Chapter II
National overview

Wang Chunfeng[1] and Unna Chokkalingam[2]

[1] *Afforestation Department, State Forestry Administration, 18 He Ping Li Dong Jie, Eastern District, Beijing 100714, China*

[2] *Center for International Forestry Research (CIFOR), P.O. Box 6596 JKPWB, Jakarta 10065, Indonesia*

1. Introduction

China has a long history of forest degradation and rehabilitation[1]. In 1949, the year the People's Republic of China was founded, forests covered roughly 120 million ha or 12.5 percent of the national land area (MOF 1949-1993). At the time, deforestation and land degradation were largely the legacy of agricultural and pastoral expansion, over-cutting for construction and fuelwood and repeated wars (Shen 2003). Over the last 56 years, China has made continuous efforts to rehabilitate its degraded forest lands[2].

Most activities have been carried out by governments at various levels. Since 1998, six key national programs have steered China's forestry development. Five of these programs mainly involve forest rehabilitation. Provincial and local governments have launched their own independent rehabilitation activities in addition to participating in the national programs. Since the 1980s, the private sector[3] and foreