their problems but they need help in identifying options to solve them. Public extension services have the potential to make great contribution to communities in remote and isolated rural areas but need new initiatives to improve communication. Unless this occurs rehabilitation of degraded forests will be difficult as villagers will find it hard to find alternative sources of income.

Shortage of Capital for Investment

Shortage of funds is a constraint most farmers face when they want to regenerate natural forests, establish plantations or undertake other agricultural and non-farm activities. This was a general problem at the research sites. In Shanxin, one of difficulties in implementing the 'mountain closure' strategy was how to cover operational costs. In the Huitong villages, farmers had to change their plan to replace degraded Chinese fir plantations with chestnuts and oranges because they could not raise funds for these species from external sources and were not able to cover all the costs themselves. Finally they decided to plant *Ginkgo biloba*, a tree used to provide medicinal products, because the forestry department at that time provided loans only for that species.

Some of these problems in the research sites were solved by financial support by the project and special allocations by local governments but this is not a solution that can be replicated elsewhere. Improved rural credit services, such as the microfinancing arrangements of Grameen Bank and other rural financial institutions which have already shown promise in some areas in China, are needed.

Farmer Motivation

It is essential to harness interest of all stakeholders, but especially rural communities, in rehabilitation and sustainable management of degraded forests in south China. Without their active involvement, there is little likelihood of success because so much of forest land in the region is managed either by households or by village collectives. Our research, and that of others, shows that incentives are related to policy factors, marketing of forest products, and comparative economic benefits. At policy level, tenure insecurity, over-taxation on timber and restrictive regulations on wood harvest and trade are factors that have been disincentives to farmers to invest in timber tree planting and forest management. It also is important to manage incentives as over-enthusiasm for planting of a particular crop can have a negative impact on forests, as in the case of widespread planting of bamboo for shoot production in Lin'an.

Tenure Insecurity

Tenure insecurity has been not only one of factors responsible for deforestation and forest degradation in China but also a disincentive for farmers to be involved in forest rehabilitation. The frequent change in policy for forest ownership over the three decades to the mid-1980s led to a great lack of confidence among villagers in tenure security. With perceived insecure tenure, villagers did not manage forests sustainably and did not want to invest in establishing timber plantations or managing timber forests that need a long period to generate income. In contrast, farmers were extremely enthusiastic over bamboo and other NWFP plantations that can generate income in just a few years. The behaviour conforms to that reported by others on property and investment incentives in other parts of China and elsewhere (e.g. Fortmann and Bruce 1988, Besley 1995).

The tenure issue also involves the rights of owners to dispose their property. A frustration among Chinese farmers is to have trees, recognised by law and policy as their property, which they are not permitted to harvest because of environmental concerns. The logging ban in natural forests in most areas of China (Yang 2001) is an example. Such a ban may be necessary for the country's environmental benefits but then farmers should be properly compensated for their contribution. If this does not occur they will again lose confidence in policy for forest tenure and have no incentive to manage their forests.

Over-Taxation on Timber

Distribution of forest benefits, if not properly designed and implemented, can be a significant disincentive for farmers and other investors. Timber income is distributed between outside stakeholders (including government, forest departments and timber companies) and community/individual households. Our data show that local government and the forest department captured about half of the turnover of wood trade in the form of tax and fees; costs of logging and timber transport are estimated at about 30-35% of sale price; and farmers received only the remaining 15-20%. Profits to farmers from timber were nearly zero when establishment and management costs are taken into account. Shares of timber income were similar in Lin'an, Zejiang, with outside stakeholders seizing half of gross timber income (trade price). In the case of Chinese fir log in Huitong, government captured 25% of trade price; forestry department about 15%; timber company around 35% (including costs of transport and profits); and farmers, 25% of which 9% is logging cost. Sun (1992) refers to other studies that show the farmer captures only a very small part of income from timber sales. As a result, farmers shift to develop NWFP plantations such as bamboo (e.g. Ruiz-Perez *et al*. 1996), fruits, nuts and others, because tax on these products is very low, e.g. tax on bamboo shoots is less than 1% of sale price.

The reduced level of benefits to farmers due to over-taxation of timber in part explains why they have little enthusiasm about timber plantation establishment and forest management. It is also clear that where the state has reduced its influence on production and marketing of other crops farmers have been motivated to increase production.

Regulations on Wood Harvest and Trade

Wood harvesting is highly regulated in China through a system of cutting quotas and permits. The logging quota set by government, rather than market supply and demand, is the most important factor determining China's annual timber production (Sun 1992). A cutting permit is required to cut trees irrespective of whether they belong to private households or collectives. Timber must be harvested at a time, location, and in the amount specified by the cutting permit. When the quota is filled for a county or town, then no more cutting permits will be issued that year. Quotas are limited and obtaining permits is a difficult, costly and time-consuming process. The regulation is discouraging because it inhibits farmers from responding quickly to market signals. They may not be able to harvest and sell their wood when prices are high due to failure to obtain a permit. It also provides an incentive for illegal logging and selling.

Current wood marketing regulations are a disincentive. The timber market is a monopoly with only the government forest department, or institutions designated by the forest department, entitled to purchase timber from villages and households. Consequently, farmers may obtain prices much lower than market prices, while the state timber company benefits. In comparison, the market environment for NWFPs is much better as farmers can sell their products freely. This, in part helps explain why farmers are more enthusiastic about NWFPs than timber. To motivate farmers to establish and manage forests, monopolised purchases by the forest department and other regulations must be reviewed and modified to give farmers more flexibility and authority in wood marketing.

Market Demand and Prices

Market demand and prices for forest products have a strong influence on farmers' motivation, especially in the case of NWFPs. When demand and prices are low, farmers have little incentive to invest time and money managing their forests properly. For example, farmers in Lin'an left their bamboo forest for dry shoot production and tea plantations untended because demand for the two products was low. Conversely, high prices encourage farmers to develop plantations and manage forests. Farmers in Lin'an were so enthusiastic about Lei bamboo that they planted the species on unsuitable sites, a practice that resulted in plantations with low productivity and associated soil erosion. While this is clearly undesirable, it is not uncommon for proper species-site matching to be neglected when prices for a commodity are high.

Comparative Advantage in Economic Benefits

Farmers will plant trees and manage their forests when their products are more profitable than products from other agricultural activities. Farmers in Laofan village were not interested in tree planting because cultivation of winter vegetables is much more profitable and is their major cash income. The income is generated within a year and so they rely little on trees and plantations for their livelihoods. When tree planting is profitable or has the potential to be more profitable than other agricultural activities, farmers will take action immediately as the rapid diffusion of neem trees in Yuanmou and other areas attests.

This is a factor that must be taken into account when the government urges rural communities to restore environmental conditions through planting trees and grass in environmentally sensitive areas such as the upper reaches of the Yangtze River.

Raising Environmental Awareness

Harnessing self-interest of stakeholders is essential but not sufficient. Although profitability was the major driving force for farmers to be involved in forest establishment and management, the research found that villagers are also not active in planting trees because there is a lack of awareness of environmental benefits of forest and tree plantations. Generally they did not recognise direct benefits from improved agroecological conditions and reduced soil erosion. Farmers in Yuanmou showed little interest in revegetating bare hilly land even though there was evidence that rising salt levels in the soil was beginning to affect the productivity of their more fertile crop lands (Figure 2.1). This finding raises a need for education among villagers to build and raise their environmental awareness. They may participate more actively in forestry if they are convinced environment restoration is not only beneficial to others but also to themselves.

Improve Plantation Development Guidelines

Guidelines by forest authorities on plantation development may need to be modified to prevent forest plantations declining in productivity. In the 1960s-1980s, some forest authorities were so ambitious to establish extensive plantations that they ignored the silvicultural principle of species-site matching and practices to maintain soil fertility. Plantations developed under the guidelines are poor and with low productivity. The inappropriate silvicultural technologies of Chinese fir in Huitong (site mismatch, multiple cropping [*duodai lianzai* in Chinese], monoculture plantations, burning and intensive site preparation practices) are mainly a result of poor guidelines rather than a lack of appropriate technology. However, further research and the establishment of demonstration plots with new technologies may be necessary to show the effects of burning logging slash on the long-term productivity of plantations. Research to understand the effects of site management on Chinese fir and other tropical species in plantations has begun (e.g. Nambiar *et al.* 2000).

Developing Effective Interventions for Forest Rehabilitation

Forest degradation is a complex process and results from many inter-related factors. As discussions and analysis of the research project results have shown, these factors involve policy, sociology and economic aspects as well as technical issues. Diagnosis of problems (extent and causes of forest degradation) and constraints to rehabilitation interventions and livelihood enhancement require more innovative approaches than the conventional, single discipline approach usually applied in China.

Our research demonstrated that a participatory and interdisciplinary approach is very effective. All stakeholders, i.e., villagers, researchers and government officials, played an important role in developing strategies. Villagers know their own circumstances and local conditions and can make significant contributions to the identification of problems and designing interventions to address them. Involvement of professionals can provide expertise and new ideas, and improve communication between government agencies and villagers. Government officials are important for forest rehabilitation because their participation will help them make effective policies and their networking with government agencies will help villagers to gain access to public resources such as extension services, rural credit and market information.

Three lessons can be learnt from the research experience to encourage active participation of the three parties: 1) building partnerships to address problems requires all participants to trust each other; 2) responsibilities of each of the parties involved and the potential benefits must be clearly specified at the start of discussions and self-interest harnessed to encourage participation; and 3) farmers and their indigenous knowledge must be respected and recognition given to their ability to participate in and contribute to identification and implementation of effective solutions. Illiteracy should not be equated with ignorance. Without such preconditions, it is impossible to achieve genuine farmer participation when normally farmers are rarely involved in the design and planning strategies for sustainable forest management.

A multidisciplinary approach is effective in developing interventions and strategies for forest rehabilitation and associated improvements in the livelihoods of rural communities. Our research recognised the complementarity of the skills of social scientists, economists and range of forestry researchers, but the research teams may have performed better with greater inputs from social science. We found that adoption of a multidisciplinary approach required: 1) team members to commit to cross-disciplinary collaboration with members working within their disciplines, but contributing to overall outputs; 2) members of different disciplines to listen to and respect others' opinions and to think more broadly than their own discipline; and 3) a team leader with skills to guide a multidisciplinary team, manage disciplinary conflicts and negotiations, and synthesise views and findings from various stakeholders.

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Chapter Two

Reclaiming Degraded Forest Lands in the Dry, Hot Climate of Yuanmou County, Yunnan

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Introduction

The dry and hot valley climatic type occurs mainly in the southwest provinces of Yunnan, Sichuan and Guangxi. In Yunnan, this climatic type covers 13 000 km^2, between latitudes 22.5°-28.0° N, and makes up 3.4% of the area of the province (Yang 1992). As the name suggests, it is a hot, dry climate providing harsh growing conditions for plants and the aridity is a critical constraint to tree planting and plantation establishment.

Little forest vegetation remains in areas with these climatic conditions. Forest land is often seriously degraded, has had its vegetation cover reduced to sparse shrubs or even bare land, and severe soil erosion is common. Existing, limited forests are degraded or seriously degraded with low productivity, resulting from excessive exploitation and unsustainable practices. Given the inadequate vegetation cover and serious land degradation, environmental restoration in the areas will have to be achieved through the planting of trees, shrubs and grass. Improvement of the deteriorating ecological environment and achieving economically and ecologically sustainable development of forest lands is a great challenge to foresters/biologists, villagers, and local governments at different levels.

Research to identify tree and shrub species adapted to the harsh ecological conditions and to develop effective planting technologies are in progress (Yu 1997, Yu *et al*. 1997, Zhou and Zhang 1998, Li and Zeng 1999, Yang *et al*. 1999). The research has focused on technical interventions, however, experiences show that improved technology practices alone are not sufficient to bring about an expansion of tree planting and plantation establishment in this area. It is essential to understand why this is the case and what other interventions and options are needed for effective reclamation of degraded lands and forests.

Our research was carried out in Yuanmou County, Yunnan. Yuanmou has a typical dry and hot valley environment and areas of severely eroded land. It has a mean annual temperature of about 22°C; mean annual rainfall is only 630 mm, while potential evaporation is nearly six times the rainfall. Only 6% of Yuanmou's land area was covered with forests in 1993. The majority of its designated forest land is covered with poor quality bushes or grass and sometimes there is no vegetation cover at all. Heavy rains in the short wet season cause severe erosion of the unprotected soil and restoration of cover by planting trees, shrubs and grasses is necessary to address this problem.

This chapter presents research methods; describes biophysical and socioeconomic

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circumstances of the research site, providing a setting for the research; and examines the state of forest land degradation. It discusses strategies and interventions for reclaiming local serious degraded forest lands: incentives and environmental awareness of farmers, and appropriate species.

Research Methods

As an action-oriented research project, this research adopted a logical procedure from diagnosis through design to delivery. It used a participatory approach complemented by the more conventional inputs from expert consultants. The participatory approach involved great attention to interacting with key stakeholders to develop the options and strategies. This was a departure from top-down approach used in traditional forest research and governance practices in China. Therefore, the research itself was an experiment with innovative research methods for natural resource management and reclamation of degraded forest land.

Participatory Approach

Villagers, government officials and agricultural extension agents and researchers in relevant disciplines were actively encouraged to interact to analyse problems, to identify constraints and opportunities, and to develop appropriate options and strategies to address degradation problems.

A number of PRA tools were used at the diagnosis stage, including secondary data collection, household interviews, group interviews, and direct field observations. In addition, a participatory program of species testing was implemented at the delivery stage.

Secondary data were collected from relevant county government agencies such as the Forestry Bureau, Statistics Bureau and Meteorological Bureau, from township governments, and from previous research projects and programs. The data included biophysical conditions and socioeconomic settings such as climate, land uses, forest resources, changes in forest tenure and management, tree planting policies, role of forest in the local economy, demography, and extent of infrastructure development.

Household interviews were used to determine villagers' views on land degradation and their attitudes to tree planting and utilisation of the uncultivated land. A random sample of 33 households was made and each household interview lasted 1.5-2 hours. The interviews were conducted in the form of a semi-structured interview complemented by questionnaire survey. After a pre-testing phase, 20 questions covering nine topics were used in the household interviews. The topics were (1) family size, labour, education and production activities, (2) land resources, (3) land use, (4) livestock and fodder, (5) household income, (6) household expenses for production, (7) household expenses for non-production activities, (8) value of fixed assets, and (9) taxes and fees paid. We sought to understand the level of interest in tree planting, the perceived constraints to plantation establishment and the incentives needed to encourage planting.

Group interviews examined questions of relevance to the whole village. Five groups (village leaders, women, elders, youths, and progressive villagers) were interviewed. Each group consisted of 10-12 people and most had not been involved in household interviews. Each group interview took 2.5-4.0 hours to complete. After pre-testing, 21 questions covering 10 topics were discussed. The topics included the state of forest land degradation, the views of villagers on two forms of tree planting in the area (government chief model plantation and planting by villagers), attitudes and constraints to tree planting at the village level, and especially the issues that were controversial or which individual households failed to explain adequately.

Direct field observations were made by a group of two forest researchers and three farmers who had good knowledge of their village and its lands. Findings from these observations were recorded and maps were made. The data and maps cover a wide range of issues such as village boundaries, topography, land uses, irrigation, forest types, state of degraded lands, crop calendar, transport, gender distribution of work, and indigenous knowledge.

A small program of field testing exotic tree species not previously grown in the area was initiated based on the villagers' view that they did not have sufficient choice of well-adapted species for profitable tree planting. The process was participatory and collaborative. Local communities (villages) provided land for field experiment and were responsible for tending seedlings. Yuanmou County Forestry Bureau provided part of funding and made the necessary arrangements. The research team took responsibility for obtaining tree seeds and provided technical support for nursery establishment and part of the funds. It also took advantage of the availability of specialists with international experience in tree species selection and access to computer-based selection methods. Potential species were selected on the basis of their suitability for reclamation and their potential profitability was assessed. A total of 15 exotic tree and shrub species were introduced and tested for their adaptability to the dry and hot climate and impoverished soils. Commitment to the project varied between villages and this may have influenced the maintenance and performance of some trials.

Expert Consultancy

Expert consultancy, the usual approach to forestry problems in China, was used to help with the identification of options for reclamation. During the research process, consultations took place with Kunming-based specialists from the Research Institute of Resource Insects, Southwest Forestry College, Yunnan Academy of Forestry, Yunnan Institute of Forestry Planning and Design, and Yunnan University. Local professional staff from Yuanmou County Forestry Bureau were also consulted. Topics discussed included the state of land degradation, technical and socioeconomic constraints to tree plantation establishment and strategies for successful plantation development in Yuanmou.

Background Information on Yuanmou County and Laofan Village

Research was conducted at both county and village levels. Studies were undertaken in four villages: Laofan and Xiaocun villages of Zuolin township, Moke village of Nengyi township, and Bingyue village of Laocheng township. These villages are situated either in the Yuanmou basin or the transitional zone from the basin to the mountainous area.

Overall biophysical conditions and the social setting of Yuanmou county are described and Laofan village is used to illustrate village-level conditions as there were similarities in climate, vegetation, land uses, socioeconomic circumstances and land degradation in the four villages studied.

Yuanmou County

Climate

Yuanmou county is a typical dry and hot valley area in central Yunnan and is located at 25°23'-26°06'N latitude and 101°35'-102°06'E longitude (see Map 1.1 in Chapter 1). The mean annual temperature is 22°C, May is the hottest month with a mean temperature of 27°C, and the coldest month is December with a mean temperature of 15°C. Mean annual rainfall is 629 mm and annual evaporation is 3729 mm. Rainfall is not distributed evenly throughout the year. Most rain falls during June to October. The 7-month dry season, from November to May, averages less than 100 mm or 14% of the mean annual rainfall. (Table 2.1)

The dry climate makes successful tree planting a challenging operation. It also makes natural regeneration extremely difficult after forests are harvested or cleared. The survival rate of trees planted using planting technologies that are effective in other areas was very low in this area during the period 1952-1988 (Yuanmou

Table 2.1 Climatic data for Yuanmou (1956-1990)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean temperature (°C)	15.2	17.8	21.8	25.2	26.9	26.4	26.4	25.4	24.3	21.3	17.6	14.9	21.9
Rainfall (mm)	3	4	5	13	45	115	142	125	88	65	18	6	629
Evaporation (mm)	251	318	461	514	506	340	294	233	222	203	191	196	3729
Relative humidity (%)	44	37	32	34	44	60	66	70	67	66	61	53	53

Source: Yuanmou Meteorological Station (Yuanmou County Forestry Bureau 1997).

County Forestry Bureau 1997). This in part explains why forest cover is so limited and why few plantations have been successfully established in Yuanmou.

Land use

The land area of Yuanmou is 201 970 ha. Two thirds of the area is designated as forest land; 19% is food crop land; and 15% is grazing land, water bodies and settlement areas. In 1993 forest covered only about 6% of Yuanmou's area while 47% of the land had poor quality bushes (Yuanmou County Forestry Bureau 1997).

Socioeconomic setting

Yuanmou County has 13 townships and had a population of 198 000 in 1998 with most people depending on agriculture for their livelihood. Agriculture, broadly defined as including crop production, animal husbandry, forestry and agricultural products processing, plays a very important role in employment and income generation of the rural population of Yuanmou. In 1998, agriculture contributed nearly 70% of the gross output value of society with the balance to the economy contributed by the manufacturing, construction, transport, and tertiary industry sectors. Gross output value of society is a measure of Chinese economy. It is the sum of gross output value of agriculture, industry (manufacturing), construction, transport, and commerce, the five material production sectors. The sum of gross output value of agriculture and industry is called gross output value of industry and agriculture. The gross output value of agriculture comprised: crop production 76%; animal husbandry about 20%; and forestry slightly more than 3%. Although the forest contribution to the economy is usually systematically underestimated in China, its very low contribution to the Yuanmou economy is in sharp contrast to the 66% of land area allocated to the forestry sector in the county.

Winter vegetables, livestock and sugar cane are major sources of cash income for villagers, especially farmer households in the Yuanmou Basin. Relatively high temperatures in winter make vegetable cultivation possible and profitable. People in Yuanmou began planting winter vegetables in 1978, and now these are marketed in more than 150 cities throughout China and are the most important source of cash income for many farmer households.

Forests contribute little to the material welfare of communities and villagers of the Yuanmou Basin area. Alternative sources of energy such as coal and electricity have been substituted for the fuelwood on which villagers were dependant for cooking and space heating prior to the 1980s. Other profitable products, such as winter vegetables, have increased peoples' income and enabled them to afford the new types of energy. The railway from Kunming (capital city of Yunnan) to Chengdu (capital city of Sichuan) goes through Yuanmou, and a good road system has been developed in the county. This infrastructure provides ready access to markets for local products. These factors have had a major influence on the attitude of people to tree planting in the area.

Laofan Village

Land use

The land area of Laofan village is 115 ha. About 50% of total area of the village is used for food crop production, including paddy fields, irrigated land and rain-fed land. However, farmers often do not cultivate food crops on the rain-fed land because its productivity is low. Instead, they graze their animals on it. Plantation forest and denuded land make up about 40% of the village's total area. The plantation forest is *Eucalyptus exserta* that was first introduced to this area in 1966. Farmers also graze their animals in the plantation and on the denuded land. Water bodies and residential areas make up nearly 10% of total area. (Table 2.2)

Socioeconomic setting

Situated in Yuanmou Basin, Laofan village is 6.5 km from the Yuanmou County town. It is a small village with a population of 441 (1995), comprising 108 households, and with 51% of the population female and 49% male.

Although it is not far from the county town, Laofan is a typical agricultural community, with crop production and animal husbandry providing primary employment and sources of income. In 1995, the labour force of the village was 322 of which 93% was involved in agriculture. Labour age for rural women is 16-54 years old and for rural men 16-59 years old. Agriculture, broadly defined, contributed 94% of the annual gross output value of society of Laofan, while non-farm activities was only 6%. Within the agricultural sector, food grain and vegetable production and animal husbandry are primary contributors of the economy. Food grain and vegetable production contributed 67% of gross output value of society and animal husbandry 27%. The contribution of forestry to gross output value of society was less than 1%.

A sealed road links Laofan to the county town and provides villagers with ready access to markets for vegetables and other agricultural produce.

Forest tenure and management

Forest tenure and management in Laofan has undergone similar radical changes to other parts of China (Liu 2001). Prior to the nationwide Land Reform Campaign in 1952, landlords (wealthy village households), religious groups and clans owned forests in Laofan. All these categories of forests were confiscated during the Land Reform and redistributed equally to farmer households as private property. However, following the agricultural collectivisation - the establishment of the advanced (agricultural) cooperatives in 1956 and the people's commune in 1958, forests became collective property and were managed exclusively by the village collective until the early 1980s.

Table 2.2 Land use in Laofan Village

	Paddy fields and irrigated land	Rain-fed land	Plantation forest	Denuded forest land (*huangshan*)	Water bodies and residential area	Total
Area (*mu**)	632	231	300	400	160	1723
% total area	36.7	13.4	17.4	23.2	9.3	100
Area head^{-1} (*mu*)	1.4		0.7			3.9

Source: field survey data.
* 1 mu = 0.066 ha

Laofan experienced two periods of destructive deforestation from the late 1950s to the early 1980s. The iron and steel making drive in 1958-59 caused the first deforestation. At that time a considerable amount of wood was cut and used to fuel numerous backyard furnaces. The collectivisation of forest resources made the waste possible. The second deforestation happened immediately after collective agriculture was replaced by household-based agriculture (known as the agricultural production responsibility system) in the early 1980s. The replacement led to a breakdown of the management system of collective forest. Forest remained a collective asset at that time but nobody was given authority to manage it, especially to protect it from illegal cutting. Consequently, villagers cut down almost all the eucalypt trees that had been introduced and planted in Laofan in the mid-1960s. The village leadership had to sell the remaining collective trees to individual farmer households in the village in 1983.

As an area in the upper catchment of the Yangtze River, Yuanmou is entitled to funds of a large government-sponsored environment restoration program - *the Yangtze Shelterbelt Program* (Conservation Forest on Upper and Middle Reaches of Yangtze River) that was initiated by Ministry of Forestry in 1989 to plant trees and to protect existing forests. Yuanmou County Forestry Bureau implemented the program in Laofan village. To encourage farmers to plant trees, the village leadership allocated collective forest land use rights equally to individual households, and the Forestry Bureau again promised the policy 'whoever plants the tree owns it'. A eucalypt plantation of 20 ha (300 mu, see Table 2.2) was established and it was the only plantation forest in Laofan when this research was conducted. The Forest Bureau appointed a villager to guard the plantation and made regulations to protect it. Only branches can be harvested because the plantation was developed for soil erosion control and environmental services; tree harvest is not allowed unless a permit is obtained from the Bureau, and grazing is prohibited in the plantation. In practice, the farmers have ignored the grazing regulation.

Land Degradation Assessment

Yuanmou County

Only 6% of the land area of Yuanmou was covered with forests in 1993. The existing natural forests and plantation forests are degraded. The majority (90%) of designated forest land has either poor-quality bushes or no vegetation cover at all. The bush vegetation is degraded and the denuded forest land is seriously degraded. This situation is a cause for concern and has both local and regional implications. It requires significant efforts for ecological and environmental restoration through planting trees, shrubs and grass.

Laofan Village

Our field surveys showed that much of the land in Laofan is degraded or seriously degraded, including the denuded forest land, plantation forest, and the rain-fed land (see Table 2.2 above). The extent of degradation varied on the different types of land but exceeded 50% of total area of the village.

Figure 2.1 Highly salinized land in a low lying area

The denuded forest land of Laofan is seriously degraded. It can be further divided into two sub-types: (1) land along a small stream that is highly salinized (Figure 2.1) and (2) the denuded forest land on which either only a few plants of a small shrub, *Dodonaea angustifolia*, and grass occur or there is very little or no vegetation cover. Heavy rains in the rainy season result in severe erosion of the unprotected soil and there are numerous erosion gullies of varying length, width, and depth on the land (Figure 2.2 and Figure 2.3). Little organic matter remains and fertility is very poor.

Figures 2.2 and 2.3 Erosion of the unprotected soil resulting in numerous erosion gullies of varying length, width, and depth on the land

Figure 2.2

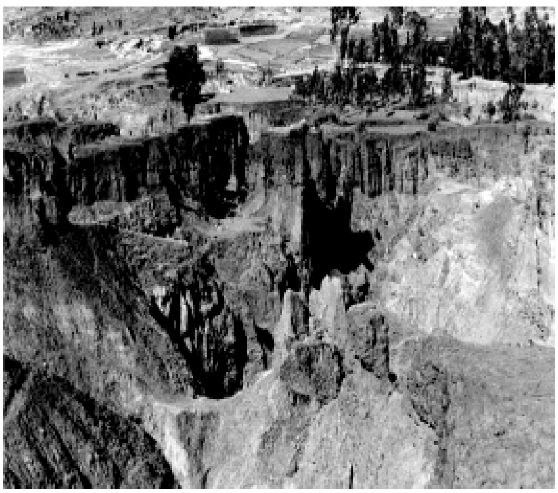
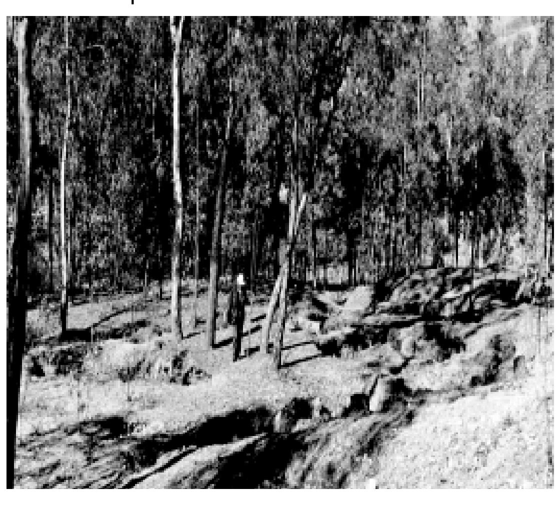


Figure 2.3

The eucalypt plantation is seriously degraded. Indicators are slow growth of trees, lack of understorey plants and continuing development of numerous soil erosion gullies (Figure 2.4). Although the eucalypt species in the plantation is one of the most tolerant of poor soil conditions, the stand is irregular and lacks vigour. Most species of *Eucalyptus* are less effective in controlling soil erosion in dry areas, because they provide very little shading of the soil due to their open crowns and because their roots compete very effectively with understorey plants for the small amount of water available. This suggests that from perspective of soil erosion control and ecological benefits, appropriate species are those trees with characteristics such as dense spreading crowns and either deep rooting or low water use (Boland 1997). This is also a lesson farmers in Laofan and beyond have now learned from their own experience. Although eucalypts may inhibit understorey development in dry areas, uncontrolled animal grazing exacerbates the situation here and the erosion damage appears to be increasing.

The rain-fed crop land is also degraded, though not as seriously as the denuded forest land and the eucalypt plantation. The degradation is indicated by low productivity of the land. Farmers now either grow only sweet potatoes

Figure 2.4 Erosion damage appears to be increasing even in the plantation area



on this type of land, or in most cases no longer crop it. This is a type of degraded land to which future reclamation efforts designed for dry and hot valleys in Yuanmou and other areas must give attention.

Land degradation is a deterioration of local agroecological conditions and has direct impacts on local welfare. Land degradation in this area also contributes to the problems in Yangtze River. For example, soil erosion leads to silting of the river, and the lack of forests and other vegetation increases the likelihood of disastrous floods, such as those in 1999.

Clearly, there is a need to reclaim degraded lands in dry and hot valleys in Yuanmou and adjacent areas, both for improving local agroecological conditions and welfare and for environmental benefits and services in middle and lower reaches of Yangzte River. Hence reclamation of degraded lands in the area is of national significance.

Strategies and Interventions for Land Reclamation

This section discusses socioeconomic factors and technical aspects of reclaiming degraded forest lands in the dry and hot climate zone by analysing the ways in which tree planting is organised currently in Yuanmou and drawing lessons and implications from our species testing. The purpose is identifying strategies and distilling policy recommendations for reclamation efforts in the harsh ecological conditions.

Organisation of Tree Planting

Plantation establishment is organised in two ways in Yuanmou: (1) by villagers with or without government support, and (2) by government, with the local government chief taking overall responsibility. The second category of establishment is called 'government chief model plantation' or '*yangbanlin'*.

Local communities and villagers have so far been the primary force of plantation development in Yuanmou, though governments at various levels have played a greater role since the late 1980s. Over the six years from 1989-1994, about 8400 ha of plantations was established in the county, two thirds by communities and villagers, and the rest by county and township governments and village leaders (Table 2.3).

Government chief model plantation

A government chief model plantation is a high quality plantation established through administrative means by a given level of government using reforestation funds. The government chief at each level takes overall responsibility for plantation establishment and management. One purpose of 'government chief model plantations' is 'demonstration' to convince villagers that it is feasible to establish plantations successfully and increase forest cover in the harsh environment.

Table 2.3 Plantation establishment in Yuanmou (1989-1994)

Year	Total planted area (ha)	Tree planting by villagers		Government chief model plantation	
		Area (ha)	% total	Area (ha)	% total
1989	796	656	82	140	18
1990	2096	1645	79	451	21
1991	1815	1403	77	412	23
1992	1046	299	30	747	70
1993	1658	1217	73	441	27
1994	1004	412	41	592	59
Total	8415	5632	67	2783	33

Source: Yuanmou County Forestry Bureau (1997).

In Yuanmou, government chief model plantation establishment started in 1989. The County government chief, township government chiefs and village leaders must develop their model plantations respectively. Their success in establishing plantations is an indicator used to assess their performance and is used as a reference for promotion. The chief model plantation is a strategy designed to effectively establish plantations through better use of available funds, and clear and specific responsibility.

Responsibilities of each party involved are clearly set out. The government chief takes overall responsibility for plantation establishment, including selecting planting sites, making this land available, ensuring no conflict over the lands; coordinating villagers whose lands are used with the forest department and related agencies; making funds available; and monitoring results of the tree planting. Forest departments take specific responsibilities for plantation establishment, including managing funds, selecting sites and tree species, making operational schemes, organising planting, protecting trees planted, and initial evaluation of plantation development. Likewise, the performance of participating forest officials in plantation development is recorded and used as a reference in promotion.

Lands for the establishment of government chief model plantation belong to villagers. Hence, by policy, trees planted are the property of villagers who own lands. However, the rights of villagers to trees/plantations are very limited: Only branch lopping is allowed because such plantations are developed largely for ecological services. Villagers who contribute lands are given priority in planting, or tending and guarding as paid labour.

Capital investment in the reforestation is from three sources: local government budget; reforestation funds from central, provincial and prefectural governments; and contributions by public sector staff as their obligation of "Voluntary Tree Planting". A policy made by Chuxiong Prefecture that governs Yuanmou County, requires the county government to spend 1-2% of its yearly budget on forestry. Yuanmou received reforestation funds totalling 1.6 million Yuan annually from central, provincial and prefecture governments during the period from 1993-1996. Contributions by public sector employees are also an important investment source of government chief model plantation establishment. Initially, people must plant trees in person to fulfil their obligation of "Voluntary Tree Planting", a requirement by law for all adult citizens. Later in Yuanmou, the requirement was adapted to allow cash contributions rather than planting trees in person. Each public sector employee contributes 20 Yuan a year for tree planting.

The amount of capital spending varies across different levels of government chief model plantations. Planned investment is 1500-1800 Yuan ha^{-1} for model plantation of county government chief; 1200-1500 Yuan ha^{-1} for model plantation of a township government chief; and 750-1200 Yuan ha^{-1} for model plantation of a village leader. However, actual input in county chief model plantations in 1998 was 2700 Yuan ha^{-1}. About 20% of capital investment is used for seeds and seedlings, 50% for labour for land preparation and tree planting and the remainder for fertilisers and plantation tending and guarding.

Tending after planting is essential for successful tree survival and growth in the local hot, dry climate. Recognising this, the forest department recruits forest guards (from villagers) to tend and protect plantations for three years after planting or five years in extremely difficult areas. Subsequently, local communities are responsible for plantation management.

Experience over the last decade shows that this form of plantation development is effective. The approach was helpful in obtaining necessary financial inputs, using them effectively and generating a comprehensive tree planting effort. As a result, the government chief model plantation is an important way of organising plantation development in Yuanmou. Over the period of 1989-1994, the area of chief model plantations accounted for one third of total area of plantations established. In two of the years, the ratio of chief model plantations to total plantations established in the year rose to more than 50% (Table 2.3). This form of plantation development significantly improved the quality of tree planting and increased seedling survival rate. Survival rates increased from about 50% (1989-1992) to over 80% (Yuanmou County Forestry Bureau 1997).

Nevertheless, the government chief model plantation is not sufficient as it mainly involves government effort. Government funds are limited and government alone is unlikely to reclaim all the denuded and degraded forest lands that make up about 60% of the total area of Yuanmou. Without complementary efforts by communities and villagers, there is little likelihood of revegetating Yuanmou and providing environment services locally and to other areas along the Yangtze River.

Incentives are essential to encourage active involvement of local communities and villagers, but current policies do not provide enough incentives for villagers to plant trees, especially timber species. Although villagers who contribute lands to the development of government chief model plantations are owners of trees planted but they have very limited rights to cut trees. Villagers have little incentive to become involved in the development of timber plantations, as timber harvesting is highly regulated and they can expect little return from their labour and capital investment. While strict restrictions on logging (timber harvesting) may be necessary for the environmental services for Yuanmou and other areas of the Yangtze watershed, there is concern that compensation be paid to local communities and villagers who provide such services through their trees and plantations. The ongoing countrywide government program of 'food for trees and grass' (*tuigen huanlin*[1] in Chinese) does encourage farmers to plant trees. The program is progressing well, with farmers asking a greater quota of tree planting than the government is providing.

Species choice is another issue that needs to be addressed in government chief model plantations. More than 10 species have been used in these plantations in Yuanmou, including species of *Eucalyptus, Acacia, Albizia, Leucaena, Pinus*, *Ziziphus oenoplia* and *Cajanus cajan.* Timber species are dominant and most plantations are monocultures. Large-scale, highly intensive, plantation forests are usually grown in monocultures to maximise production of a defined product such as pulpwood. However, the risk factor in smaller-scale plantings by farmers and communities, which often have less certain markets, can be reduced by using more than one species and producing multiple products. The implication here is that more attention must be given to multipurpose trees when selecting species for planting. This way, villagers can expect material benefits from plantation forests of multipurpose species that provide environmental services and economic products, a point that is well demonstrated widely else where. In parts of southern China *Acacia mearnsii* (black wattle) has been planted on degraded lands. This nitrogen-fixing tree provides ground cover and commercial products such as tannins, poles and timber (Ho and Fang 1997). Though monoculture plantations of multipurpose species with dense spreading crowns and deep rooting can also provide protective cover of soil, there are other benefits for using mixed species plantings for soil conservation and rehabilitation plantings. For example, mixed plantings may provide more habitats and encourage greater biodiversity than monocultures. Mixtures including a nitrogen-fixing species may have better nutrient cycling than pure stands (Khanna 1997), and increased growth and productivity (DeBell *et al.* 1997).

Tree planting by villagers

Villagers and communities have been responsible for the majority of plantations established in Yuanmou. Even though government chief model plantations were initiated in 1989, plantations developed by villagers accounted for two thirds of total plantation area in the years from 1989 to 1994 (Table 2.3). Villagers established small woodlots

Food for Trees and Grass Program
(*tuigen huanlin)*

The program started in 1999 after the disastrous Yangtze floods in 1998. Farmers of upper catchment of the Yangtze River and upper and middle catchments of the Yellow River are required to stop cultivating food crops and to plant trees and grass instead on their crop lands on steep slopes. To encourage them to do so, the central government provides them with food grain, cash subsidy and funding for tree seedlings. Every year, farmers get 2.25 t of grain ha^{-1} once they have done so in the upper catchment of the Yangtze, and 1.5 t ha^{-1} in the upper and middle catchments of the Yellow River; and cash subsidy of 300 Yuan ha^{-1}. They get 750 Yuan ha^{-1} for seedlings at beginning of planting. The government provides grain and cash subsidy for eight years in the case of plantation forest developed largely for ecological services and five years in the case of NWFP plantations. In the latter case, the hypothesis is that farmers will be able to generate income from their plantations in five years.

on denuded forest lands and on rain-fed crop lands and were responsible for choosing the species and planting methods and for deciding the extent of planting.

However, the area planted by villagers has been far less than it could be and what is needed. Our surveys found four factors affecting plantation development by villagers. First and most important is the disincentive for them to plant trees compared to other crops. Besides restrictions on their rights to harvest and market timber products as discussed earlier, villagers in Yuanmou have more profitable investment opportunities. Since the late 1970s, vegetable growing in winter has been a profitable enterprise and vegetables have been a primary source of farmers' cash income. Moreover, vegetable growing can generate income within a few months while returns from tree planting cannot be expected in at least a few years. Also, it is not easy to grow trees profitably due to the low productivity of denuded lands and excessive government taxes and charges. While it is not easy to change the productivity of the land, changes in policies on rights to harvest and market timber and a more favourable approach to taxation and charges could provide a greater incentive for tree planting.

The second factor is the lack of capital for tree planting. The availability of funds is an important feature contributing to the high quality of government chief model plantations. Capital input was 2700 Yuan ha^{-1} for county chief plantations in 1998. In sharp contrast, reforestation funds provided by the forest department to villagers was only 300 Yuan ha^{-1}. It is unfortunate that since 1989 most villagers have received little or no funding support for tree planting as almost all public funds allocated for tree planting have been used to develop government chief model plantations. This suggests a necessity to find a mechanism to overcome the funding constraints villagers face for plantation establishment.

Thirdly, it is essential to identify sufficient tree species well-adapted to local ecological conditions that can be grown profitably.

Finally, villagers do not value tree planting for environmental protection. Villagers in Yuanmou Basin and the transition zone now rely little on forests as they have alternatives sources of fuel and building materials. They are not keen to plant trees when they can expect little material benefit from the forest. Our surveys found that in four study villages, most villagers did not consider it in their interest to develop plantation forests for environmental services. They did not recognise direct benefits from improved agroecological conditions and reduced soil erosion that might result from revegetating the degraded land. This finding implies a need to demonstrate potential direct benefits of environmental restoration to villagers and local communities.

Species Selection

Identification of a sufficient number of species well-adapted to the dry and hot climate and able to be grown profitably is one of the keys to restoring vegetative cover and rehabilitating degraded forest lands in Yuanmou. So an important component of this research was to identify additional species to those that are currently planted in the area.

Introduction of plant species to Yuanmou can be traced back to the 1920s. Considerable work on introduction of species started in 1958 and about 110 species were tested during 1958-1992 (Yuanmou County Forestry Bureau 1997). Most of the species came from other parts of China but some were from other countries. They included both timber species and species for non-wood products. The efforts of more than four decades did identify some well-adapted species. However, with change in economic conditions and markets, some of these species are no longer profitable to grow in plantations.

Our research in Yuanmou introduced 15 new species to expand the range of species available for selection by farmers and to understand what species farmers want and why, because only those species accepted widely by farmers are appropriate species. Species tested included *Azadirachta indica, Acacia* spp., *Eucalyptus* spp., and *Casuarina* sp.

Experiments, demonstration and extension of neem

Neem (*Azadirachta indica*) is a small to medium-sized tree, usually about 15 m tall, with a spreading evergreen crown. It is thought to have originated in the Assam-Myanmar region and is distributed throughout the Indian subcontinent. It has been cultivated for many years in Indonesia, Malaysia and Thailand. More recently it has been grown as an exotic in many parts of the world. It is a multipurpose tree adapted to poor soils and hot, dry tropical conditions. It grows best where there is an annual rainfall of 1000 mm but will tolerate as low as 400 mm. It is grown for shade and shelter, timber and fuel, and to control erosion. In India, oil from the seed is used for soap making but is well known for its medicinal and insecticidal properties. The species is fully described by Ahmed and Idris (1997).

It was introduced into Yuanmou in 1995 at beginning of this research project. Seedlings were raised and planted in around village and homesteads, and on the denuded forest lands at Laofan during the rainy season of 1996. A total of 350 seedlings were planted. In August 1997, after one year of planting, the height of young trees averaged 2.6m, with a maximum of 3.5m; and diameter at ground level averaged 3.8 cm, with a maximum of 6.2 cm. In August 1998, after two years of planting, the height of young trees averaged 3.8 m, with a maximum of 5.9 m; diameter at breast height averaged 6.4 cm, with a maximum of 10.2 cm; and crown size averaged 2.0 x 2.0 m, with a maximum of 2.9 m x 3.0 m. It was also in the year that the trees flowered and fruited.

Four additional *Azadirachta* provenances (seed sources) were introduced to Yuanmou from Myanmar and Africa in 1997. Experiments with these were made in Xiaocun village and a total of about 0.5 ha was planted. A survey after three months of planting found that survival rate was over 98%. Experiments with neem have now been carried out in other counties of Yunnan province such as Yuanjiang and Jinggu and show similar encouraging results.

These experiments demonstrated the high potential of this species for planting in Yuanmou and adjacent areas with similar ecological conditions. Of particular interest currently is the oil that has many biologically active compounds. Recognising the great market potential, several processing enterprises have entered into contracts with farmers in Yuanmou to purchase fresh *Azadirachta* seeds at prices of 1Yuan kg^{-1}. The economic potential of neem has also attracted considerable attention from governments and farmers. Governments at different levels are now encouraging farmers to plant these species and villagers themselves are enthusiastic.

Azadirachta indica could be the most successful introduced species in Yuanmou. Eight plantations, with a total area of 37 ha, were developed in Yuanmou in 1998. Of these, 17 ha were established with government capital investment, while 5 plantations totalling 20 ha were established exclusively with farmers' money. This is in sharp contrast to the attitude of farmers to other introduced species. The driving force of the rapid expansion of neem plantation is the economic potential of the neem tree products, especially the oil. The lesson from this experience is that tree species must be both ecologically suitable and economically profitable to generate enthusiasm among farmers to invest their time and money to plant them. Planting for environmental improvement reasons alone is not sufficient incentive to attract farmers' interest.

Testing other species

Australian tree species have been successful as exotics in many parts of the world. Many are multipurpose species adapted to harsh tropical environments (Doran and Turnbull 1997). Using computer-assisted climatic analysis (Yang *et al.* 1996) the climate of Yuanmou was compared with that of Australia to identify species with a high probability of being adapted to the hot and dry local conditions.

Ten species, mostly from central Queensland, were identified. Some of the species have already shown potential in dry areas in Vietnam, parts of West Africa and elsewhere. Seeds were provided by the CSIRO Australian Tree Seed Centre, Canberra and the experiment was established in Xiaocun in 1998. The species are: *Acacia difficilis, A. holosericea, A. neriifolia, A. plectocarpa, A. torulosa, A. tumida, Casuarina cunninghamiana, Eucalyptus camaldulensis* var. *obtusa, E. exserta* and *E. punctata*.

Initial observations show that performance varied across these species. Eight species show initial positive results, with the survival rates and average height of seedlings comparable with those of endemic species such as *Albizia kalkora* and *Phyllanthus emblica*. Two species, *Acacia torulosa* and *Acacia tumida,* failed in the nursery, probably because local nursery techniques were not suitable for them. Some of these species fix atmospheric nitrogen and could be planted in association with neem, especially on highly degraded soils. *Acacia holosericea* is already being used in mixed plantings with eucalypts in Guangdong province, China. Villagers stated that no vegetation survived under eucalypts and this is probably related to competition for water in the dry environment. There would be less competition if eucalypts were planted at wider spacing and this might permit acacias to be interplanted and provide better ground cover and a potential source of animal fodder.

Conclusions

Improvement in the ecological environment and people's welfare through planting trees in the seriously degraded forest lands with a dry and hot valley climate in southwest China is a great challenge. It needs the combined efforts of local communities and villagers, governments at different levels, and the academic community.

Our research highlighted what others have been finding in other regions and counties, namely that both socioeconomic factors and technical aspects must be addressed to encourage active involvement of *local communities and villagers* in this task. The former includes economic returns villagers can expect from tree planting, removal of government disincentives, increased environmental awareness among villagers, and the availability of capital for investment in reforestation. Appropriate technologies include identification of appropriate species and the development of planting technologies effective in the harsh climatic and soil conditions.

Economic Incentives

Reasonable economic returns are essential to encourage active involvement of villagers. Such returns can be achieved through several pathways. One is the adoption of multipurpose tree species for non-wood products in plantations because such plantations can generate material benefits without harvesting the whole tree thus maintaining environmental services. The rapid diffusion of neem in Yuanmou and other counties in Yunnan demonstrates that farmers are willing to plant trees if they can expect economic returns from their investments. Another possible incentive would be to have appropriate compensation for villagers for the environmental services their plantation forests provide. Government policies can also have a significant influence on the profitability of forestry plantations.

Government Policies

While timber harvesting has to be controlled strictly in the upper reaches of the Yangtze to reduce erosion and flooding, it is a disincentive for farmers to invest in tree plantations. Yin (1994) recognised the disincentives of governmental market controls and price distortions and such disincentives were evident in Yuanmou. Changes in government policies on rights to harvest and market timber and a more favourable approach to taxation and charges could provide a greater incentive for tree planting. The ongoing countrywide government program of “food for trees and grass” is an example of a positive approach to the problem. An expansion of the program in size or a development in similar programs is required.

Availability of Capital

One constraint that needs to be addressed is insufficiency of capital for investment in plantation establishment. Currently villagers use any surplus income for fixed assets, such as house construction, television, or to pay for marriages. Investment capital will be required to encourage villagers to develop quality plantations. Government reforestation funds have been limited, and most of them have been used to develop government chief plantations with little support to villagers. Investment by government in plantation establishment is public spending and should be used to develop forests with environmental services as the primary objective. Investment by villagers should be used to establish profitable multipurpose plantations. The case of rapid adoption by villagers of neem trees shows that provided the economic incentives are there the more wealthy farmers can overcome capital shortage.

Appropriate Technologies

Technical difficulties that need to be overcome include identification of sufficient appropriate species to provide a choice of options and the generation of economical and effective planting technologies for the dry and hot area. Appropriate species means species that are well-adapted to local climatic and soil conditions and have characteristics that help control soil erosion, such as dense spreading crowns and either deep rooting or low water use, and are also profitable to grow. The neem tree appears to be a good example of the type of tree that is required. Technologies that are effective but costly inhibit widespread adoption, as shown by planting techniques developed by several other research projects.

A participatory and collaborative approach to testing species and silvicultural techniques has advantages including the rapid uptake of appropriate technologies. This has implications for the design of future projects of land reclamation and forest rehabilitation.

Environmental Awareness

There is a need for environmental education for villagers to build and raise their awareness of environmental issues. This implies a need for efforts to demonstrate potential direct benefits of environmental restoration to villagers and local communities. They may participate actively in developing plantations if they are convinced that environment restoration through tree planting is not only beneficial to others but also to themselves. Locally this may mean controlling severe soil erosion, preventing salinization of soil and improving land fertility and productivity.

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Chapter Three

Degradation and Rehabilitation of Evergreen Broadleaf Forest in Cangwu County, Guangxi

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Introduction

Evergreen broadleaf forest is typical vegetation in China's extensive subtropical zone in most hilly and mountainous areas to the south of the Yangtze River. The majority of these forests are secondary forests and most have been degraded to a greater or lesser extent. Only a few primary natural forests exist in isolated locations (Ministry of Forestry 1996).

Degraded evergreen broadleaf forest is characterised by a reduced number of tree species and much lower biomass than normal forest. In the forest there is a loss of biodiversity and off-site effects of forest degradation include increased flooding, lower water quality and siltation of dams. These forests have received considerable attention from foresters and local communities but there is limited understanding of the extent and causes of their degradation and its impact on people's welfare. Few effective strategies or solutions, especially overall packages, for rehabilitation of these forests have been identified. Nevertheless it is clear that degradation of such forests is continuing and if left unchecked will have serious consequences for people depending on forests for their livelihoods and for the environment in general. Part of the problem has been failure to recognise that technical 'fixes' alone are not sufficient and more innovative multidisciplinary approaches with participation of stakeholders are required.

Our research was carried out Shanxin village, Cangwu County, in eastern Guangxi. Evergreen broadleaf forests comprise two thirds of forest area of the village and most of the remainder is mixed coniferous and broadleaf stands. For over 100 years the broadleaf forests of this and other villages in the area have been managed largely for fuelwood and charcoal. These products were consumed on farm and exported to the Pearl River Delta and Hong Kong to provide an important source of cash income. Now 75% of the broadleaf forest is degraded and 10% has deteriorated into bush-covered land and grassland. Forest degradation appears to have resulted in significant decline in forest output and to threaten local livelihoods and environmental services.

A participatory approach was used to examine critically the extent and immediate and underlying causes of degradation of evergreen broadleaf forest in one village to achieve an improved understanding of the issues. Then we aimed to identify effective strategies/solutions to reduce degradation and to test some of the solutions in the village's forests through action research.

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This chapter presents results of our research. It briefly presents research methods, describes biophysical and socio-economic conditions of the village, and examines the extent and causes of degradation of evergreen broadleaf forest. It discusses disincentives to management of broadleaf forest for timber and other wood products; and identifies strategies for forest rehabilitation and analyses their effectiveness based on results from testing them at the study site.

Research Methods

As part of a multi-location research project, the research in Shanxin village used similar methods to those in the other study sites (Chapter 1). This required a participatory approach combined with the logical procedure of diagnosis of the problem, design of possible solutions and finally testing of proposed solution through action research.

Participatory Approach

Participation is now widely advocated and accepted as a strategy for rural development and natural resources management. It is referred to as 'Participatory Rural Appraisal' (PRA) (Chambers 1994a, b, c, Chambers and Guijt 1995). The participatory approach recognises that it is critical to conduct research in the local social context where differences in land, labour and markets can radically change the effectiveness of proposed technological solutions to forestry problems. In this research, participation involved farmers, their families, researchers and local government officials to address forestry problems. It is an approach that has rarely been used in China.

Farmer participation

In contrast to a 'top down' approach, farmer involvement in diagnosis, design and delivery was particularly stressed in this research. More than 100 households representing nearly 20% of households in Shanxin and a number of leaders of village and village household groups who are also farmers were consulted during diagnosis stage. The overall aim of the survey was to identify factors responsible for the forest degradation, to canvass possible solutions and to find acceptable ways of implementing action research to test potential rehabilitation strategies. The survey was undertaken in two periods of about one month duration. Survey methods included common PRA tools such as secondary data collection, farmer household interviews and group interviews/meetings. In the first survey 54 households were consulted and 52 households during the second survey. These households were chosen through random sampling from village household groups at different levels of economic development. Specifically, the 54 sampling households were selected from two wealthier village household groups, four middle-income groups, and two poor groups. Households were consulted largely through semi-structured interviews complemented by a questionnaire survey. During the first survey period, three group meetings were organised, each with the village leaders, the leaders of village household groups, and representatives of farmers.

Views and opinions were listened to and respected throughout the research process. For example, initially the researchers proposed a shareholding system when discussing natural regeneration through mountain closure (*fengshan-yulin* in Chinese) and reclamation of a small area of sloping land. However, farmers rejected the proposal. After much debate, the farmers proposed and adopted a form of common management involving no changes in tenure. Similarly, the researchers worked with farmers to develop options but farmers decided whether to adopt them or not.

Involvement of researchers

More than 10 researchers and extension personnel were involved. They were from the national Research Institute of Tropical Forestry and South China University of Agriculture, based in Guangzhou, and from local government services such as agricultural extension, forest bureau, and scientific and technical commission. Researchers and extension staff played an important role in identifying appropriate options/ strategies, and providing necessary extension services and information. This was extremely important in this isolated mountainous area where farmers have poor access to information and extension services. Participation of researchers helped improve communication between government officials and the farmers.

Participation of government officials

Over 20 government officials from six government agencies, including county bureaus of agriculture, forestry, and science and technology, and from township government participated in this research. Involvement of government officials helped facilitate successful implementation of strategies identified because their participation made a significant contribution to the raising of investment funds and to conflict resolution.

Action Research

The research in Shanxin adopted a logical project procedure of diagnosis, design and delivery. The researchers worked together with villagers and government officials to achieve a good understanding of local forest resources and to identify the state and causes of forest degradation and opportunities and constraints to forest rehabilitation. On the basis of this, a range of activities was identified to address the problems of rehabilitation of degraded forests. These activities were either direct, such as the mountain closure to promote natural regeneration, or indirect, such as planting trees to provide non-wood forest products (NWFPs) and developing yard activities to provide sources of incomes that did not involve harvesting of products from the broadleaved forests. These activities were then tested in and around the village to determine their appropriateness and effectiveness, which is action research or the delivery part of the research process.

Conventional Forestry Research Methods

Forest vegetation survey

Conventional methods for forest vegetation survey were used to understand plant species, forest resources, and the extent of forest degradation. The survey team consisted of five researchers and two villagers. It was carried out in sample plots measuring 20 m x 20-50 m. A plant inventory was made to document biodiversity, and the extent of forest degradation was assessed using indicators such as fuelwood output and standing biomass of forest over time. To achieve an understanding of forest degradation a comparison between the current state of forest and past forest conditions was made. This was based on available research data and recall of senior villagers. For the same reason, a comparison between forest in Shanxin and primary forest in a nearby reserve was also made.

Soil surveys

The survey team undertook soil surveys in different types of forests and in forests degraded to a different extent of to understand relation between changes in soil properties and forest degradation. Type, texture, depth and fertility of soil and its capacity for holding water and fertility were observed and measured.

Background Information on Shanxin Village, Cangwu County

Location, Terrain and Climate

Shanxin village is an administrative village governed by Cangwu County It is located at 23°19’31”-23°26’50”N latitude, 111°40’41”-111°50’00”E longitude in eastern Guangxi (Map 1.1 in Chapter 1). It is close to towns and cities, being only 30 km from Wuzhou city and 45 km from Cangwu County town.

The terrain is predominantly hilly with an altitudinal range of 55-300 m above sea level but mainly 110-250 m. The mountains are steep, with slopes of 25-35 degrees in general and up to 45 degrees. This rugged topography makes food cropping difficult and less productive. The climate is warm, rainfall abundant, and summer is much longer than winter. For the period 1959-1992, mean annual temperature was 21°C, and mean annual rainfall 1516 mm. Most of the rainfall (80%) comes in spring and summer, and autumn and winter are very dry. Although the lands and climate are quite favourable for tree growth, the hilly topography increases the cost of logging and wood transport.

Forest Resources

Shanxin has an area of 2940 ha. Data in Table 3.1 shows that 83% of the area is forest whereas cropland is only 4%. About 13% of the area has other uses, such as grazing and habitation. Primary forests in Shanxin were natural evergreen broadleaf forests. Now, due to long-term over-harvesting and other human interventions, secondary natural forest has become the most common type of vegetation in the village and adjacent areas. Currently, the forests can be grouped into three broad categories: evergreen broadleaf forest, mixed coniferous and broadleaf forest, and NWFP plantation (Table 3.1).

Evergreen broadleaf forest

Evergreen broadleaf forest is common in Guangxi and is the typical vegetation in subtropical areas of several other provinces in south China. In Shanxin it comprises two thirds of forest area (Table 3.1). This natural forest has become less rich in species composition but still includes many species. Our surveys indicate that the most common tree species in this forest type are: *Castanopsis hickelii, Castanopsis fissa, Castanopsis fargesii, Lithocarpus fenzeliana, Quercus griffithii, Cinnamomum camphora, Sassafras tsumu, Michelia macclurei, Schima superba, Schefflera octophylla, Cratoxylum ligustrinum, Altingia chinensis, Madhuca subquincuncialis, Rhodomyrus tomentosa, Phyllanthus emblica* and *Melastoma candidum. Miscanthus florodulu* and *Pteridium aquilinum* are the most common herb species.

Evergreen broadleaf forest in Shanxin has been managed mainly for fuelwood and wood for making charcoal, although it also provides materials for farm tools and NWFPs. Until the late 1970s, some fuelwood and charcoal were consumed on farm and the remainder exported to cities in the Pearl River Delta and Hong Kong. Demand for these products has gradually diminished due to the availability of alternative energy sources such as electricity and natural gas. However, a new demand for wood has appeared. Many wood processing enterprises, especially the Wuzhou Wood Factory, have been established since the 1980s, and these enterprises need significant amounts of small-diameter wood. In addition, fuelwood is still the primary source of energy for local rural communities.

Table 3.1. Land use in Shanxin village

Types of land	Area (ha)	% Total	% Total forest area
Total land area	2940	100	
Total forest	2446	83	100
Evergreen broadleaf forest	1462		67
Mixed forest	728		30
NWFP plantations	76		3
Crop land	103	4	
Other (grazing land, settlement area)	391	13	

Source: Cangwu County Forestry Bureau and Guangxi Institute of Forestry Inventory and Planning.

Figure 3.1 Bundles of bamboo stems for a local paper factory in Cangwu County

Mixed forest

Mixed forest of conifers and broadleaf trees accounts for 30% of the forest area of Shanxin (Table 3.1). Dominant species in this type of forest are Masson pine (*Pinus massoniana*) and some broadleaf tree species. Masson pine is natural and secondary in origin. There are also plantations of Chinese fir (*Cunninghamia lanceolata*) but they are very limited in extent comprising less than 1% of forest area. The mixed forests are managed mainly for timber production, although resin is tapped from the Masson pine.

NWFP plantations

These plantations are limited in area and make up only 3% of the forest (Table 3.1). They are mainly plantations of *Cinnamomum cassia*, *Illicium micranthum* and bamboo. *Cinnamomum cassia* is a medicinal plant, its bark is used directly in Chinese medicine and its leaves and branches are distilled to produce oil. Fruits of *I. micranthum* are a common spice in Chinese food. Bamboo is managed for timber to make baskets for farming use, as building material and for paper pulp (Figure 3.1). Edible bamboo shoots are also produced. Plantations of *Cinnamomum* (Figure 3.2) and *Illicum* account for 1.7% of forest area of the village; and bamboo, 1.4%. In addition, *Camellia* sp. is planted for tea oil in several hamlets.

Shanxin is rich in forest resources on a per capita basis. On average, each villager has about 1 ha of forest land and 8.5 m^3 of timber. However, the endowment varies significantly among hamlets of the village. For example, per capita forest area is only 0.27 ha and 0.35 ha respectively in two hamlets but is 1.9 ha in another hamlet.

Contributions of forest to income generation and villager livelihoods

Shanxin village is a typical agricultural community, and if those who find off-farm employment are excluded, farmers contribute the majority of the production of the village. The contribution of different sub-sectors of agriculture has varied over time. Forestry has become more important in income generation since the early 1990s, with its share increasing from less than 10% in the early 1990s to nearly 20% in the mid-1990s. In this period it became as important as animal husbandry in the village. In contrast, the share of cropping decreased from over 80% to about 60% over the same period, although it is still the largest sub-sector (Table 3.2). Fuelwood is the sole source of energy for cooking and space heating for local people; and

Figure 3.2 Leaves of *Cinnamomum cassia* harvested for oil production

Table 3.2 Gross output value of agriculture in Shanxin by subsector (1991-94)

Subsector	1991		1992		1993		1994	
	Yuan 000s	%	Yuan 000s	%	Yuan 000s	%	Yuan 000s	%
Cropping	1802	83	1911	73	1930	61	2293	62
Forestry	153	7	163	6	597	19	728	20
Animal husbandry	223	10	533	20	621	20	703	19
Fishery	3	0.1	3.6	0.1	6.0	0.2	5.6	0.2
Village total	2182	100	2611	100	3155	100	3730	100
	Yuan capita^{-1}		Yuan capita^{-1}		Yuan capita^{-1}		Yuan capita^{-1}	
Cropping	694		743		751		894	
Forestry	59		64		233		284	
Animal husbandry	86		207		242		274	
Fishery	1		1		2		2	
Total	840		1016		1228		1454	

Source: Shanxin Village Office, Annual Statistical Reports of Shanxin Village, Wangfu Township, 1991,1992, 1993, 1994.

sales of fuelwood, small-diameter wood and NWFPs are important sources of cash income, while the crops produced are largely for on-farm consumption.

Demography, Infrastructure and Wealth

Shanxin has a population of 2570 in 521 households (1995) with 43% of the population at labour age. The dependant ratio is not high, so, poverty is not much related to this factor. About 64% of the population has primary school level education; 32% has junior middle school education; and nearly 3% is illiterate. Few villagers have senior middle school education. Almost all those with senior middle school education and a large proportion of those with junior middle school education seek part-time or full-time off-farm employment in urban areas of Guangdong and Guangxi.

The village has relatively good access to transport. The highway from Wuzhou to Hexian County passes through the village and provides for it access to vehicle transport. Six of 24 village household groups reside along the highway and 11 of them are connected by dirt road to the highway, though seven groups are far from the main road or have no access to motorised transport. In addition, the Xijiang River (a branch of the Pearl River) provides transport between Wuzhou city (30 km from Shanxin) and many cities in the Pearl River Delta and Hong Kong.

The village is rather isolated in terms of telecommunication. The village office had no access to telecommunication and officials had to rely on oral or written messages when they needed to contact leaders of the village household groups.

Shanxin village is poor compared with the other 20 villages within the same township. Average per capita gross output value of agriculture of the village was 77% of township average; and average per capita income about 65% (Table 3.3). Average per capita output of food grain was also lower than the township average due to a smaller area suitable for crop production and poorer land productivity. As a consequence, 80% of households were not able to achieve food sufficiency and had to buy grain to make up the deficit.

Extent and Causes of Degradation of Evergreen Broadleaf Forest

Extent of Degradation

In this chapter, two indicators - biomass ha^{-1} and forest composition – are used to assess the forest in Shanxin village. It is compared with its previous state and with an undegraded forest in a nearby reserve.

Table 3.3 Agricultural economic performance in Shanxin and Wangfu township (1994)

	Mean annual gross output value of agriculture (Yuan capita^{-1})	Average annual income (Yuan capita^{-1})	Gross output value of agriculture '000s Yuan				
			Total	Cropping	Forestry	Animal Husbandry	Fishery
Shanxin	1454	980	3730	2293	728	703	5.6
Wangfu	1888	1509	5030	3161	511	937	421
Shanxin as % of Wangfu	77	65	74	73	143	75	1.3

Source: Shanxin Village Office (1994), Annual statistical reports of Shanxin village and Wangfu township, 1994.

Our surveys in 1997 showed that 75% of evergreen broadleaf forest in the village is degraded, 10% severely degraded and about 15% slightly degraded. The degraded forest comprises impoverished and ecologically unstable stands equivalent to those classified as 'overlogged forest' by Banerjee (1994). Its output of fuelwood is less than 20 t ha^{-1} on about a 7-year cutting cycle. The seriously degraded forest has become shrub land or bare land. It can provide little fuelwood, compared to the 30 t ha^{-1} or more from slightly degraded forest.

Biomass of Shanxin's forests has declined remarkably over the last five decades. Based on the recall of senior villagers, standing biomass of the forest in the early 1950s averaged about 100 t ha^{-1} and could reach 150 t ha^{-1}. It declined to about 65-100 t ha^{-1} in the early 1980s and further to only 30 t ha^{-1} in the late 1990s (Table 3.4) so the past 20 years saw a substantial reduction in the biomass. Wood output has shown a similar trend. Yield decreased from 50-60 t ha^{-1} in the early 1980s to about 20-30 t ha^{-1} in the late 1990s.

Biomass of the evergreen broadleaf forests in Shanxin is also sharply lower than that of forest with same dominant species in a nearby natural reserve. Survey showed that forest biomass in the reserve is 280 t ha^{-1}, about eight times that of the forests in Shanxin. This further demonstrates the severity of degradation of the village's forests.

Although Shanxin's forests are degraded or severely degraded, soil fertility in the forests did not show a similar trend. Our survey data showed that soil fertility between the degraded forests in Shanxin and the primary forest in the reserve did not differ significantly. This suggests that land in the degraded forests still has great potential for forestry production.

Forest composition has become less diverse. Senior villagers in Shanxin recall that tree species preferred for house building and furniture making such as *Castanopsis hystrix*, *Erythrophleum fordii*, *Phoebe nanmu*, and *Madhuca subquincuncinalis* were very common in evergreen broadleaf forest in the early 1950s. Due to prolonged selective cutting, there are now not many trees of these species left. Fast-growing species such as *Castanopsis fissa*, *Quercus griffithii*, *Alangium chinense* and *Schefflera octophylla*, are now very common so the value of the forest is lower. In addition, as a result of shorter interval between wood harvests, the proportion of large-diameter trees in the forests is very small.

Causes of Degradation

Forest degradation has received increasing attention throughout the world but convincing research on causes of forest degradation is still limited in China. Our research in Shanxin focused on causes of degradation of evergreen broadleaf forest to better understand the issue and to identify effective strategies for rehabilitation. The research indicated a number of factors responsible for forest degradation. They are:

- over-harvesting
- inappropriate logging methods

Table 3.4 Changes in forest biomass

Forest type	Biomass (t ha^{-1})	
	Early 1980s*	1997**
Castanopsis fissa forest	98.5	33.5
Schima superba forest	65.1	
Mixed forest of *C. fissa* and *S. superba*	77.2	
Castanopsis hystrix forest		33.7
Mixed forest (I)		29.3
Mixed forest (II)		6.8
Shrubs		4.4
Primary forest (natural reserve)		281

* Data from a survey on fuelwood by Guangxi Academy of Forestry.

** Data from our field survey.

- radical development policy and breakdown of collective forest management system, and
- tenure insecurity

Over-harvesting

Cangwu County has been a fuelwood and charcoal production area for more than a century exporting these products to Guangzhou, other cities in the Pearl River Delta and Hong Kong. Overlogging, driven by local and outside demands for fuelwood and charcoal, has caused forest degradation in the county, including Shanxin. This took place largely during the period from 1954 to the late 1970s.

Although farmers sold these products before 1954, the quantity marketed to outside areas was limited, mainly due to the lack of transport infrastructure. Construction of the highway from Wuzhou to Hexian in 1954 provided villagers in Shanxin with easy access to transport and facilitated increased production and marketing of fuelwood and charcoal. These were primary sources of cash income for farmers in Shanxin and other villages in Cangwu and beyond at least until the late 1970s. Since then demand for them in Hong Kong and the Pearl River Delta declined significantly as other energy sources became available. In 1977 Shanxin stopped making charcoal because of very limited demand. However, there is still market demand for fuelwood, because this remains the sole source of energy for cooking and space heating in the area.

High consumption of fuelwood on-farm and local market demand places a huge pressure on the forest. Our survey of 74 households in Shanxin in 1995 showed these households annually harvested 940 t of fuelwood, nearly 13 t per household. On-farm consumption was 68% and 32% was marketed. About 70% of households in the village sold fuelwood, and more than half earned most of their cash income from these sales. Each of 40% of households earned 1000 Yuan or more annually from fuelwood selling. Shanxin village harvested 6711 t of fuelwood in 1995. As noted earlier, average fuelwood output of 7-year-old forest is estimated to be around 30 t ha^{-1}. This suggests that Shanxin needs to harvest more than 220 ha of forests annually for fuelwood only. This is equivalent to about 13% of evergreen broadleaf forest in the village.

A new demand for small-diameter wood appeared in the mid 1980s with the establishment of a number of wood-using enterprises. The largest is the Wuzhou Wood Factory, located in Cangwu County, which produces fibreboard and particleboard and needs 90 000-100 000 t $year^{-1}$. It is estimated that current demand in Cangwu County for small-sized wood is 180 000-190 000 t $year^{-1}$. On the supply side, the county is not able to meet this demand. The area of secondary broadleaf forests in Cangwu is 67 600 ha, assuming harvesting is at 7-year intervals, so about 9660 ha can be harvested a year. Experience indicates that average output of small-diameter wood of 7-year-old broadleaf forest is only about 10 t ha^{-1}. This suggests that Cangwu County is able to supply about 96 000 t of small wood at present and in the near future, or only able to meet the requirement of the Wuzhou Wood Factory. Clearly, there exists a substantial gap between demand and supply of wood in this county. The situation has placed great pressure on the already degraded local forests.

Over-harvesting also occurs because of over-dependence of local communities on forest resources. Surveys showed that more than 80% of households depend on small wood and other forest products as main sources of cash income and they have limited cash income from other sub-sectors of agriculture and non-farm activities.

A possible solution is to increase small wood output by developing fast-growing plantations and tapping other sources of income to reduce over-dependence on the degraded forests. Empirical evidence shows that there is a close interrelationship between dependence on forest and development of other sub-sectors of agriculture and non-farm activities. Forests in Fuzhu hamlet of Shanxin have been conserved and are in relatively better condition than those in other hamlets, as village households in Fuzhu have developed animal husbandry, fruit orchards and food processing enterprises and do not rely heavily on forests for income generation.

Inappropriate logging methods

Poor logging methods, including selective logging, and shorter intervals between harvesting have contributed to the degradation of forests in Shanxin and other villages in the area. Excessive application of selective cutting has resulted in less individuals of slower growing species preferred for house building and furniture making, while less valuable, lower quality species, such as *Castanopsis fissa* and *Quercus griffithii,* have become dominant. Hence tree diversity and wood quality have diminished. Increasing demand for wood resulted in cutting cycles being reduced from about 8 years to 5-6 years, which also means that slow-growing species that produce higher quality wood have disappeared from the forest.

Radical development policies and collective forest management breakdown

Forest degradation in Shanxin also has something to do with the radical development policies of the late 1950s and a unique political circumstance that caused the breakdown of collective forest management system in the late 1960s.

In 1958, the Chinese Government launched the radical ‘Great Leap Forward’ campaign to establish the people’s commune and attempt to realise country’s industrialisation with a vision that China’s steel output would surpass that of Great Britain in 15 years. Throughout China people were mobilised and forced to make iron and steel using backward backyard furnaces. These furnaces used a very large amount of fuelwood and charcoal but failed to produce usable iron and steel. Shanxin suffered from this event as a large number of people from the neighbouring town came to the village to cut trees and make iron and steel. At that time 190 charcoal making places were established in the village. Patches of higher quality evergreen broadleaf forests were cleared and many other dense forests became poor quality secondary forests with low stocking. As fuelwood and charcoal output peaked it was accompanied by the first serious deforestation in Shanxin since 1949.

In 1966, Chairman Mao initiated the ‘Great Cultural Revolution’. The campaign paralysed almost the whole governance system from central to village level and resulted in the breakdown of management system of collective forests in many rural areas. The leadership of Shanxin village also lost control over forest management at that time and illegal cutting increased significantly. In the period 1966-1968, fuelwood and charcoal output in Shanxin and adjacent areas experienced another peak, which implies serious deforestation, though not as severe as occurred in the late 1950s in terms of forest stock logged.

Insecurity of forest tenure

Further significant deforestation and degradation of forests took place in Shanxin and other villages following the distribution of collective-owned forests to individual households in 1982. This is shown by the significant decline in forest biomass over the last two decades as previously noted.

Frequent changes in policy for forest tenure over the three decades to the early 1980s were the underlying cause of this deforestation due to insecurity of forest tenure (Liu 2001). As in other parts of China, Shanxin village experienced radical and frequent changes in forest ownership. Forest was private property of rural households in the first half of the 1950s, collectivised in 1956-1957 and became commune's property in 1958, and owned and managed exclusively collectively until the early 1980s. The ownership of scattered trees around homesteads also experienced similar change. They were collectivised in 1958, returned to individual households in the early 1960s, and taken away again by commune from farmers in mid-1960s.

The frequent changes led to a great lack of confidence among farmers in tenure security. With perceived insecure tenure it made little sense to them to manage forests sustainably. Instead, they immediately harvested trees distributed to them to realise their value, a reasonable response based on their past experience.

Disincentives to Managing Evergreen Broadleaf Forest for Commercial Timber and Other Wood Products

The case study in Shanxin showed that government policies for timber harvesting and taxation on timber discourage farmers from properly managing timber forests. Local farmers preferred to sell all their wood as fuelwood on the free market rather than directing their small-diameter wood to the wood processing factories even though demand is great and prices for small-diameter wood are higher than for fuelwood. This apparent aberration can be explained largely by farmers' response to the two government policies.

Timber harvesting is highly regulated in China. Usually, one must obtain a cutting permit to harvest timber no matter whether this is in collective-owned forests and plantations or in household plantations. Furthermore, cutting certificates are tied to logging quotas. When an administrative area has used up its quota in a given year, it is not allowed to issue more cutting certificates that year. Experience shows that farmers are usually in a disadvantageous position to get certificates for the quantity they wish to harvest and at the time they want to harvest it. Timing is important to ensure the best price is obtained. In Shanxin, however, regulations were not strictly followed for harvesting fuelwood.

Data indicate that local governments and the forest department collected and charged 14 kinds of tax and fees on timber in Cangwu County. Consequently, half of the turnover of wood trading went to the outside stakeholders. As costs of logging and timber transport are estimated at about 30-35% of market price for timber, it follows that the farmers received only the remaining 15-20% of sale price. Profits of farmers from timber production were nearly zero when their costs of planting, tending and guarding of trees are taken into account. Taking pine timber an example. The price was about 500 Yuan m^{-3} in 1997-1998, from which the farmers received only 60-80 Yuan (12-16% of market price). Although fuelwood prices were only 160 Yuan t^{-1}, much lower than for timber, farmers received more income from it than from timber, because they were subject to little taxation when selling fuelwood. This explains why farmers preferred to sell their wood as fuelwood.

Less restrictive regulations on timber harvesting and less taxation on timber sales would provide incentives to encourage farmers in

Shanxin and other villages to plant timber trees and manage timber forests more effectively by enabling a better return on the products.

Strategies for Rehabilitating Degraded Evergreen Broadleaf Forest

Degraded and seriously degraded forests must be targets of rehabilitation efforts, because if left untreated their yields will continue to decline and restoration of their productivity will be time consuming and expensive. In their degraded state they will not be able to provide the normal environmental functions of a forest. In contrast, slightly degraded forest has high potential to recover its productivity in a reasonable period of time.

The most important causes of forest degradation in Shanxin are over-harvesting and short intervals between harvests. This problem can only be addressed by reducing the farmers' dependence on the forest for income generation. The strategies identified to rehabilitate the seriously degraded and degraded evergreen broadleaf forest included direct and indirect interventions. Three broad strategies emerged:

- natural regeneration through closing mountain (*fengshan yulin* in Chinese),
- plantation establishment, and
- development of other sub-sectors of agriculture and non-farm activities.

The first strategy was designed to restore the degraded forest by restricting access and leaving it to regenerate naturally for a sufficient period. The second was designed to reclaim the seriously degraded lands and expand opportunities for income generation to reduce dependence on the existing forests through developing plantations, especially NWFP plantations, which could provide income in a relatively short time. The third strategy was to develop agroforestry systems, including raising animals with trees, and non-farm economic activities in household yards and on lands around homestead. The purpose of this third option was to expand opportunities for income generation for households.

Natural Regeneration through Mountain Closure

Natural regeneration of forest through closing the mountain or hillside has been a common silvicultural practice in China over the last four decades. It aims to promote regeneration of secondary forest through prohibiting or restricting specified activities such as grazing on a tract of degraded mountainous land. It is technically feasible since broadleaf trees readily sprout by coppice shoots and coniferous trees regenerate easily by seeds. The favourable subtropical climate with warm temperatures and adequate rainfall provide ecological conditions for successful natural regeneration of secondary forests. Many secondary forests have been successfully regenerated in this way and the practice is cost-effective and much cheaper than establishment of artificial plantations (Yang and Ou 1987, Xu and Zheng 1994). Experience in other parts of Cangwu County also shows that secondary forest recovery begins two years after closing the area and this enables small diameter wood to be harvested in 7 to 8 years.

The experiment at Shanxin began in early 1998 and the area closed was 670 ha. Informal village regulations on mountain closure specify that participating households collect forest products only from their own patch of forest, and no tree removal, fire or grazing in the closed area is permitted. However, several challenges of governance and management needed to be addressed and some constraints overcome if the mountain closure was to succeed in Shanxin. These challenges and constraints, and strategies to address them are summarised in Table 3.5 and discussed below.

Collective action and tenure security

Forest holdings became very fragmented as a result of the inappropriate implementation of the policy for the distribution of collective forest land and forests to individual farmer households in China in the 1980s. In almost all cases, forests on a mountain slope now belong to many households. Therefore, closing an area of the mountain requires some form of collective

Table 3.5 Challenges, constraints and strategies for 'closing mountain' for natural regeneration

Challenges and constraints	Strategies
Fragmentation of household holdings	Common management of household forest resources without any changes in forest tenure and benefit distribution.
Maintaining access to forest when closing mountains	- "Shifting closure of a mountain" at village level (only half of forest was closed at one time) - "partial closure" at household level (just part of forest of any a household was closed at a given time)
Encouragement of active farmer involvement	Harness their self-interest and build their awareness of the importance of mountain closure.
Set up an effective management system	Establish a governance group, a management group, a supervision group,and appoint full-time forest guard (s).
Overcome lack of operational funds	County Forestry Bureau, Township Government, and the research team jointly agreed to cover the costs.

action. At first, we recommended a shareholding system to farmers. Under the system, villagers would pool their forest resources for common management and share benefits from the forest in accordance with resources they contribute. This involves a change in the form of forest tenure and benefit distribution. Farmers in Shanxin rejected this proposal. Through consultation an option was identified that did not change forest tenure and did not involve redistribution of benefits. Each household with forest land in the closed area remains the holders of trees, has use rights to the land and will harvest products from their own land when the mountain is reopened. Nobody is allowed to collect forest products from the forest areas of other households within the closed area.

Farmers adopted and implemented the option. Two points are stressed. First is that tenure security is crucial to ensure success in closing mountain reforestation. Farmers are very sensitive to tenure as a consequence of the frequent changes in forest tenure over the past several decades. They are still not confident of security of their use rights to land, which is one of main reasons they are not keen to invest in tree planting and sustainable use of forest resources in China in general. This in part explains why farmers in Shanxin refused the initial idea of a shareholding system for closing mountain regeneration. The other point is that there must be an agreement on an acceptable mechanism for benefit distribution. Farmers refused the initial proposal because they were concerned that village leaders who hold power for benefit distribution under a shareholding system would appropriate proceeds derived from their forest area. Such a problem has occurred elsewhere in China.

Current access to the forest

If mountain closure is to be an effective strategy for forest regeneration, villagers' current access to forest resources needs to be addressed while the regeneration area is closed. Villagers in mountainous areas in China are forest-dependent, as in Shanxin. They collect fuelwood for self-use and wood and/or NWFPs to sell for a cash income. Options completely denying access to forests are impracticable and definitely not acceptable to farmers. In Shanxin, we worked with the farmers to develop a plan that required half of the degraded evergreen broadleaf forest to be open for use when the other half is closed. When the closed half re-opens after several years, the other half of mountain will be closed for rehabilitation. At household level, some households had all or the majority of their forests in the designated closed area. We addressed this issue by helping coordinate an exchange of forest land such that these households exchanged part of their forests with those with the majority of their forests outside the designated closed area. This way no household had all their forests closed in one time and so maintained current access to forest resources. Moreover, agreement was reached to waive children's education tuition fees for several very poor households whose income would decrease as a result of reducing their access to forests.

Farmer participation

The Shanxin experience shows that farmer participation is essential to the successful rehabilitation of degraded forests using the mountain closure approach. Regulations, statutory or informal, and measures for forest management will not work without their collaboration. Only when their self-interest is harnessed and their awareness raised of the importance to their future income of rehabilitating degraded forests by natural regeneration using mountain closure, will they be willing to be actively involved.

Governance system

An effective governance system is essential in ensuring success in the mountain closure strategy. The system we facilitated in Shanxin consisted of a governance group at township level, a management group at village level, and a supervision group. Responsibilities of each of the groups are clear and specific. The governance group is responsible for dealing with any illegal deforestation cases and for providing extension services. The management group takes its responsibilities through two key persons: a forest officer and a forest guard. Duties of the forest officer are liaison and communication between the supervision group, the forest guard, and other members of the management group. The forest guard is responsible for patrol, forest fire control and prevention of damage by domestic animals. The supervision group consists of representatives of farmers with forest in the closed area. It is responsible for monitoring performance of the forest officer and the forest guard and will report any problems to the management group. In the event that this group does not take timely action on the problem the supervision group can report problem to the governance group. Informal regulations on forest management were formulated to ensure forest protection and maintenance and all farmers involved are required to help with this task.

Operational costs

There are operational costs that must be met. Natural regeneration through mountain closure requires at least a full time guard to patrol forests and prevent illegal cutting and grazing damage. This involves payment of a salary and other costs. However, a majority of rural communities in mountainous areas are too poor to contribute funds to cover such costs. In the experiment in Shanxin, the Cangwu County Forestry Bureau, the Wangfu Township Government and the research team agreed to pay for essential operational costs for the first period of mountain closure. Farmer households will reimburse these bodies when they harvest products from the regenerated closed forest. This money then will go into a fund to cover the costs of next round of mountain closing. It is the aim that economic sustainability of the system can be achieved by using this rolling fund.

Progress

Since the mountain closure in Shanxin began in early 1998, initial experience in the experiment suggests that the arrangements are working satisfactorily. The forest guard fully assumed his responsibilities. The informal regulations farmers made have strictly been followed, with no illegal cutting or animal grazing in the closed area. The experiment in Shanxin has demonstrated the potential for developing arrangements suitable for poor villages with a development level similar to that of Shanxin to rehabilitate their degraded subtropical broadleaf evergreen forests.

Plantation Establishment and Management

There are about 160 ha of seriously degraded forest representing about 10% of the area of evergreen broadleaf forest in the village. Further forest degradation will occur if measures are not taken. However, villagers have few other sources of cash income apart from the forest. Over-dependence of local communities on forests for their welfare is a primary, underlying cause of over exploitation. Plantation development is one option to improve livelihoods as it will provide additional opportunities for income generation. It can also ameliorate ecological conditions where the land is degraded.

Development of plantations involves many socio-economic and technical issues. Technically, different species may be needed for different parts of a mountain slope. For example, adaptable timber species, such as *Pinus* spp., may be appropriate on shallower, less fertile soils on the upper slopes and ridges. More site-demanding NWFP plantations and agroforestry systems may be ecologically suitable and more profitable on the middle and lower slopes. From management and policy viewpoints, successful plantation development requires a mechanism to ensure implementation of collective action and needs to provide incentives to farmers to become involved. Farmers' incentives to plant NWFP are related, to large extent, to the availability of appropriate species that are ecologically suitable, with good market prospects (high demand and prices) and high economic returns that can be expected within a few years. Three initiatives were designed to address these issues in Shanxin:

- reclamation of a small area of sloping land,
- development and management by individual farmers of NWFP plantations, and
- exotic NWFP species experiment.

The first initiative gave attention to a mechanism for collective action involving many stakeholders, the second examined factors that encourage farmers to establish and manage NWFP plantations, and the third tried to identify new species for NWFP with market prospects and quick returns.

Reclamation of a hillside

An experiment to improve productivity and vegetation cover on a seriously degraded hillside was initiated. Thirty-eight households of Shanxin village owned a piece of sloping land of about 10 ha in extent. All had to agree to participate in the collective planning effort. Technical actions had also to be integrated. The agreed plan was to plant the native pine (*Pinus massoniana*) for timber and soil and water conservation on the upper part of the slope and NWFP trees (mainly *Illicium verum* and *Canarium album*) in an agroforestry system with food crops on the middle and lower slopes.

As with the mountain closure for native broadleaf forests, the researchers initially proposed a shareholding system. The land owners rejected the idea as they perceived it as re-collectivisation and were concerned that their interests might be appropriated by village leaders. An arrangement similar to that for the mountain closure was finally adopted. Under the arrangement, each of the household would plant trees based on the integrated plan and collect products from their own patch of land. An oral agreement was made among all the households involved that grazing would not be allowed on the area. The research team provided the households with tree seedlings and fertilisers without charge.

The planning took place in October 1996. Soon after agreement was reached the land was prepared in late 1996 and trees, cassava, beans, green beans and corn were planted in March 1997. The survival rate of *Illicium verum* was a satisfactory 90%, while that of *Canarium album* was only 50%, largely due to poor quality of the seedlings and late planting. However, 80% of the young trees were damaged by the browsing of domestic animals after the intercropped crops were harvested in July and August 1997. This was a serious breach of the agreement reached by villagers.

What went wrong? It had been decided that the village leader would have overall responsibility for 'management' of the area but no one, even on a part time basis, was assigned to tend, care and guard the tree seedlings. Moreover, no action was taken when the first grazing damage took place. Other villagers began to graze their cattle on the tree planting area when they found no discipline for the destruction. Some of households therefore did not observe the agreement on grazing and the village leader did not fulfill his responsibility in punishing those whose animals damaged seedlings. The village leader had no incentive to take action as he did not own land on the slope and there was no reward for his participation.

The failure of the experiment shows factors that work to affect common action/management as has been the experience elsewhere (Arnold 1998). An agreement is important but a mechanism to ensure its strict observation is equally, if not more, important. Disciplinary measures are needed when someone breaks the agreement to encourage all people involved to observe the rules. This is a platform for collective action of natural resource management involving many stakeholders. Incentives are essential for the person responsible for disciplinary measures. The person's interest must be harnessed either as a stakeholder or through other material returns commensurate with his responsibility.

The lesson drawn from this experience is that an effective management mechanism is essential in rehabilitating land owned by many households.

Development and management by individual farmers of NWFP plantations

While the slope rehabilitation involved collective action of natural resource management, another group of activities was initiated to assist individual farmers to develop and manage NWFP plantations. The purpose was to determine the critical factors involved in the development and management of NWFP plantations by households or individuals. Two case studies were conducted.

One study examined the tree management by individual farmers of a collective forest farm. The forest farm had an area of 14 ha of hilly land. It was established and is owned by the township government. Pine (*P. massoniana*) was planted on the upper slopes, Chinese fir (*Cunninghamia lanceolata*) on middle slopes, and NWFP trees such as *Cinnamomum cassia*, *Illicium verum*, *Canarium album* and plums (*Prunus saliana*) on lower areas. The farm planted the trees but contracted management such as tending, caring and guarding to three farmers. The farm covered salary of the three farmers and other operational costs. In the agreement the farm paid the farmers a basic amount of money monthly and the balance at the end of year based on their performance in managing the trees. The plantation has grown well as a result of adequate tending and caring. *Cinnamomum cassia* planted in 1993 and 1994 was ready for harvesting in 1998. Linking the farmer performance to financial rewards was an effective strategy.

The other case involved establishment of small NWFP plantations by individual households. Six households planted *Cinnamomum cassia*, a species chosen by the farmers. They stated that they planted this species because they believed it has potential for high economic returns after 4 to 5 years in the case of bark harvesting and in only 3 years for leaf products (Figure 3.2). Market demand and prices for *Cinnamomum* products are high. In 1997-1998 the mean value of bark was 6000-7000 Yuan ha^{-1} and leaves from three-year-old trees yielded 2500 Yuan ha^{-1}. Some small factories were established locally to process oils from *Cinnamomum* leaves and branches. Implications from this activity are that market demand and reasonable returns in a short period of time were the driving forces of plantation establishment by farmers. It is very important for farmers to have information on markets and to assess future trends in demand for their products. Reliance on a single product can be a problem if the market collapses.

Experiment with exotic NWFP species

The availability of species adapted to local ecological conditions is critical for successful development in NWFP plantations. Identifying such species that also have good potential for markets is an important 'technical' activity. Our research in Shanxin also gave attention to the identification of appropriate species by testing the adaptability of selected rattan and bamboo species.

Three rattan species (*Calamus simplicifolius*, *C. tetradactylus* and *Daemonorops margaritae*) were introduced to Shanxin village and a nearby village in spring 1997. One household in each of the villages was involved in the experiments. One household planted rattans in *Michelia macclurei* plantation, while the other planted them in a secondary evergreen broadleaf forest. Each planted an area of about 0.8 ha. Preliminary observation suggests that the three species grow well in the local conditions and may be a potential source of income generation for local farmers.

The experiment with bamboo was an attempt to identify a multipurpose bamboo species that could produce both shoots and timber. Cangwu County has a long history of bamboo planting but almost exclusively for timber. Market demand for bamboo timber is shrinking so there is a need for alternative sources of income. A multipurpose bamboo species has potential to provide a new opportunity for income generation. Tissue cultured plantlets of five bamboo species (*Bambusa pervariabilis* x *[Dendrocalamus latiflorus* x *B. textilis]*, No. 1; *Bambusa pervariabilis* x *[Dendrocalamus latiflorus* x *B. textilis]*, No. 7; *Dendrocalamus latiflorus*; *Dendrocalamus brandisii*; and *Bambusa oldhami*) were planted in March 1997 by two households. Performance varied greatly among the species, but the growth of two of them was rather rapid for this area and they produced a large number of shoots. While more testing of adaptability and management is necessary, these new introductions show considerable potential for expanded planting in the area.

Development of Other Agricultural Sub-Sectors and Non-Farm Activities

Results of our surveys in Shanxin indicated that over-dependence of local villagers on forest was because their sources of cash income other than from the forest are quite limited. Food grain was produced largely for on-farm consumption; and each household raised only 1-2 pigs and a few chickens and ducks. Growing bamboo for local traditional commodities such as building materials and baskets was practised but plastic and other materials are replacing these products in the market.

Development of other agricultural sub-sectors and non-farm activities is an option to diversify sources of income for farmer households and to reduce over-dependence on existing degraded forest. Other agricultural sub-sectors include cropping, animal husbandry (poultry, pigs etc.) and processing of agricultural and forest products. This group of strategies attempts to address forest degradation by taking full advantage of house yards and land around homesteads for non-forestry agricultural activities and non-farm industrial activities. Small processing industries suit farmer households because of low capital investment and simpler techniques. Farmer households have the flexibility to develop activities according to their own circumstances. We worked with three households to determine whether it is feasible to find other sources of income and to identify constraints to their development and strategies to overcome them.

The first household developed an agroforestry system comprising fruit trees and pig raising on 4 ha of land. Part of the land was an abandoned school property and the rest an abandoned collective orchard. The household leased the land for 5 years for 7000 Yuan year^{-1} with a possibility for contract renewal. The family then planted persimmon (*Diospyros kaki*) and plum *(Prunus saliana)* and raised 80 pigs on the land. Pig dung was used to generate methane gas for lighting and cooking, and as fertiliser. This was a typical household business as the household was responsible land leasing, tree planting and tending, and raising the pigs.

The second household developed an agroforestry system that included more elements. It included fruit trees, food crops, and poultry on a plot of 0.3 ha. With our technical assistance, the family raised chickens and ducks in their yard, planted fruit trees such as citrus and persimmon on land around homestead, and intercropped the fruit trees with food crops such as peanuts, cassava and beans. Preliminary observation shows that the family was able to raise and sell some chickens and achieve a reasonably good output of food crops.

A third household was involved in non-farm activities plus growing fruit trees. The family had already established a small factory making chess pieces from local wood and was achieving a good economic return. Lack of technical knowledge prevented the family from effectively using the land around the homestead and it was left almost uncultivated. We encouraged the household to take advantage of their land and tap another source of income by planting fruit trees on it. With our technical assistance, the family planted persimmons and intercropped them with cassava, beans and peanuts.

In all three cases, we provided information on market demand for goods, helped design various agroforestry systems and non-farm activities, and provided advice on agroforestry and in some cases free seedlings. It is clearly possible to expand sources of income for local farmers by these means but there are several constraints to be overcome. There is a need for access to information on market demand for products on which basis agroforestry systems can be developed. In addition, there is a need for improved extension services, especially for advice on development and management of agroforestry systems and non-farm enterprises. There is also a need for improved rural finance services since a lack of capital investment is also a constraint to development of non-forestry agricultural activities and non-farm economic undertakings.

Conclusions

Causes of Forest Degradation

Several factors were responsible for the degradation of evergreen broadleaf forest in Shanxin village. The participatory approach adopted in the research greatly facilitated the identification of these factors. The radical development policy (Great Leap Forward campaign) in the late 1950s and the abnormal political environment (the Cultural Revolution) in the 1960s to 1970s contributed to significant deforestation in the Shanxin area. Lack of confidence among farmers in tenure security, resulting from frequent changes in forest ownership over the three decades to the early 1980s, caused another major deforestation early in the 1980s. Excessive logging and selective cutting, driven by poor financial returns for forest products and over-dependence of the population on the forest, have been a continuing cause of forest degradation. This dependence has been exacerbated by a lack of opportunities for other income generation activities due to poor access to market information and technical advances, and unavailability of rural credit.

Strategies and Policy Recommendations on Forest Rehabilitation

The evergreen broadleaf forests are very resilient and can recover provided they are given sufficient time. Reduction of the level of dependence on the forests by identifying other sources of income is the key to reducing the level of exploitation and giving them time to recover. Several strategies to generate income from animal husbandry, agroforestry, and non-farm activities were identified. Natural regeneration, through mountain closure, was used to improve degraded forests, while agroforestry was used to revegetate seriously degraded forest land.

The action research in Shanxin demonstrated that these strategies can be effective. They mainly used existing technologies, although there is potential for introducing new crops to produce new products. Resolving socioeconomic and management problems through active participation of the stakeholders was a major factor in achieving positive outcomes. The research provided some instructive lessons and implications.

Motivating farmers

Farmer participation is key to the success in natural regeneration through mountain closure and the establishment and management of plantations whether through common action or by individual households. To encourage this participation, it is most important to harness farmers' interest, especially through financial incentives.

In Shanxin, farmers could also appreciate the somewhat longer-term benefit of improving the yield from the degraded evergreen broadleaf forests. The prospect of financial benefits within a reasonable time from the production and sales of NWFP was also attractive to Shanxin farmers and the community. Such activities can be beneficial even to those who only provide labour, as was shown by the three farmers who managed the plantation of NWFP on the township-owned forest. It is also clear that researchers attempting to identify new species for farmers to grow should seek those that are both ecologically suitable and have the potential for good returns in a short period of time.

Organization of common management of household resources

Both mountain closure and hillside reclamation involve common management of households' forest resources. The form of management (a shareholding system or common management without changes in individual forest tenure and benefit distribution), should be decided by relevant stakeholders. Tenure issues are very sensitive and management skills limited in isolated and poor areas, as was the case in Shanxin. In this situation a shareholding system was neither appropriate nor acceptable to farmers.

When common action for resource management, such as hillside reclamation and mountain closure, is needed, it is essential to ensure that all people concerned observe agreed rules. Disciplinary measures should be specified and implemented to establish a platform of common action.

Current access to forest resources

Villagers in mountainous areas depend heavily on the forest for income and other livelihood needs. It is not appropriate to completely deny them access to forest resources during the rehabilitation process. The compromises agreed in Shanxin i.e. 'shifting closure of a mountain' at village level (only half of the forest was closed at one time) and 'partial closure' at household level (only part of the forest of a household was closed at a given time) show that the access problems are not insurmountable.

Improved rural services

There are opportunities to develop other sub-sectors of agriculture, agroforestry, and non-farm activities for income generation to reduce pressure on existing forests. To do this effectively, it is necessary to overcome a range of constraints faced by farmers. Important first steps suggested by the research in Shanxin are better access to market information and technical advances through improved agricultural extension, and availability of rural credit/finance from both public and private sources.

Government policies

The current restrictive regulations on timber harvesting and high taxation on timber sales are disincentives to farmers in Shanxin and other villages to plant timber trees and manage timber forests more effectively. A review and amendment of such government policies could enable farmers to achieve a higher return on their forest products and would encourage them to make greater efforts to manage their forests and reduce forest and land degradation.

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Chapter Four

Rehabilitation of Degraded Chinese Fir Plantations and Evergreen Broadleaf Forest in Huitong County, Hunan

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Introduction

Huitong County, Hunan, is in the subtropical climatic zone and its primary vegetation is evergreen broadleaf forest. Extensive Chinese fir (*Cunninghamia lanceolata*) plantations have been developed since the first cultivation of this species in the county in 1368, and especially during the last 50 years they have replaced evergreen broadleaf forest. As a result, now Chinese fir plantations cover 22% of the land area and evergreen broadleaf forests 18% (Huitong County Forestry Bureau 1993a). Moreover, forests in Huitong, and in Hunan province and beyond are degraded with less standing timber volume, reduced species diversity and declining soil fertility. Forest degradation and a reduction in forest cover have resulted in a significant decline in ecological services by forests and have impacted negatively on the livelihoods of forest-dependent people. They are now able to collect less timber and non-wood forest products (NWFPs) and their income from forests is reduced.

There has been research on causes and prevention of degradation of nature forest and Chinese fir plantations since the 1960s (Institute of Forestry and Pedology 1980, Research Team of Intensive Cultivation of Chinese Fir 1992, Chen 1992 and Xu 1992). Zhu (1991) examined human impacts on changes in biodiversity and soil fertility in secondary broadleaf forests. These studies centre on biological or technical causes of forest degradation and identification of technology-oriented solutions.

Our research, carried in Dongxi village and Xiangjian village in Huitong, targeted two major forest types: evergreen broadleaf forest and Chinese fir plantation. In collaboration with local officials and farmers the researchers examined the state and causes of degradation and identified activities for forest rehabilitation respectively for each forest type. We then tested some of the activities to assess their effectiveness. We also gave considerable attention to disincentives among farmers to sustainable management of their forests in an attempt to address forest rehabilitation at a policy level.

As in other chapters, research methods and biophysical and socio-economic settings of the two villages are described. The state of

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degradation, factors responsible for degradation, and strategies for rehabilitation of evergreen broadleaf forest and Chinese fir plantation are discussed. Finally, the disincentives to rehabilitation and sustainable management of degraded forests are highlighted.

Research Methods

The research in Huitong used methods similar to those in the other sites of this research project but different from those in traditional forestry research in China. They included a logical procedure of action research; use of a participatory approach involving villagers, government officials and researchers and a multidisciplinary team of socio-economic and biophysical scientists, complemented by some conventional research methods; and attention to indigenous knowledge.

Farmer Participation in at All Stages of Project Process

In this research, the logical procedure started from diagnosis through design to delivery. Farmer involvement, at all stages, was emphasised. More than 500 villagers contributed to the diagnosis of problems and the subsequent design and testing of strategies and options.

Diagnosis

This phase aimed at obtaining reliable baseline information on the two villages and beyond, and achieving a good understanding of the extent and causes of forest degradation and constraints to rehabilitation. Participatory rural appraisal tools used included:

- secondary data collection
- participatory observation
- household interview (semi-structured interview, complemented by questionnaire survey)
- key informant survey (semi-structured interview), and
- group interview/meetings.

Secondary data were collected largely from Huitong County Forest Bureau, Huitong County Archives and the township government responsible for the villages where the research took place. Data were collected on climate, soil, land uses, forest resources, tenure and management system of forest, taxation of forest products, population, education, labour force, income, village social organisations and infrastructure.

Participatory field observation was carried out immediately after secondary data collection. We worked with several senior villagers and village leaders familiar with local circumstances on field visits to observe and discuss land use, types of crops and their patterns of cultivation, types of forest, extent of forest degradation and village infrastructure.

Household surveys were mainly in the form of semi-structured interviews plus a questionnaire survey. Sixty households were interviewed. Criteria for sample strata included level of family wealth, family composition of sex and age, and distance between household and market and between household and village office. Household surveys aimed to identify problems, constraints and opportunities at household level, and topics discussed included family population and number of members at labour age, land uses, forest area and volume, forest degradation, constraints to rehabilitation, major livelihood means, sources of family income, and family expenditure by activity.

Key informant interviews used semi-structured interviews and aimed at analysing problems at village level. Topics covered population, education, labour force and gender division of labour, land uses, crop calendar, village social organizations and governance institutions, forest resources, forest tenure, village regulations on forest management, timber prices, household collaboration regarding forest production (shareholding system, for instance), and extension and credit services.

Group interviews/meetings also used semi-structured interviews. The first interviews were with villagers at the two villages to validate the secondary data and baseline information collected through the key informants. The second interviews were with groups of villagers of different ages, women, and village leaders to identify causes of forest degradation. Finally, a meeting was held with villagers, township government officials, and forest officials from Huitong County Forestry Bureau and Huaihua Prefecture Forestry Bureau to further analyse causes of forest degradation.

Design and testing

Villagers were involved in the identification and testing of options for forest rehabilitation. Many discussions were held in 1996 and 1997 to develop strategies and the villagers made decisions on whether or not to adopt them. For example, when identifying species for home garden development, researchers provided advice and options for promising fruit varieties but farmers selected those they considered to have good market potential and were easy to store.

Participation of Government Officials

Participation of local government officials from prefecture, county, and township was essential because they had knowledge of problems and constraints from an institutional and policy point of view, had access to financial and extension resources, and were able to coordinate project implementation activities. Over 50 government officials were consulted and some of them participated directly in the research. Several meetings were organised with them at the diagnosis stage to discuss the circumstances of the two villages. At the design stage, there were more meetings to identify options and strategies for forest rehabilitation.

Involvement of Researchers and Multidisciplinary Approach

The research team comprised of seven specialists in forest resource management, forest ecology, forest economics and silviculture. At the beginning of the study, four team members attended training courses on the application of social science research methods in natural resource management.

Indigenous Knowledge

Local people have rich local knowledge that can be as useful and effective as modern technology. For example, villagers developed a sustainable system of establishment and management of Chinese fir plantations over the last 600 years (Wu 1984, Yu 1994). This, and other indigenous knowledge, was used in our research to develop strategies for rehabilitating degraded Chinese fir plantations.

Conventional Forest Survey Methods

Conventional forest survey techniques were used for part of this research. Four investigations were undertaken. Thirty sample plots were used to gather information on types and species composition of evergreen broadleaf forest, the extent and causes of forest degradation, and tree growth and soil fertility under different cultivation practices in Chinese fir. Other investigations measured the growth of crops and trees and changes in soil physical features and fertility in agroforestry systems.

Farmer Training

Lack of necessary skills among farmers is one of the constraints to rehabilitation. Hence, improvement in farmer skills is of critical importance in forest rehabilitation in short term and sustainable resources management in the longer term. Five training courses were organised, involving more than 250 villagers.

Background Information on Dongxi and Xiangjian Villages, Huitong County

Location and Biophysical Conditions

Huitong County (26°40’00”-27°09’13” in N latitude, 109°26’48”-110°07’56”in E longitude) is in the west of Hunan province (Map 1.1 in Chapter 1). Research was undertaken mainly in two villages of the county, Xiangjian and Dongxi, both of which administratively belong to Ma’an Township. They are near to each other and about 25 km from the county town that is the political and cultural centre of the county. Both villages have good access to transport as a highway and a railway cross them.

Huitong has a subtropical monsoon climate. The frost season is short, both rainfall and relative humidity are high, and there are four distinct seasons in a year. Climatic data (1957-1992) show a frost season of about 60 days, mean annual temperature is 16.6°C, mean annual rainfall is 1265 mm, 54% of which comes between April and July, with the greatest in May (212 mm) and the lowest in December (37 mm). Average annual evaporation is 1148 mm and relative humidity 82%.

The villages of Xiangjian and Dongxi are situated in a landscape of hills and low mountains. The altitudinal range of the area is 50-650 m above sea level. Forests cover the mountains while in the valleys there are paddy fields, rain-fed crop lands and streams. The streams are the primary source of water for irrigation. There are two broad categories of soil: 'red soil' makes up 40% and occurs in areas below 400 m, 'yellow soil' makes up 60% and occurs in areas above 400 m. Most soil is acidic and deep, with organic matter content higher than 1%. The subtropical climate and relatively fertile soil are suitable for the growth of forest, food crop production and animal husbandry.

Land Uses and Forest Resources

Most land is classified as forest and forest land. Xiangjian village with an area of 1234 ha, has 73% forest land and 4% crop land with the remainder for other uses. Dongxi village has 1021 ha of land of which 75% is forest land, 5% crop land (Table 4.1).

Crop land

Crop land is used intensively with villagers usually growing one summer crop and one winter crop annually. Rice is the main summer crop and this is the staple food in the villages of the area. Villagers also grow other food crops such as corn, sorghum and sweet potato, and cash crops such as cotton, fibre plants, watermelon, chilli and ginger. Winter crops include rape seed, wheat and beans.

Chinese fir plantations

Forests in the two villages consist of Chinese fir plantations, evergreen broadleaf forests, and cash tree crops. Chinese fir plantations are very common in the provinces of Hunan, Fujian, Guizhou, Guangxi, Jiangxi and Zhejiang and a very important source of industrial timber. They represent the largest forest type in Xiangjian and Dongxi, making up about 35-45% of area (Table 4.1) and 72% and 81% of total standing timber volume of the two villages respectively.

Evergreen broadleaf forest

Evergreen broadleaf forest of the two villages, Xiangjian and Dongxi, is secondary forest formed by natural regeneration. It is smallest in extent, comprises just about 10% of area (Table 4.1) and 28% and 19% of standing timber volume respectively in Xiangjian and Dongxi. However, these secondary natural forests are significant in local livelihoods and welfare. They

Table 4.1 Land use in Xiangjian and Dongxi

Land use	Xiangjian		Dongxi	
	Ha	%	Ha	%
Total land area	1234	100	1021	100
Forest land	910	73	775	75
Chinese fir plantations	451	36	451	44
Evergreen broadleaf forests	168	13	105	10
NWFPs	290	23	219	21
Food crop land	60	4	49	4
Other (roads, water, buildings)	264	21	197	19

Source: Project survey 1995.

provide villagers with fuelwood and NWFPs, and timber for marketing and making farm tools. Our household surveys showed each household uses about 0.5-0.7 m^3 $year^{-1}$ of fuelwood. In 1995, the volume of fuelwood used was larger than the volume of commercial timber used in the two villages, which is common in south and southwest China. Moreover, evergreen broadleaf forest provides more environmental services than Chinese fir and NWFP plantations.

Broadleaf trees are the dominant species in these secondary forests, but conifers also occur. The most common broadleaf species include:

> *Castanea henryi, C. mollissima, Castanopsis fargesii, C. sclerophylla, C. tibetana*, *Cyclobalanopsis glauca, Quercus fabri, Cinnamomum camphora, C. porrectum, Litsea cubeba, L. coreana, Machilus lichuanensis, M. pauhoi, Neolitsea cambodiana, Liquidambar formosana, Dendrobenthamia japonica, Adinandra bockiana, Elaeocarpus japonicus, Sloandea sinensis, Ilex chinensis, Diospyros kaki, Engelharatia roxburghiana, Styrax suberifolius, Huodendron tibeticum, Sorbus folgneri, Photinia biauverdiana, Eriobotria cavalerieri, Daphyniphyllum oldhamii, Ulmus parvifolia, Tarenna mollissima, Clethra varbinervis, Meliosma flexuosa, Mallotus japonicus, Albizia macrophylla, Kalopanax septemlobus, Celtis sinensis* and *Ormosia henryi*.

NWFP plantations

These plantations are the second largest, making up about 20% of area in the two villages respectively (Table 4.1). They are a major source of cash income of local villagers. The main species are bamboo (*Phyllostachys pubescens*), tea oil (*Camellia oleifera*), *Vernicia fordii*, chestnut, orange, and plum. Bamboo has become an important species in Huitong because of new factories using it as raw material.

A large proportion of NWFP (cash tree) plantations are in villagers' yards and/or homesteads. Most plantations are part of an agroforestry system because villagers usually raise cows, buffaloes, pigs, chickens and ducks in them. In recent years villagers have raised goats in their plantations as well. In Dongxi village households have an average holding of 30 goats and derive more income from animal husbandry than villagers in Xiangjian (Table 4.2).

Forest Tenure

There have been frequent, radical changes in forest tenure over the last 50 years. Before 1952, over 90% of forests in Xiangjian and Dongxi villages were the private property of landlords and rich peasants. Private forests were confiscated and then equally redistributed to all rural households (including former landlords and rich peasants) in the early 1950s. These private forests were collectivised in 1956 when advanced agricultural cooperatives were formed. They were transferred in 1958 from advanced cooperatives to communes, larger collective institutions. In 1961, the ownership of timber forest was devolved from commune to production brigade (former advanced cooperatives); and ownership of cash tree plantations from commune to production team, a level lower than production brigade. These property regimes remained till the early 1980s.

In the two villages, the Chinese government's forest reform in 1982 allocated 40% of collective forestland/forest to farmer households as family plots. Most of the remaining 60% was distributed to households as responsibility hills in 1984. In total, 92% of forest land of Xiangjian village and 66% of forest land of Dongxi village was distributed to individual households. This tenure pattern has so far been maintained and household management is the dominant form of forest management.

Forest as a Major Income Source

Xiangjian and Dongxi villages are typical agricultural communities. Agriculture, broadly defined, is the primary pursuit from which most of total output value or farmer income is generated.

Table 4.2 Average income of villagers in Xiangjian and Dongxi villages

	Xiangjian				Dongxi			
	1993		1995		1993		1995	
Source	'000 Yuan	%	'000 Yuan	%	'000 Yuan	%	'000 Yuan	%
Total income	1544	100	1650	100	1105	100	1208	100
Cropping	463	30	545	33	386	35	463	38
Forestry	559	36	428	26	343	31	205	17
Animal husbandry	337	22	337	20	312	28	408	34
Other	185	12	340	21	64	6	132	11

Sources: Data for 1993 from village statistics and for 1995 from the project's farmer household surveys based on a sample of 21 households in Xiangjian and 29 households in Dongxi. Comparisons of 1993 and 1995 data are not accurate because of different data collection methods.

In 1993 agriculture generated nearly 90% of farmer income in Xiangjian, and even more in Dongxi village (Table 4.2). Forestry, as a sub-sector of agriculture, contributed around 30% of farmers' income in 1993. The contribution of forest to the economy in the two villages is higher than in Yuanmou, Yunnan (Chapter 2) and Shanxin village, Cangwu, Guangxi (Table 3.2, Chapter 3).

Social and Economic Setting

Demography of the two villages is similar. There was a population of 1170 in 335 households in Xiangjian village (1995). Ethnic minorities make up more than slightly half of the population: *Dong* nationality accounts for about 37% and *Miao* 18%. There were 880 people of labour age, with equal numbers of male and female. About 40% of people have primary education, 40% attended junior middle school and about 4% went to senior middle school. The remainder is illiterate.

Dongxi village had a population of 782 in 228 households (1995). *Dong* people make up 42% and *Miao* 15%. There were 368 people of labour age with 230 male farmers (62%) and 138 female farmers (38%). About 43% of villagers have primary schooling, 43% attended junior middle school and 4% have a senior middle school. About 10% is illiterate.

Most villagers of labour age in the two villages undertake food cropping, forestry and animal husbandry. Less than 10% found off-farm employment (65 people in Xiangjian village and 15 people in Dongxi village). Data on labour distribution by season showed that villagers harvest timber mainly in the period when they are not involved in food production, but tree planting and camellia tending must take place in the same season as food production.

The two villages were at average level of rural economy development for China as a whole in the mid-1990s. In 1993, average annual income per person was 1302 Yuan in Xiangjian village and 1329 Yuan in Dongxi village. In nominal terms, in 1995 it rose to 1526 Yuan in Xiangjian and 1545 Yuan in Dongxi, compared the national average of 1600 Yuan in that year. There were some households of Dongxi village unable to produce sufficient food grain for themselves. However, the wealth level was higher than that of Shanxin village, Guangxi (Chapter 3). Agriculture generated 80-90% of income (Table 4.2). While non- and off-farm employment is encouraged, the forestry sub-sector should be able to make greater contribution to local employment and livelihoods.

Chinese Fir Plantations

Degree of Degradation

The Ministry of Forestry (MoF, now State Forestry Administration) set technical indicators for fast-growing Chinese fir plantation by cultivation region: mean annual increment (MAI) is 12-15 m^3 ha^{-1} in the central area of cultivation and 12 m^3 ha^{-1} in other areas (Department for Reforestation, MoF 1982). Our investigations in Xiangjian and Dongxi villages showed MAI of Chinese fir is 16.0 m^3 ha^{-1} for the best plantations and 10.5 m^3 ha^{-1} for average plantations.

Chinese fir plantations in the two villages were classified as slightly degraded (MAI >10.5 m^3 ha^{-1}) (Figure 4.1), degraded (MAI = 6-10.5 m^3 ha^{-1}), and seriously degraded (MAI <6 m^3 ha^{-1}) (Figure 4.2). Based on these indicators, in Xiangjian village 32% of Chinese fir plantations is degraded and 32% is seriously degraded and Dongxi village has 12% degraded and 36% seriously degraded (Table 4.3).

Figure 4.1 Normal Chinese fir plantation

Figure 4.2 Degraded Chinese fir plantation

Causes of Degradation

Degradation of Chinese fir plantations is due to several factors. The traditional cultivation practice of Chinese fir is a sustainable system with components such as establishing modest-sized plantings on suitable sites, allowing land to lie fallow after two or three successive crops, and intercropping with food crops or cash tree crops. However, these traditional technologies were abandoned for various reasons after about 1960. From this time, extensive Chinese fir plantations were often developed on inappropriate sites, and fallows and mixtures were not used. In addition to changes in silvicultural practices, selective harvesting and forest tenure insecurity have contributed to degradation of Chinese fir plantations.

Site selection

Chinese fir is adapted to relatively fertile, well-drained, moist soils on the lower slopes of hills. Forestry authorities have been so ambitious to establish extensive Chinese fir plantations that they ignored the basic silvicultural principle of species-site matching. The consequence of planting Chinese fir on shallow, infertile soils on upper slopes has been the slow tree growth and low productivity of plantations. Our surveys in the two villages show Chinese fir plantations on poor sites with an MAI as low as 1.5 m^3 ha^{-1} which is less than 20%

Table 4.3 Degradation of Chinese fir plantations

Degree of degradation	Xiangjian		Dongxi	
	ha	%	ha	%
Slightly degraded	161	36	236	52
Degraded	145	32	53	12
Seriously degraded	145	32	162	36
Total	451	100	451	100

Source: Project's forest survey 1995.

of the MAI of an average plantation. Inappropriate guidelines of the government forest department for Chinese fir plantation development are a cause of this problem.

Multiple cropping (duodai lianzai in Chinese)

Chinese fir develops after evergreen broadleaf forest is harvested or destroyed (Institute of Forestry and Pedology 1980). In its long history of planting Chinese fir, Huitong County developed a traditional cultivation technology incorporating fallow. The first crop of Chinese fir, planted after evergreen broadleaf forest was harvested, was followed by a second Chinese fir crop. After two crops, land was usually left fallow for 10-20 years to recover soil fertility. The fallow practice has been discontinued in recent decades. This changed silvicultural practice has resulted in lower soil fertility and forest land degradation (Fang 1987, Yu *et al.* 1992), and plantation productivity of later rotations is low. Our surveys in the villages indicated that average MAI of Chinese fir plantations has decreased from 10.5 m^3 ha^{-1} in the first crop to 9.2 m^3 ha^{-1} in the second crop and 6.0 m^3 ha^{-1} in the third crop. These figures suggest that the decline in tree productivity becomes significant in the third crop.

Monoculture plantations

Degradation of Chinese fir plantation may also be related to the development of monocultures instead of the former practice of intercropping with either food crops or tree crops. There is experimental evidence in the Huitong area that soil physical and chemical properties are better and productivity higher in mixed stands of Chinese fir and evergreen broadleaf species *Michelia macclurei* than in pure Chinese fir plantations (Chen and Zhang 1991). This suggests that intercropping with food crops and/ or tree crops and mixed stands are options for improving productivity and sustainability in Chinese fir plantations.

Selective harvesting

Poor harvesting practice is another factor in the degradation of Chinese fir plantations. Since the early 1980s, farmers in Huitong County (and elsewhere) have selectively harvested timber from large, vigorous trees and leaving the small and weak trees. This practice resulted in sparsely-stocked stands of low productivity. The MAI of such stands is about 4.5 m^3 ha^{-1}, less than half that of normal stands. Adoption of this practice is largely attributed to the very strong market demand and higher price for large-diameter timber.

Tenure insecurity

Forest tenure insecurity is a critical factor that has contributed to forest degradation in Huitong, as well as in other areas of China. The frequent, radical changes in forest tenure, already discussed, have had at least two negative impacts. Significant deforestation took place in Xiangjian and Dongxi villages immediately after forests were distributed to farmer households in the early 1980s. Farmers, concerned that government would repossess forests and trees, responded by immediate harvesting. According to a villager in Xiangjian village, over 70 ha of Chinese fir plantations established by one hamlet of the village in the early 1970s were cut in the early 1980s. Tenure insecurity has also discouraged farmers from investing in tree planting. Frequent changes of tenure are not consistent with the long period of time required for timber production. A cycle of traditional cultivation of Chinese fir consists of two successive crops plus a fallow period, which takes about 50 years. The negative impacts of forest tenure insecurity apply to Chinese fir plantations and to other types of forest.

Strategies for Rehabilitation

The above discussion suggests that strategies for improving degraded forest land and the productivity of degraded Chinese fir plantations must address silvicultural techniques, harvesting methods and tenure security. Options identified for improving silvicultural techniques included some agroforestry systems, development of mixed species forest stands, and replacement of Chinese fir with multipurpose species through planting and/or natural regeneration.

Agroforestry

Agroforestry is part of traditional cultivation system of Chinese fir in Huitong and other areas in south China, and still can be employed to help create productive Chinese fir plantations today. Many types of agroforestry have been practised, including a taungya system in which Chinese fir was intercropped with food crops for the first three years after the trees were planted (Menzies 1988, Fu *et al.* 1995) or with cash tree crops such as *Vernicia fordii* (a species with oil-bearing seeds). These systems were abandoned during the period of collective agriculture from the 1950s to the early 1980s. Since then intercropping with a range of crops in Chinese fir plantations has resumed in different provinces (Wu 1984, Yang *et al*. 2001).

Our research identified five agroforestry technologies to promote the establishment of productive Chinese fir plantations in Huitong. The first four were designed to use in young Chinese fir plantations and the fifth for older plantations.

- Chinese fir and *Amaranthus* sp. (grain amaranth)
- Chinese fir and *Citrullus vulgarisschard*
- Chinese fir and *Paspalum notatum*
- Chinese fir and *Vernicia fordii*
- Chinese fir and *Gastrodia elata*

The first three options were tested in Chinese fir plantations of Lianshan Forest Farm of Huitong County Forestry Bureau. These species were new to Huitong and it was necessary to test their suitability. The research team provided the forest farm with seeds, fertilisers and a training course, while the Forest Farm contributed the land and labour for the experiment.

The tests showed that these intercropping options are beneficial to the establishment of productive Chinese fir plantations through increased growth of the young trees. After one year, the average height of Chinese fir seedlings without intercropping was 1.3-1.4 m, in comparison, seedlings intercropped with *P. notatum* it was 1.6-1.7 m, with *C. vulgarisschard* it was 1.6 m, and with *Amaranthus* sp. it was 1.4-1.5m. The increase can largely be attributed to an improvement in soil properties through cultivation and added organic matter from leaves and stems. Grain amaranth takes up potassium effectively and so promotes cycling and use of this element. Soil organic matter in the Chinese fir plantation intercropped with *C. vulgarisschard* was 17% higher than Chinese fir plantation without the intercrop.

Growth of these species was variable. Grain amaranth, an annual plant with high protein content and a quality fodder for domestic animals, grew poorly. *Citrullus vulgarisschard*, a species that can produce about 280 kg ha^{-1} of edible seeds in normal conditions, grew well. *Paspalum notatum* grew best, with a biomass of 5.5 kg m^{-2} of fresh grass. The *C. vulgarisschard* and *P. notatum* grew well enough to show potential for intercropping with Chinese fir and to increase economic benefits.

Intercropping Chinese fir with *V. fordii* was a traditional and well-developed agroforestry system (Wu 1984, Yu 1994), and remains a promising option. The mixture has two important ecological benefits for Chinese fir. First, *V. fordii* is a tree that provides a canopy cover able to improve moisture relations in the plantation by reducing radiation and wind speed. Second, it can improve physical and chemical properties of the soil. Data from the research indicate that growing stock volume of the Chinese fir-*V. fordii* mixture is 25-30% greater than that of Chinese fir monoculture.

Cultivation of *Gastrodia elata* is a complex technology, and it involves the establishment of *Armillariella tabescens* as the former lives on the latter. *Armillariella tabescens* lives on a tree. Cultivation of *Gastrodia elata* builds on this relationship as Chinese fir plantation (and other forests) provides a suitable site for *G. elata*. This research did not test the option because it was not new in Huitong at that time. As an important Chinese medicine, *Gastrodia elata* cultivation can be profitable. Data show that profits of the species stood at 20 000-90 000 Yuan ha^{-1} in the area in the first half of the 1990s. As with many such products, there can be a marketing problem if promotion of the product results in over production.

Mixed stands

After intensive discussions between farmers and the research team and among farmers themselves, they decided to plant bamboo in degraded Chinese fir plantations. This strategy was implemented in Xiangjian village, involving a total of 20 households. Funds needed to plant bamboo were provided by the County Forestry Bureau in the form of seedlings and the loan must be repaid (including interest) when the bamboo is harvested.

It is too early to assess effects of the mixed plantation on soil fertility or plantation productivity improvement. The choice of bamboo for the mixture was based less on its ecological suitability than the fact that it can generate economic benefits quickly.

Replace Chinese fir with other tree species

This strategy aimed at rational use of land on which there are seriously degraded Chinese fir plantations. These plantations are often the result of planting Chinese fir on inappropriate sites or poor harvesting practice. There are many species that can be grown on sites unsuitable for Chinese fir. With the present pattern of land tenure in rural China, developing even a small plantation involves many households due to small size of landholdings. Hence, this strategy not only involves choosing another species but addressing the issue of common management of household resources.

The establishment of a *Ginkgo biloba* plantation was designed and tested. The plantation was developed on land in Xiangjian village with a seriously degraded Chinese fir plantation. The plantation area was 17 ha and was managed by 40 households.

A major factor that influenced selection of this species was the availability of funds for plantation development. In 1996 villagers wanted to replace the Chinese fir with chestnuts on higher part of the mountain and oranges on the lower slope. However, they could not raise funds for these species from external sources and were only able to cover part of the costs of establishment from their resources. Although it was suggested that they implement the option step by step with their funds, villagers wanted to reclaim all the land immediately. Huaihua Prefecture Forestry Bureau was able to provide loans for *G. biloba* planting only and the villagers agreed to this.

As in the case of mixed plantation development, potential market demand for products was most important factor that influenced species selection. Villagers agreed on *G. biloba* because it is a multipurpose species with leaves, fruit and timber providing potential for income generation. In recent years, the value of *G. biloba* as a medicine has been widely recognised and many ginkgo-based food and medicinal products are being developed (Xing *et al*. 1998, Commonwealth Agricultural Bureau International 2000). Domestic and international demand for ginkgo products is great, and prices are high at present. For example, the price for ginkgo seeds is 40 Yuan kg^{-1} or higher, leaves sell for 2.4 Yuan kg^{-1} and the price for timber is about 6000 Yuan m^{-3}. Moreover, income from leaves can be obtained after only two or three years.

Villagers in the area have planted *Ginkgo biloba* for a long time but only around homesteads. To develop a plantation on land belonging to many households they had to pool land and practise common management. A shareholding system was adopted with villagers getting shares based on land contributed and government agencies their shares through capital investment and/or their work in managing the plantation. Land shares made up 20% of the total and were distributed among the 40 households. Management shares represented 10%, half of which are owned by the village committee and forest guards and another half by representatives of Huitong County Forestry Bureau at township level and the Township Government. The remaining 70% is owned by the investors (Huitong County Forestry Bureau and its representative at the township) who provided the capital. Profits will be distributed among the shareholders based on shares they hold.

Each shareholder has clear responsibilities. The County Forestry Bureau's representative at township level is responsible for the tending (weeding and fertilising) and guarding the plantation. The village committee and representatives of land shareholders assist with guarding of the plantation and implementation of the scheme for benefit distribution. A contract that was made between the County Forestry Bureau's representative and the village committee agreed that the ginkgo plantation must be established within 3 years and generate benefits in 10 years or the village, as landowner, will be entitled to use the land for other purposes. The farmers were allowed to cultivate food crops in the plantation in the first 3 years when the land was not fully covered by tree canopy.

Evergreen Broadleaf Forests

Extent of Degradation

When an evergreen broadleaf forest community becomes degraded, the number of tree species and families decreases and forest structure becomes simpler. Tree species diversity indices e.g. Simpson Index and Shannon-Wiener Index (Department for Science and Technology, Ministry of Forestry 1994), were used to assess the extent of degradation of secondary broadleaf forests. Using the two indices, secondary evergreen broadleaf forests in the villages were classified into:

- normal or slightly degraded (Simpson Index >0.8, Shannon-Wiener Index >3.0)
- degraded (Simpson Index = 0.3-0.8, Shannon-Wiener Index = 1.0-3.0), and
- seriously degraded (Simpson Index <0.3, Shannon-Wiener Index <1.0).

The number of species is significantly reduced in degraded forests. In seriously degraded forests few tree species remain and many trees have been reduced to a shrubby form. About 70%-80% of evergreen broadleaf forest in the two villages is degraded and seriously dergraded. (Table 4.4)

A consequence of degradation of secondary broadleaf forests is a significant change in some soil properties. Analyses showed soil porosity was less and there was a reduction in soil organic matter and nitrogen in seriously degraded forests.

Causes of Degradation

Prolonged over-exploitation of forest resources is the major cause of degradation of evergreen broadleaf forests of the two villages. Local residents rely heavily on this type of forest for timber, for sale and on-farm use, for fuelwood that is the primary energy source of the villages, and for non-wood forest products. They depend on forest to generate cash income from timber and NWFPs. Clearly, there is a need to reduce dependence on broadleaf forest to halt degradation and allow rehabilitation to take place. A more recent pressure on these forests is the browsing effects of goats as goat raising is now practised widely in the area.

Table 4.4 Extent of degradation of evergreen broadleaf forests in Xiangjian and Dongxi

Extent of degradation	Xiangjian		Dongxi	
	Area (ha)	%	Area (ha)	%
Slightly degraded	35	21	32	31
Degraded	126	75	40	38
Seriously degraded	7	4	33	31
Total	168	100	105	100

Source: Forest survey by this research, 1995.

Rehabilitation Strategies

Mountain closure

Evergreen broadleaf forests usually occur on steep slopes and in ravines. These areas are ecologically fragile so it is easy to cause soil erosion if they are subjected to artificial planting. Natural regeneration through 'mountain closing' is an ecologically sound and cost-effective alternative. Our surveys indicated the cost of this technique was about 40 Yuan ha^{-1}, much lower than for plantation establishment.

Mountain closure was a traditional practice in Huitong, and in other areas of south China, before 1950. In Huitong, every year or two all adults in each village gathered to discuss which area to close and what penalties would apply for infringements. Forest owners contributed funds and food for the meeting. All signed a document recording the agreement. It usually included: no cutting of Chinese fir trees without a permit; no fuelwood collection in broadleaf forest at a given time of year; no tree theft; no grazing of domestic animals in newly developed areas; no clearing of forest for food crop production; and no collecting tea oil and *Vernicia fordii* seeds before the mountain or forest is open for that purpose. Tools or animals of offenders were confiscated, and they were fined and had to compensate for loss incurred. The offender also had to host a feast for all the villagers. The governance mechanism worked well and there were few offenders.

Today the situation is different and two constraints must be overcome in mountain closure for natural regeneration. One is current access of villagers to collect fuelwood and graze their domestic animals in evergreen broadleaf forests. The other is the fragmentation of forest land use rights into very small patches resulting from inappropriate implementation of the forest reform policy in the first half of 1980s. Now one household has several tiny patches of forest land in different locations and some kind of collaboration among households or joint management is needed to implement the 'closing mountain' option.

The option was initiated in a forest of 133 ha in the boundary area of Xiangjian and Dongxi villages in 1998. Partial closure and a shareholding system were used. Partial closure means closing part of the mountain during a given period and leaving other part open. The shareholding system was designed to address forest holding fragmentation. Households with forest land in the closed area obtained shares based on their land and trees. In calculating shares, both the area and quality of land and the stock of all trees with diameter at breast height of 6 cm and over were taken into account. An inventory of forest was made to estimate the standing volume of each household's trees.

A governance group, a supervision group and a forest guard group were set up to implement the strategy. The governance group is responsible for making management regulations, distributing benefits, coordinating relationship among households involved and between households and village committee, and seeking support from the government forest department. The supervision group, consisting of villager representatives, oversees activities of the governance group and the forest guard group. Duties of the forest guard group include control of forest fire and prevention of tree theft and illegal cutting. Benefits from closed forests, mainly income from timber, are then distributed among all the stakeholders. The governance group is entitled 10% of benefits, 25% of income is used to pay forest guards, and the remaining 65% is distributed to households on the basis of the shares they hold.

Home gardens

This strategy was not designed directly for a particular type of degraded forest. It was intended to reduce excessive pressure on all forest types by generating income from outside the forest. This strategy is attractive because income can be produced quickly.

Home garden is a household-based land use system and an important component of the agricultural economy in Huitong and elsewhere in south China. It is a traditional land use system that integrates agriculture, forestry, animal husbandry, and processing of agricultural and forest products at one site. It takes full advantage of lands around homesteads to plant trees and raise animals to generate cash income. The tenure of such land is usually clear and more secure than for other types of land, so there is less conflict and a good opportunity for investment of capital and labour.

A survey of households and village leaders in the two villages in 1995 revealed that 129 (43%) of 304 households in Xiangjian village have a home garden with an area of 0.03-0.05 ha. In Dongxi village 139 households (73%) have a home garden mainly of 0.03-0.2 ha (but up to 0.8 ha). There are three types of home gardens in the two villages based on their main components: (1) animal (goat) raising dominant, (2) a combination of animal raising and fruit trees, and (3) mixed tiny plantation of fruit and other cash trees.

Although widely adopted, home gardens in the two villages had low productivity. One problem was the inferior varieties of fruit and other cash trees that were planted so market demand was not great and prices were low. For example, the price for locally produced oranges was 0.8 Yuan kg^{-1} or less in 1996-1997. Another reason was poor home garden management (including tending) with investment lower than required. Adequate investment was estimated at 6000-7500 Yuan ha^{-1} in young orchards and 12 000-13 500 Yuan ha^{-1} when orchards are fruiting. Actual investment was only 1500-4800 Yuan ha^{-1}. This analysis suggests that identification and propagation of species/varieties with good market demand, greater capital investment, and improvement of management skills among local village households must be addressed to develop quality home gardens.

In response, new, better-quality varieties of orange and plum were introduced. The effort with oranges achieved a positive result with survival rates of grafted varieties being 60-70%. In 1998, over 600 plum seedlings were provided for eight households, four in each of the two village, and they were well established when this report was prepared. From several proposals, villagers chose these species/varieties because of their market potential and ease of storage. A fruit technician from Huitong County Fruit Association passed on grafting skills and provided advice on fruit varieties. The research team provided free seedlings and grafting materials, which helped overcome the capital constraint. Skill development for home garden operations and management was promoted largely through training courses. Four courses were organised, covering topics such as pest and disease control, pruning and fruit storage. Apart from skill development, these training courses enabled some households in the two villages to establish and maintain contacts with fruit technicians in Huitong County town.

Disincentives to Forest Rehabilitation

There are government policies and practices that are disincentives to farmers to plant trees and manage existing forests and plantations sustainably.

Taxes and Fees

High taxes and fee charges on timber products are very common in China. In Huitong County, in the case of Chinese fir log grade, local government tax and fees amount to about a quarter of wood trade prices. The forest department collects about 14% as reforestation fund but little is returned to farmers. Farmers obtain 16% of the log price after deducting logging costs (Table 4.5).

In the 1990s, costs of planting, tending and guarding of Chinese fir plantations were 40-45 Yuan m^{-3}, which meant farmers obtained a net income of about 80 Yuan m^{-3} (129 Yuan minus 40-45 Yuan) for Chinese fir logs that took 20 years to grow. In contrast, there are few taxes and fees on fruit and fuelwood. According to a farmer in Xiangjian village, he can gain an income of 200 Yuan m^{-3} from fuelwood with less capital and labour investment. A farmer in the village leased 2000 orange trees from his village collective and earned an income of 20 000 Yuan $year^{-1}$. This in part explains why farmers are not enthusiastic about timber plantation establishment and are more interested

Table 4.5 Distribution of income from two grades of Chinese fir timber

Timber grade	Gross income	Local government		Forestry department		Transport and marketing		Farmers	
		Tax	Fees for township and village	Refores-tation fund	Other	Costs	Profits	Logging costs	Income
	Yuan m^{-3}								
Yuantiao*	580	104	119	76	15	80	60	50	77
	%	20	21	13	3	14	10	9	13
Log**	800	76	121	96	14	110	185	70	129
	%	10	15	12	2	14	23	9	16

Source: Huitong County Forestry Bureau, its representative office at township, and Ma'an Township Government
* Less than 5 m in length and 8 cm in diameter.
** Over 5 m in length and 8-12 cm diameter

in fuelwood and NWFPs. It also explains why some farmer households converted their timber forests into orchards, bamboo plantations or other cash tree plantations.

Harvesting and Marketing Regulations

Restriction of rights to harvest and market forest products, especially timber, is another factor that discourages farmers from planting trees and managing forests. Wood harvesting is highly regulated through a cutting quota and cutting permit system that extends throughout China. In Huitong, the County Forestry Bureau and County Planning Commission allocate the yearly cutting quota to townships, each of which is responsible for reallocating quotas to villages under its governance. Village offices then allocate their quotas to households. Quotas are limited and obtaining a cutting permit is a difficult, costly and time-consuming process.

The timber market is a monopoly with only the government forest department, or institutions designated by the forest department, entitled to purchase timber from villages and households. As a consequence, farmers receive prices that are much lower than market prices. For example, the market price for Chinese fir log was 800 Yuan m^{-3} in 1996, while state timber company obtained a profit of 185 Yuan, and farmers about 130 Yuan (including costs of tending and guarding) (Table 4.5). In contrast, regulations on marketing NWFPs are much less restrictive as farmers can sell their products in local free markets.

Conclusions

Causes of Forest Degradation

Degradation of Chinese fir plantations and evergreen broadleaf forests in Huitong County is associated with many factors, including inappropriate silviculture practices, poor harvesting methods, tenure insecurity and over-dependence on forest resources. Silvicultural methods, such as planting Chinese fir on unsuitable sites, planting successive crops of Chinese fir without a fallow period and establishing monocultures are technical issues but are promoted by government forestry department's planning and guidelines on plantation development. These guidelines often have negative consequences and neglect traditional management practices developed over 600 years.

On Strategies to Rehabilitate Degraded Forests

To be effective, strategies for rehabilitation must address causes of forest degradation and constraints to rehabilitation. They must be overall packages rather than technology 'fixes'.

Silvicultural practices

It is crucial to revise guidelines on plantation development on the basis of both new and indigenous knowledge to prevent the establishment of Chinese fir plantations with low productivity potential. The unsuitable sites planted with Chinese fir should be allocated to species better adapted to them. Agroforestry technologies that ensured sustainable management of Chinese fir over the last six centuries, including intercropping trees with food crops or cash tree crops, still have an important role to play.

It is essential to reduce dependence of the rural population on forest resources. Home gardens can provide income-generating opportunities and reduce pressure on forests to some extent. The reduced pressure should make forest rehabilitation easier.

Improved rural services

Improved rural credit services and expanded sources of funding are needed to overcome farmers' lack of capital to invest in rehabilitating degraded forests and production activities. Farmers' access to commercial credit is limited, as they often cannot meet bank requirements for collateral. One possibility is to introduce and adopt an innovative rural financial system, e.g. using the Grameen Bank approach. Another is to involve outside institutions to provide funds for development of plantations and/or home gardens. Capital input by Huaihua Prefecture Forestry Bureau into ginkgo plantation establishment in Xiangjian village and by Huitong County Forestry Bureau into bamboo planting are examples of such an approach.

Many farmers lack the skills and technical knowledge to effectively manage forestry and agroforestry activities. This requires better access to technical information and improved extension services, including training courses.

Organisation of common management of household resources

Fragmented forest land holdings make it difficult for farmers to adopt options such as natural regeneration of broadleaf forests through 'closing mountain' and tree plantation establishment. Tenure issues are very sensitive but joint forest management, such as a shareholding system, can rearrange forest tenure to the advantage of the landowners. This must be achieved on a voluntary basis and with proper governance or there will again be a crisis of villagers' trust in tenure policy.

Policy Changes are Essential

Restrictive regulations on timber harvesting and marketing and the high level of taxation and fees on timber sales are disincentives to farmer to establish and manage plantations of Chinese fir and other timber species. Farmers are not interested in establishing timber plantations because of the unsatisfactory returns from timber sales as a result of high taxes and fees. The restrictive regulations discourage them from investing in tree planting and sustainable management of forest. Changes to these policies to give farmers greater freedom in marketing and to obtain a greater return from timber products are essential to encourage the establishment and management of timber-producing forests and plantations.

Problem and Strategy Identification

Forest degradation is a complex process and the rehabilitation of degraded forest requires a dynamic partnership of villagers, technical professionals and government officials. Villagers know their circumstances and local conditions and are able to make significant contributions to the identification of problems and constraints and the development of strategies and options to address them. They are the means of achieving rehabilitation and sustainable management of degraded forest, and ultimately the beneficiaries of it. Involvement of technical personnel can provide expertise and innovation in developing effective strategies and improve communication between government agencies and villagers. Government officials are important for forest rehabilitation, because their participation will help make effective policies and their networking with government agencies will help villagers to gain access to public sector resources such as technical extension, rural credit, and market information services.

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Chapter Five

Rehabilitation and Sustainable Management of Degraded Forests in Gaohong, Lin'an County, Zhejiang

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Introduction

Zhejiang province is in the subtropical evergreen broadleaf forest zone. Due to excessive human intervention, however, most of evergreen broadleaf forest has now disappeared and has been replaced by secondary natural Masson pine (*Pinus massoniana*) forest and man-made plantations of Chinese fir (*Cunninghamia lanceolata*), bamboo, tea and other cash tree crops (NWFPs). Remaining evergreen broadleaf forest is secondary in origin.

A significant proportion of forests, both timber and NWFPs, in the region is degraded or seriously degraded. Standing timber volume and quality has decreased and biodiversity is diminished. Local rural communities and other forest-dependent people are able to obtain less environmental and ecological services and to collect fewer products and generate less income than formerly. Farmer income in the mountainous area is 75% of the provincial average and therefore it is a great challenge to rehabilitate and manage degraded forests and plantations to generate income and improve livelihoods.

Few comprehensive studies have been made on why forests in the region are degraded so understanding of these issues is still limited. Identification of effective strategies for sustainable management of degraded forests has largely focused on technical solutions.

In response, our research, carried out in the three villages of Gaohong Township of Lin'an County, Zhejiang, used a participatory approach and aimed at understanding root causes of degradation of timber forest, bamboo plantations (a major source of cash income) and tea plantation. We also examined disincentives and constraints to forest rehabilitation, and developed strategies for forest rehabilitation and improvement in local livelihoods.

This chapter presents research methods and background information on the three villages, deals with three types of forests/plantations: timber forest, bamboo and tea plantations by analysing the causes of degradation and disincentives and constraints to their rehabilitation., Rehabilitation options are described and the development and extension of effective forestry technology discussed. Lessons and implications are drawn that may have wider application to sustainable management of degraded forests.

Research Methods

As an action-oriented research project our research in Gaohong followed a logical procedure of diagnosis, design and delivery, and stressed participatory and interdisciplinary approaches. Participatory Rural Appraisal (PRA) was used. PRA has emerged from a synthesis of Rapid Rural Appraisal, Agroecosystem Analysis, Diagnosis

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and Design and other appraisal techniques with action research and community organization techniques (Chambers 1994a,b,c; Rocheleau 1999). This type of social science research was complemented by conventional forestry methods such as soil survey, forest inventory and landscape analysis.

Using a Participatory Approach

Participatory diagnosis

A participatory rural appraisal (PRA) team was assembled comprising 15 farmers, 15 technical specialists and researchers, and 5 government officials. PRA tools such as secondary data collection, participatory direct observation, household survey and group interviews were used.

A large amount of secondary data was collected from relevant government agencies and technical institutions at county and township levels. For example, information was derived from Lin'an County Annals, Lin'an County Annals of Forestry, Report on Forest Inventory in Lin'an County and yearly statistical data.

Direct field observations were made by researchers together with farmers. The farmers had good knowledge of local forest management and historical changes in environment. They were encouraged to draw sketch maps to support their observations.

As occurred at research sites in other provinces in this project, the primary method for farmer household survey was semi-structured interviews, complemented by a questionnaire survey. Sample households were selected through random sampling from 659 households in three villages. About 350 villagers from 175 households were consulted during the survey. The villagers consulted represented about 20% of the population in the three villages.

Representatives of seven groups of villagers in each of the three villages were interviewed. The seven groups were: senior villagers (60 years old or over), village leaders, married middle-aged and young people, unmarried young people, women, the poor, and the relatively wealthy. Twenty-one group interviews were conducted, each involved 4-8 persons and lasted up to 2 hours.

Participatory planning

Design aimed at developing effective strategies for rehabilitation and sustainable management of degraded forests based on identification and analysis of problems and constraints at the diagnosis stage. We worked with farmers and government officials in an iterative manner to identify options and evaluate the role of existing technologies and indigenous knowledge. After a number of discussions, several options were agreed for each type of degraded forest to allow farmers to choose the option(s) that best suited their specific conditions and circumstances.

Testing options/strategies

In the delivery phase, more than 10 households, with support of researchers and forest extension workers, were involved in testing effectiveness of options identified. Participating households represented different economic development levels and had different forest resources and types of degraded forest. The options that proved effective were then disseminated to villagers through training courses, printed materials, farmer household visits, and the existing extension network, and mass media (cable TV and video tape).

Conventional Forestry Methods

Soil survey

Field surveys were made to determine soil types and their distribution and collect soil samples. Analysis on chemical properties of soil samples from 29 transects in different forest types of the three villages was made to assess soil fertility.

Forest vegetation surveys

An inventory was made in 14 sample plots representing different types of forest communities. Both tree layer and shrub layer were surveyed in each of the sample plots. In the tree layer, species, diameter at breast height, tree height, trunk height to first branch, canopy class and health were recorded. Names, numbers and dimension of shrubs were also recorded.

A second field survey focused on types and amount of forest products. The survey concentrated on historical changes in forest volume, forest land and environment, and on the extent of forest degradation during the previous 20-30 years. We (the research team) worked with several experienced villagers to assess the historical changes based on field survey, villagers' recall, and secondary data obtained from forest inventories respectively in 1983, 1989 and 1994. This survey is by its nature participatory.

Forest landscape analysis

A landscape study was used to analyse degradation and features of forest to complement findings from other research. Criteria for the classification of forest polygons were decided first. Plots were located on maps during the field survey, followed by a stratified statistical analysis by forest type. The results provided an estimate of area, dominant species, and features of each type of forest. This information assisted in assessing the extent of forest degradation.

Background Information on Lin'an County

Lin'an County (29°56'-30°23'N latitude and 119°11'-119°52'E longitude) is located in northwest Zhejiang province (see Map 1.1, Chapter 1). Our research was mainly undertaken in the villages of Chenjiakan, Hongqiao and Shangfeng, all of which are under jurisdiction of Gaohong Township, though some options identified were also tested in the township-owned Gaohong Forest Farm and several other villages in Lin'an.

Climate and Soil

Situated to the south of the Yangtze River, Lin'an County has a subtropical climate, with four distinct seasons a year. Winter and summer are 124 days and 114 days respectively, and spring and autumn are each 64 days. Mean annual rainfall is 1415mm.

Soil is typically red earth, with two subtypes: yellow-red soil and red soil. Yellow-red soil is found on 55% of land area of the villages. Red earth is generally assessed as a fertile soil but due to soil erosion on some land in recent years, profiles are becoming shallower and fertility has declined. Some of this land degradation is a result of planting Lei bamboo on steep slopes by farmers. Soil fertility is also broadly related to types of forest and age of trees on it with greater fertility in natural forest than in man-made plantations, and under older stands.

Land Use and Forest Resources

There are 1128 ha of land in the three villages. The largest land use is forestry with the balance comprising food crops, settled area and water bodies. Forest land comprises 76% of total area and crop land 10% (Table 5.1).

At present, 98% of forest land is covered by forests (Table 5.1). Masson pine forest and evergreen broadleaf forest are usually regenerated naturally whereas Chinese fir and tea are planted. Bamboo is either natural or artificial depending on the species. Plantations of Chinese fir and Lei bamboo make up 32% of forest land or more than 80% of plantation area in the villages. There are only 43 ha of tea plantation.

All timber forests are young or middle-aged stands at present so the standing timber volume is low. It averages 13.5 $m^3 ha^{-1}$ in Shangfeng village, 20.7 $m^3 ha^{-1}$ in Chenjiakan and 24.3 $m^3 ha^{-1}$ in Hongqiao. Without mature forests, local farmers practise selective logging of larger trees from these immature stands to meet their timber needs. The practice has contributed to degradation of timber forest.

Local people use forest resources to meet their varied needs. Masson pine forest and Chinese fir plantation are primarily for timber production. Evergreen broadleaf forest is for timber, fuelwood, NWFPs and ecological services. Bamboo and tea are cash tree crops. Bamboo is planted primarily for bamboo shoots for cash income and on-farm consumption. Tea was also a major source of cash income but from the late 1980s was replaced by bamboo shoots. Evergreen broadleaf forest contains most

Table 5.1 Land use

Land uses	Area (ha)	% Total Area	% Forest land
Total area	**1128**	**100**	
Forest land	**853**	**76**	
Timber forests	561	50	65
Masson pine	*372*	*33*	*43*
Chinese fir	*117*	*10*	*13*
Evergreen broadleaf forest	*72*	*7*	*8*
Bamboo forests	229	20	27
Lei bamboo plantation*	*158*	*14*	*19*
*Bamboo forest producing dry shoots***	*71*	*6*	*8*
Tea plantation	43	4	5
Non-forested land	20	2	2
Crop land	**115**	**10**	
Others	**160**	**14**	

Sources: Based on the field survey 1995.
Notes: * *Phyllostachys praecox* f. *preveynalis* ** Including *Phyllostachys nuda, Phyllostachys dulcis,* and *Phyllostachys iridenscens*.

biodiversity, while Masson pine forest, Chinese fir plantation, bamboo forest, and tea plantation are much less diverse.

Agricultural and Forest Products

Important agricultural products include rice, wheat, barley, watermelons, vegetables and rape seed. Primary forest products are fresh bamboo shoots, dried bamboo shoots, timber and tea. Food grains, especially rice, are produced both for on-farm consumption and sale to fulfil farmers' obligation to the state, while other agricultural crops are mainly consumed on-farm.

Bamboo shoots now have become the main source of farmers' cash income. About 80% of shoots is marketed and 20% is consumed on-farm. Part of the fresh shoot crop harvested in a normal season is marketed, part is used on-farm, and the remainder is processed into dry shoots. About half of the dried shoots are marketed.

Timber was major source of cash income for farmers in the villages. It has been replaced by bamboo shoots since the late 1980s. It is now largely for on-farm consumption, harvested from household's own plots and/or purchased from forests under collective management. The timber market is monopolised by the state-owned timber company, which is one reason farmers have been less enthusiastic about timber plantation establishment.

Although the market demand for quality tea is still high, the quality of tea produced in the villages is poor and the amount farmers are able to sell is declining. Fresh leaves are sold to buyers who come to the villages and then sell them to tea processing factories. Most tea produced in the villages is used locally.

Forest Tenure and Management

As in other parts of China, Lin'an County implemented the policy for forestry reform in the early 1980s. The term '*sanding*' is often used in Chinese literature to refer to the forest reform. Village collectives distributed part of their forests and forest lands to village households for management, while retaining some under collective management. Forests/forest lands were distributed to farmer households in two categories: family plot (*ziliushan* in Chinese) and responsibility hill (*zerenshan* in Chinese) (Liu 2001) that are often called *liangshan* in Chinese literature on forestry.

In Lin'an County, 122 200 ha, or 50%, of forest were distributed as responsibility hills; 42 700 ha, or 17%, as family plots; and 81 900 ha or 33% were under collective management. However, in the three villages nearly 80% of forests were distributed to rural households, and only about 20% remained under collective management (Table 5.2).

Table 5.2 Forest land by tenure

Village	Forest land (%)		
	Household managed		Collectively-managed
	Family plots	Responsibility hills	
Chenjakan	66	19	15
Hongqiao	56	9	35
Shangfeng	-	97	3
Total	43	36	21

Source: Field survey 1995

In the case of family plots, there is a division of use rights and land ownership. Use rights to land were distributed to farmer households on long-term basis, while the collective remained the owner of land. The policy dictated that a land certificate had to be issued to each household when forest or forest land was allocated to them. Trees planted on family plots are private property and both the land use rights and tree ownership can be inherited. A cutting permit is required to cut trees on family plots, although in the villages this regulation has been strictly applied only to the harvesting of commercial timber and not to harvesting for on-farm use.

Responsibility hill areas were distributed to farmer households in the attempt to improve the management of existing forests. Benefits from responsibility hills are shared between the collective as owner and the households assuming responsibility for forest management. A cutting permit is essential to cut trees on responsibility hills.

The usual practice is for the village collective to appoint part-time or full-time forest guards to look after forests remaining under collective management. Income from the forests goes to the collective and is used to cover public expenses including part of village leaders' salary. Village leaders must obtain cutting permits and logging operation planning from the forest authority to harvest timber from collective forests. Villagers are given priority to purchase timber for their own use from collective-managed forests.

Demography

Almost all the population of 10 513 in Gaohong township in 1995 were Han Chinese. Based on our random sample survey, gender distribution was 51% male and 49% female. Those of labour age comprised 65% of the population. 45% of the labour force was working in primary industry (agriculture, forestry, animal husbandry, and fishery and aquaculture), 28% in secondary industry (manufacturing, construction and transport) and 27% in tertiary industry (mainly services). A high proportion of the population has primary education and 14% is illiterate. Only about 8% of villagers completed senior high school education or higher level. Most of middle-aged and senior villagers, who have had a low level of education, remain working in agriculture, while the better-educated younger generation prefers non- and/or off- farm activities as their employment and sources of income.

In the past, the three villages were typical subsistence communities. Villagers produced food grain and vegetables and raised animals mainly for self-consumption, and managed timber forest and tea plantation to generate cash income. This pattern, however, has changed since the late 1980s due to the availability of other opportunities for employment and income generation. Sources of farmer income have diversified to include bamboo, transportation, manufacturing, food crop production, trade, and animal raising in descending order. In brief, villagers rely on less agriculture and more market related economic activities.

Farmer income at the site is relatively higher than that in other mountainous areas. However, there was a considerable disparity of income among households. Data of income for the three villages show that in the mid-1990s, income of the lowest income group was 18% of that of the highest group in Shangfeng village, 32% in Hongqiao village, and 46% in Chenjiakan. Interestingly, the disparity was not because of a difference in households' landholding size but was due to the different industries pursued by villagers. In Shangfeng, in the highest income group were those with part-time off-farm employment; and in the lowest income group were those who pursued agriculture only. In Chenjiakan, most households planted bamboo and so the disparity of income among households was not as great as that in Shangfeng.

Overview of Forest Degradation in the Villages

Our surveys showed that a large proportion of forests in the villages was degraded. These degraded forests covered about 390 ha, representing 46% of forest land. Degraded Masson pine forest made up 57% of degraded forest area. Most of the evergreen broadleaf forest and tea plantations were degraded and nearly half of the bamboo forest producing dry shoots was also degraded. (Table 5.3)

From a landscape perspective, there are four features of forest degradation in the villages.

- Evergreen broadleaf forest, formerly the typical vegetation in the region, is only 7% of total area (Table 5.1). It is now secondary forest with less species and shorter trees.
- The forest has become much more fragmented with the majority of patches smaller than 6 ha.
- Forest communities with a single species in the tree layer have become dominant forest in the landscape, including Lei bamboo and Chinese fir plantation, and Masson pine forest.
- Distribution patterns of some forest landscape elements are not sound. Lei bamboo plantations and Chinese fir plantations established on steep slopes are irrational land use and lead to soil erosion.

Factors causing forest degradation and options for rehabilitation and management vary according to the different types of forest.

Degraded Timber Forests

Extent of Degradation

According to general criteria of the forest department, the following four types of forests are degraded and need to be rehabilitated. They are:

a) land with a canopy density of 10-20% and with little likelihood to naturally regenerate into stands;
b) young and middle-aged forests on any unsuitable site;

Table 5.3 Degraded forests by type

Degraded forest type	Area (ha)	% total area of degraded forests	% area of same type of forest
Broadleaf forest	56	14	78
Tea plantation	30	8	70
Masson pine forest	224	57	60
Bamboo forest for dry shoots	34	9	46
Chinese fir plantation	15	4	13
Lei bamboo plantation	33	8	20
Total	392	100	

Source: Field survey 1996.

c) young and middle-aged forests with an annual growth of less than 3 m^3 ha^{-1}; and
d) forests suffering from serious diseases, pests, forest fires and human damage.

About 60% of the Masson pine forests is degraded. The 224 ha of degraded pine forest accounts for 57% of degraded forest in the research area (Table 5.3). Generally, Masson pine forests are growing on sites suitable for the species. In the 1960s and 1970s there were dense secondary Masson pine forests with an average diameter breast height (dbh) of 26-28 cm, a mean tree height of 11-12 m and timber volume of 105-120 m^3 ha^{-1}. When we surveyed the forests in 1995, the stands were less productive with an average dbh of 8-10 cm, a tree height of 6-7 m, and a timber volume of 20-30 m^3 ha^{-1}.

Nearly 80% of evergreen broadleaf forests are degraded (Table 5.3). These forests are mainly on cool, north facing slopes that are steep and rocky, and with shallow soil. Dominant species include *Castanopsis sclerophylla* and *Cyclobalanopsis* (*Quercus*) *glauca*, often mixed with a few Masson pine trees. Evergreen broadleaf forests were in good condition in the 1960s and 1970s, with mean dbh 10-12 cm (maximum 20 cm) and a dense canopy of (80–90%). They are now in poor condition with mean dbh 6 cm, mean height 6-7 m and a more open canopy (30-50%).

Chinese fir plantations are in the best condition among the timber forests with only 13% degraded (Table 5.3). The degraded Chinese fir stands are young or middle-aged with low productivity. For example, 20-year-old plantations have an average dbh of 10 cm and a height of 7 m, standing timber volume of about 54 m^3 ha^{-1}, and mean annual increment of 2.7 m^3 ha^{-1}. All these indicators are lower than those of a normal Chinese fir stand.

Factors Responsible for Degradation

Our survey shows that immediate causes of timber forest degradation included tenure insecurity and over-harvesting of forest, including poor harvesting practices.

Deforestation resulting from tenure insecurity

In 1981, the government decided to allocate non-forested forest land and forests to farmer households to encourage tree planting and improve management of existing forests. Contrary to the policy objectives, this forest reform was followed by increased harvesting in many areas. Significant deforestation occurred in the mid-1980s, immediately after the adoption of household-based forest management. Some farmers cut trees immediately after they were distributed to them. This occurred in the three villages too. One underlying cause of the deforestation was tenure insecurity in an uncertain policy environment due to frequent changes in polices for forest and land tenure. China experienced radical changes in forest tenure and management from the early 1950s to the 1980s. The major change included from private ownership and household-based management in the early 1950s to collective ownership and management during the following 25 years. With this experience it is not surprising that farmers chose to harvest their trees rather than to manage them. This attitude is consistent with observations made elsewhere in China (Yin and Newman 1997, Liu 2001).

We found in our interviews with farmers that their misgivings about tenure security have not yet been dispelled completely. Despite policies and law assuring farmers of forest tenure security, uncertain factors remain at the implementation level. For example, certificates were not issued nor contracts made for forests allocated to farmer households in Shangfeng village. In other cases, use rights to land were often reallocated by local officials. This helps explain why many farmers are reluctant to establish and/or sustainably manage forests.

Over-harvesting of forest

Forest degradation in the villages is also closely related to poor harvesting practices. Timber has been the major source of cash income in the area for a long period of time and has resulted in over-harvesting. Over the past 20 years, farmers in the research area have practised a dysgenic selection in the forests by removing the best quality, large-diameter trees (*badamao* in Chinese) and leaving poor, often unhealthy, trees. Even today, local villagers practise selective logging of larger trees from immature stands because there are no mature forests left. Similarly, fuelwood was the only source of energy for cooking and space heating until the 1980s. This dependence on fuelwood caused depletion of the evergreen broadleaf forest.

Disincentives and Constraints to Rehabilitation

Disincentives

Disincentives to farmers to invest in timber tree planting and forest management included:

- tenure insecurity
- over-taxation on timber and
- restrictive regulations on timber harvesting and trade.

Perceptions of tenure insecurity can explain why farmers are interested in bamboo production but not timber growing. The long period needed for timber to generate income for investors requires tenure security. In contrast, farmers in Lin'an were incredibly enthusiastic about bamboo, because they can obtain income from it in just two or three years. There have been similar observations of farmers' behaviour in relation to property rights and investment incentives elsewhere (e.g. Fortmann and Bruce 1988, Besley 1995).

Poorly-designed mechanisms for benefit distribution can discourage investment. Data from our surveys show that timber income is distributed between outside stakeholders (government and forest department) and local community/households. The outside stakeholders received about half of gross timber income (trading prices) in the form of taxes and fees. For instance, the price for Chinese fir timber is about 600 Yuan m^{-3}. From this the government collected taxes and fees of about 200 Yuan m^{-3} and the forest department 95 Yuan m^{-3} for the reforestation fund. Farmers received the balance that had to cover costs of planting, tending, guarding and harvesting. As it takes at least 20 years before Chinese fir is large enough to harvest, returns to farmer investment are very low. In sharp contrast, tax on bamboo shoots is less than 1% of sale prices. From a perspective of benefit sharing among stakeholders, this explains why farmers have little enthusiasm about timber forest management and why over-taxation and fee charges are a disincentive to timber forest rehabilitation.

Regulations on wood harvest and trade also impact negatively on timber forest establishment and management. In China, a cutting permit is required to cut trees. Timber harvesting must be carried out at a time and location, and in an amount specified by a cutting permit. To some extent, this limits farmers' authority and makes them unable to respond to market signals. For example, they may not be able to harvest and sell their wood when prices are high due to the inability to obtain a permit. Present wood marketing practice also discourages farmers from developing timber forests. In most cases, the forestry department, or other institutions to which it delegates authority to purchase timber from farmers and village collectives, monopolises the timber market. Consequently, timber prices are skewed and farmers receive prices lower than those on the free market. In comparison, the market environment for bamboo shoots is much better as farmers are able to sell them freely.

From this analysis, it is clear that at policy level, three disincentives must be removed to encourage farmers to rehabilitate and manage degraded forests. (1) The government needs to further reassure farmers about tenure security, and tenure policy and law must be strictly enforced. While transfer of use rights to forest land is necessary, it should be through market mechanisms, such as leasing, rather than reallocation by political forces and administrative orders. (2) Tax and fee charges must be reduced so local communities/households can receive more benefits from sales of timber. (3) Monopolised wood purchases by the forest department should be abandoned or modified to give farmers more authority in the wood trade and to enhance their prospects for higher gains from timber sales.

Constraints

Two major constraints to the rehabilitation of timber forests need to be overcome. The first constraint is the fragmentation of forest land holdings resulting from the way collective non-forested forest land and forest was allocated to individual households in the early 1980s. When this land was allocated in the villages, villagers and local government officials emphasised absolute equity. Lands and forests were first divided into many tiny plots based on tree age, species, soil quality and distance from village etc., and then matched to family size. As a result, land holdings are very fragmented so that one household has many tiny plots in different locations, and a land or forest on one slope belongs to many households. Several households each have 10 or more plots of forest in Shangfeng village, while the average forest area is only 2.3 ha household^{-1}. This makes forest operations more costly and difficult, and makes mountain closure for natural regeneration of forest almost impossible to organise. One forest guard can easily patrol an area of forest if an effective management institution exists, but under household management each household must allocate one person at least part time to look after its many tiny, scattered forest plots.

Clearly, there is a need for an improvement in forest management arrangements. Household forest farm and shareholding systems emerging in Lin'an (and other areas) offer some possibilities to address the problem.

In household-based management, a household expands the forest land area distributed to it in the early 1980s through leasing use rights to land from, or in partnership with, other farmers. It is more efficient to manage the larger forest land area. In Lin'an County up to late 1998 more than 500 household forest farms, managing an area of over 20 000 ha, were established. Initial observations suggest that this form of forest management is effective in overcoming the constraint of land fragmentation. Tenants have capital and labour to manage a larger area, while those who lease their land use rights out usually have insufficient labour and investment capital.

In the shareholding system, all parties involved pool their land, funds or technologies to establish plantations and manage forest. They subsequently share benefits generated based on the shares they hold through their resource input. The system can take many forms based on the range of stakeholders, including collaboration among households; between households and the village collective; among households, the village collective and stakeholders outside of village community; and between households and institutions outside of community. Experience from the area shows that the shareholding system can largely overcome constraints of land fragmentation, while addressing farmers' lack of capital investment and expertise through funds and extension services from outside partners. The shareholding system has been used to develop timber forest and more often cash tree plantations in the area and beyond.

The second constraint to rehabilitation is lack of expertise and knowledge of appropriate technologies for sustainable management of timber forests among farmers. This requires development of technologies suitable for local conditions and markets and the support of an effective extension service.

Mountain Closure as a Strategy for Rehabilitation

Natural regeneration of secondary forest through 'closing mountain' is a common, traditional solution to forest rehabilitation, largely because it is cost-effective. It was identified as a strategy for rehabilitating degraded evergreen broadleaf forest and Masson pine forest distributed in location far from the village settlements. The option was tested on about 260 ha of forests in Hongqiao village. About 60 ha of the forests were household-managed family plots. Villagers formerly collected fuelwood from the broadleaf forests but now they depend less on fuelwood for cooking and space heating as gas and electricity are available. This made it feasible to implement the option.

Degraded Bamboo Plantations and Forests

Lei Bamboo Plantations

Lei bamboo (*Phyllostachys praecox* f. *preveynalis*) in the region could be planted or natural but it is mainly planted. In this chapter, the term 'plantation' is used for this type of bamboo. There has been a rapid development in Lei bamboo plantation over the last decade in Lin'an and beyond. As a result, shoots of this species have replaced tea as an important source of income for farmers. However, degradation also occurs in Lei bamboo plantation. About 20% of Lei bamboo plantations in the three villages are degraded (Table 5.3). They are characterised by low productivity, uneven mother bamboo individuals at different ages, and diseases.

Degradation is strongly associated with two silvicultural practices. One is the planting of bamboos on inappropriate sites. Local farmers were so enthusiastic that they established extensive Lei bamboo plantations on lands unsuitable for the species, such as steep slopes and ridges with infertile, shallow soil. These are the sites where Masson pine forests occur naturally. Bamboo plantations on these sites grow slowly and poorly, and have low output. Where Lei bamboo has been planted there has been serious soil erosion, further land degradation and biodiversity loss. A major reason for development of bamboo plantations on unsuitable sites has been the great market demand for the shoots and high economic returns from this crop.

The other silvicultural practice with a negative impact is the application of mulch, a bamboo cultivation technology developed in the late 1980s (Figure 5.1). Mulching stimulated shoots to sprout earlier than normal. Lei bamboo usually sprouts after Chinese New Year but mulching increased soil temperature and shoots were produced before and during Chinese New Year when prices are very high. This profitable practice unfortunately has adverse site impacts. Covering land with mulch for 3-4 months every year results in a significant increase in soil microorganisms that change the soil's physical and chemical properties. The changed growth environment makes the bamboo susceptible to diseases and makes it difficult to maintain a good age class distribution of healthy mother bamboos. Zhou *et al.* (1998) found the technology changes bamboo stands in many ways, resulting in smaller stem diameters, a higher proportion of old mother bamboos and increased flowering. The longer mulch is used the more mother bamboos flower. When land was covered with mulch for 3 years in succession over 10% of mother bamboos flowered. Jin *et al.* (1998a, b) examined impacts of long-term mulching on the growth, structure and distribution of underground rhizomes. They found that the number of rhizomes increases but total length of rhizomes and percentage of young, vigorous rhizomes (2-4 years old) decline, compared with unmulched plantations. There were 181 buds m^{-2} in the whole rhizome system of a mulched bamboo plantation compared to about half that number in an

Figure 5.1 Intensive culture of Lei bamboo using mulching in Lin'an County

unmulched plantation. Most of rhizomes occur in the upper layer of soil in mulched bamboo plantations but are found below 30 cm depth in unmulched plantations. Diseases often infect rhizomes of mulched bamboo plantations.

Two rehabilitation options were identified. The first was to replace degraded plantations with less site-demanding species. In 1996, an experiment was carried out to incorporate timber species such as Masson pine and cash trees such as *Myrica rubra* and chestnuts into a bamboo plantation area.

The second solution identified for this problem was to modify the practice to minimise the adverse effects on the mother bamboos by not mulching every year and by controlling the soil temperature. This option was first tested in a farmer's field in Shangfeng village and at the Gaohong Forest Farm. The plantation was mulched for 2 years during which not many shoots were retained as mother bamboos, followed by 1 year during which it was not mulched and more shoots were retained as mother bamboos. Ideally, a bamboo plantation should have 18 000 bamboo individuals ha^{-1}, an average dbh of 3.5 cm and over 70% of mother bamboos of 3 years old or younger. Soil temperature was reduced to help develop healthy mother bamboos and to prevent diseases by (1) using mulch materials that does not raise the temperature so much and reducing the thickness of mulch to about 20 cm, (2) reducing mulch during the second half of the sprouting period, and (3) shortening length of the mulching period.

Preliminary results of the testing were positive with an increase in both the number of buds on rhizomes and the weight of individual shoots. This could lead to an increase in healthy mother bamboo individuals and an improvement in quality of the bamboo shoots. The results of the tests resulted in adoption of the modified mulch technology by many households and this will potentially alleviate degradation of Lei bamboo plantations.

The problems of mulching Lei bamboo highlight the importance of developing forestry technologies that are not only profitable but also have with minimum adverse impacts on agro-ecological conditions. This is necessary because forest operations are often undertaken in ecologically fragile areas.

Bamboo Forest for Producing Dry Shoots

Bamboo forest for producing dry shoots occurs on upper slopes. Formerly, forests on these lands were mixed forest of Masson pine, broadleaf species and small bamboo groves. After the household-based forest management was adopted in the early 1980s, farmers cleared all the pines and broadleaf species and developed monocultures of bamboo. Nearly half of these bamboo forests were found degraded with low productivity (Table 5.3).

The research found that degradation of these forests was closely related to inappropriate shoot harvesting methods. Surveys in Shangfeng village show that local farmers harvested earlier sprouting and vigorous shoots and leaving later sprouting, weak or unhealthy shoots as mother bamboos. This selective harvesting is detrimental in the longer term to healthy and productive bamboo forest. Farmers also degrade the bamboo forest by breaking shoots off by hand instead of unearthing them with hoes or other tools.

Poor shoot processing technology contributed to the poor quality of bamboo shoot products. The processing was a manual operation in household workshops and there were no uniform standards. This produced the dry shoots of highly variable quality. The processing method also resulted in wastage of fresh shoots. Some households produced 1 kg of dry shoots from 4 kg of fresh shoots, and others used 10 kg of fresh shoots.

Prices for poor quality bamboo shoots were very low and bamboo forest management was not profitable. Consequently, more than 80% of farmer households did not tend their bamboo forests. If the quality of bamboo shoots can be improved by adopting appropriate technologies for harvesting and processing shoots, farmers will have incentives to properly manage degraded bamboo forest.

Based on this premise, we worked with farmers to identify and test several options.

- To adopt harvesting methods such as retaining vigorous shoots sprouting in the intermediate sprouting period as mother bamboos; renewing one third to a quarter of total mother bamboo individuals (4500-6000 bamboos ha^{-1} $year^{-1}$); clearing all bamboos that are older than 5 years; and maintaining 18 000-24 000 bamboos ha^{-1} evenly spaced to generate healthy bamboo forests.
- To adopt tending technologies such as clearing weeds, other tree species, and old and diseased bamboo individuals; using herbicide in July and August; scarifying the soils in the bamboo forests in November and December; and applying fertilisers twice a year.
- To improve technology and standards for shoot processing.

These options were tested in bamboo forests and workshops of several households in the three villages at first and demonstrated to other households after they were proved appropriate. The test results were encouraging. The adoption of appropriate methods for shoot harvesting together with improved tending of bamboo forest significantly improved the health of bamboo forests, as shown by increased unit output of shoots. Output of dry shoots increased from 60 kg ha^{-1} to 600 kg ha^{-1} and the improvement in shoot processing resulted in added value. As a result, on average each household now generated 6000 Yuan $year^{-1}$ from dry shoots. About 20% of households in Shangfeng village adopted some of these technologies in 1998-1999. This suggests there are good prospects for an improvement in management of bamboo forests for dry shoot production.

Degraded Tea Plantations

Tea was formerly one of three primary products in Lin'an County and an important source of income for farmers. At that time, tea plantations were in good condition and their output of fresh leaves was as high as 7500 kg ha^{-1}. As a consequence, Lin'an County ranked third in Zhejiang province in tea output in the early 1980s. Since then 70% of tea plantations in the county have become seriously degraded (Table 5.3) and the output of fresh leaves has dropped dramatically to less than 1500 kg ha^{-1}.

The "degradation", or low productivity, was closely related to the disinclination of farmers to manage tea plantations because: 1) market share of Lin'an tea declined considerably as more tea plantations were established throughout China; 2) developing tea plantations that produce general tea is much less profitable than planting Lei bamboo. Data collected from the villages indicated that returns to investment in Lei bamboo could be 10 times that for tea cultivation. Farmers responded by producing bamboo shoots and neglecting tea.

Similar to the case of timber forest, landholding fragmentation is a constraint to effective and profitable management of tea plantation. In the early 1980s Hongqiao village distributed its tea plantations to households across the contours of the hills so that every household received an equal share of both good and poor lands. This pattern makes tending, pruning and fertiliser application difficult and less effective. It is also not good for tea making because processing superior tea requires a certain scale of plantation area that is hard to achieve under the fragmented landholding pattern.

We worked with farmers to develop two options. One was conversion of tea plantation into bamboo plantation where site is suitable for bamboo and production of high quality tea. In Hongqiao village, where land is more suitable for Lei bamboo than in the other two villages, part of the tea plantations have been replaced by bamboo, with results being positive. In an innovative approach an exotic variety of quality tea, 'white tea', was introduced to the Gaohong Forest Farm in 1997. This tea is largely for export, with prices as high as 2000 Yuan kg^{-1} (US$240 kg^{-1}). About 2 kg of white tea was produced from an area of 0.06 ha in 1997, which suggests the venture could be profitable.

The other was an expansion of tea area managed by a household as a production unit. This was to be achieved by leasing use rights to land from other households. In Hongqiao village, for example, a household rented tea plantation land from several other households, obtaining use rights to a single tea plantation area of 0.33 ha. It also was to be achieved by combining several tiny pieces of land owned by several households into a larger piece managed by one household through voluntary exchange among themselves.

Development and Extension of Forest Technology

Forest technology has an important part to play in the rehabilitation and sustainable management of degraded forests. It is essential to generate appropriate technologies with farmers and then support their dissemination. Three questions then arise: (1) What are appropriate forest technologies? (2) How they can be generated? (3) What are effective ways to disseminate technical information to stakeholders?

Appropriate Technologies for Rehabilitation

Rogers (1982) argued that agricultural innovations have five characteristics that affect their rate of adoption:

- relative advantage (productivity gains)
- compatibility (ecological compatibility to local conditions)
- complexity (consistent with local capacities to adopt; including low risk in adopting)
- trialability; and
- observability

This list is helpful in reviewing the experiences in Lin'an. The mulch technology for Lei bamboo shoot production was rapidly adopted by 90% of households in the villages because it has high productivity gains. The returns on investment in applying the method are predictable and farmers quickly benefit from increased income. The more predictable the benefits of a new technology the more rapidly farmers will adopt it. The technology is simple and was developed on the basis of existing practice, and hence involves just a minor modification of the traditional method. All villagers can understand and use it whether they are literate or not. Mulching involves little risk and so takes into account the vulnerability of poor farmers. Most poor farmers are not innovators because they cannot afford to take risks. The mulch technology fits most of Roger's criteria but it must also be sustainable. Unfortunately, the mulch technology for Lei bamboo is profitable in short-term but was not sustainable in the long run.

Development of Appropriate Technology

Participatory and interdisciplinary approaches are effective ways to generate appropriate technologies. Farmer involvement is particularly important because they fully understand local ecological conditions, socio-economic circumstances, and their technology needs. Technical options identified must be tested with farmers in their fields. In this study farmers were involved in at all stages of research process, from identification and analysis of problems, constraints and options through planning to testing of options and solutions. They helped the researchers improve their understanding of local situations and contributed to the generation of effective strategy packages for the rehabilitation and sustainable management of degraded forests of the villages. The researchers used their knowledge of biological processes and experience from other places to contribute to problem identification and solution generation. The research approaches offer a model for the generation of forest technology in general. It supports the observations by others on participatory technology development (e.g. Rao 1985, Waugh *et al*. 1989, Scoones *et al*. 1993, Chambers 1994a,b,c).

Extension of Forest Technology

Effectiveness of pathways for information dissemination may vary across user groups and areas. A pathway that works well in an area with easy access to transport and mass media may not be effective in more isolated localities.

Our surveys in the villages found that farmers obtain technical information through neighbours, relatives and friends, visits to outside areas and television programs in descending order of importance. They indicated they expect to continue to rely heavily on neighbours, relatives and friends, and visits to outside areas in the future for technical information, probably because they can see the technologies being adopted. They are less confident in those technologies shown on television because their suitability for local conditions may not have been tested. This emphasis on local observation suggests the importance of extension methods such as demonstration plots and demonstration households in the transfer of forest technology.

The surveys also showed three areas of forest extension that need improvement:

- mismatch between the role of the existing technical organisations and farmer demand for extension services;
- insufficient number and limited role of demonstration households; and
- lack of extension organisations at village level.

There are several technical organisations providing extension services at the township level, including the Society of Science and Technology, forestry station, Bamboo Association and Association of Forest Farms. The township Society of Science and Technology is responsible for research and technology related affairs in the township. The township forest station is the lowest level of the Forest Department and has forest extension as one of its responsibilities. The Bamboo Association is made up of bamboo growers and the Association of Forest Farms comprises, on a voluntary basis, those involved with township forest farm, village forest farms and household forest farms plus technical professionals. Both are non-government organisations and were set up to provide members with technical advice and opportunities for information sharing and exchange. Although they have much potential, these four organisations are not effective in providing extension services for villagers as only 8% of households interviewed knew these organisations existed in the township.

Demonstration households play an important part in forest extension in general, and in information dissemination in particular, given the farmers' preference for this type of information source. Several demonstration households have been appointed in Gaohong township but they are insufficient for the role they are supposed to play and lacked institutional support.

Based on this analysis, we tried to improve forest extension in the area by:

- appointing additional demonstration households and empowering existing demonstration households;
- establishing experimental and demonstration plots;
- providing short training courses for farmers;
- enhancing the bamboo and forest farm associations;
- setting up village technical groups, and assisting the formation of a network of extension services comprising township technical organisations, village technical groups and farmer households.

Three additional demonstration households were appointed and one experimental and demonstration plot established in each village to test options identified for sustainable management of degraded forests and as a way of technology transfer. Existing demonstration households were empowered through (1) granting them membership of technical societies at township level or some societies at county level, and (2) providing them with training courses and opportunities for involvement in adaptive research and with some experimental and demonstration projects.

Short training courses were provided for about 3300 villagers and 150 township officials in Lin'an County, covering a wide range of topics such as sustainable rural development, sustainable forest management, non-wood forest products, and other specific forest technologies. The courses assisted dissemination of technical information and development of appropriate technologies.

The Bamboo Association and Association of Forest Farms were enhanced through promoting membership and improving their rules, including requirements for regular meetings. The aim was to support them as functional organisations and to improve their role in extension, materials supply and product marketing.

Lack of technical organisations at village level was addressed by establishing a technical group in each of the three villages as a link between farmer households and the technical organisations at township level. Core members of the village technical group are demonstration households, and other members are representatives of farmers who are innovators or risk-adverse in adopting technologies. The village technical groups were effective in communicating with farmers because it is indigenous and consists of only farmers. They also provided an opportunity for interaction between innovative and less-innovative farmers and an opportunity to transfer technologies to a wide range of farmers. The technical network helped farmers obtain more information and facilitated technology transfer to them from government organizations on the one hand. It also provided feedback to the government organizations on the other hand.

Conclusions

Causes of Forest Degradation

There are more types of forests and a higher proportion of plantations in Zhejiang as a result of prolonged intensive economic activities than at the other three sites of this research. These forests provide villagers with many opportunities for employment and income generation but all forest types are now degraded.

Factors causing forest degradation in Lin'an County varied across forest types. Major causes of timber forest degradation include deforestation, over-dependence on forest, and inappropriate methods of harvesting. Underlying causes of deforestation were development policies such as the 'Great Leap Forward Campaign', and tenure insecurity resulting from land reform policies from the 1950s to the early 1980s. Degradation of Lei bamboo plantations was directly related to poor silvicultural techniques including planting bamboo on unsuitable sites and using the profitable but unsustainable mulching technology. The underlying cause is huge market demand and high prices for Lei bamboo shoots. Conversely, the shrinking demand and falling prices for dried bamboo shoots and tea discourage farmers from properly managing the tea plantations and bamboo forest resulting in low productivity. Degradation of bamboo forest producing dry shoots is exacerbated by poor shoot harvesting methods.

Rehabilitation Strategies

The research provided insights into the problems of rehabilitation of degraded forests and some ways to address them. Timber forest rehabilitation must address disincentives to farmers (tenure insecurity, over-taxation, and restrictive regulations on product harvest and trade) and constraints (landholding fragmentation, and lack of expertise and technology among farmers). Landholding fragmentation is also a constraint to tea plantation management. The action research in Gaohong demonstrated that some of these constraints can be overcome.

Government policies

Farmers' incentives to plant trees and manage forest involve a number of factors, including tenure security; and favourable policies for harvesting, marketing, and taxation of forest products.

Tenure insecurity is an underlying factor in forest degradation and a disincentive to rehabilitation. It discourages farmers from planting trees and managing existing forests sustainably. Deforestation after the adoption of household-based forest management in the mid-1980s is closely related to lack of farmer confidence in the security of tenure of forests allocated to them, a lack of confidence resulting from the radical, frequent changes in polices for forest and land tenure during the period from the 1950s to the early 1980s. Perceptions of tenure insecurity resulting from the many policy changes partially explain why farmers are more interested in bamboo production than timber growing. The long period needed for timber to generate income for investors requires tenure security. Although current policies and law assure farmers of forest tenure security, uncertain factors remain at the implementation level and these need to be addressed by government.

The current restrictive regulations on timber harvesting and high taxation on timber sales are disincentives to farmers in Gaohong to plant timber trees and manage timber forests sustainably. A review and amendment of such government policies could enable farmers to obtain a better return on their forest products and would encourage them to make greater efforts to manage their forests and reduce forest and land degradation. Farmers in the area were highly enthusiastic about bamboo planting rather than timber forest because they do not have problems with harvesting, selling or high taxation of the product.

Common management of household resources

The development and acceptance of household forest farms and shareholding systems in Lin'an County shows that farmers can find acceptable ways to overcome the problems caused by land holding fragmentation. Our research there provided examples of successful common management of household land resources to make a tea plantation of larger scale feasible and more cost effective. It was also possible to get agreement for mountain closure to enable the area to be naturally regenerated with trees.

Appropriate technologies

Technology has an important role to play in rehabilitating degraded forests and plantations. For instance, development of profitable and sustainable technology for Lei bamboo planting, production of quality tea through introducing new varieties and processing methods, improvement of quality of dry shoots by adopting appropriate harvesting and processing techniques. Technologies promoted for forest rehabilitation must be suitable for local ecological conditions and socioeconomic circumstances, and both profitable and sustainable. A technology is not appropriate if it is profitable but not sustainable, as illustrated by the Lei bamboo mulch technology. Improving product quality by technical means may help increase market share of products and so encourage farmers to provide better management of their forests and plantations.

Improved rural services

There are opportunities to improve the management and profitability of forests that are currently degraded. To do this effectively, it is necessary to overcome a range of constraints faced by farmers. Important first steps suggested by the research in Lin'an are better access of farmers to technical advances and market information through improved services. This can be achieved by establishing village technical groups to facilitate communication between farmer households and the technical organisations at township level. Such means are also effective in improving communication among farmers, which provides an opportunity for technology transfer. This is so because the village technical groups formed part of a technical network that helps farmers obtain more technology and market information from government organisations and disseminate among themselves and is able to provide feedback from farmers to the government organisations.

Further ways of improving extension and demonstrating new technologies can include: appointing additional demonstration households and empowering existing demonstration households; establishing experimental and demonstration plots; providing short training courses for farmers; and enhancing local non-governmental organisations such as bamboo and forest farm associations.

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Degradation of forests and forest lands is a problem in many parts of the world and is particularly serious in south China. Chinese forest policy reforms in recent years have enabled rural households to generate income from forests, to own the trees they have planted, and have offered new opportunities to manage forests sustainably. Rehabilitation of degraded forests and forest lands is one of the possible pathways to improve livelihoods of poor farmers and others in the rural communities.

This report documents the results of four case studies in south China in which farmers, local officials and researchers analysed the problems of degraded forests and forest lands, and formulated options for their solution. Opportunities to improve forest management and people's livelihoods are dependent on overcoming a range of biophysical, socioeconomic and political constraints. Action research was used to implement and test some of the options identified. The experience and analysis should be of value for researchers, resource managers and government officials in China and elsewhere to address poverty and environmental concerns through a multidisciplinary, participatory and holistic approach.

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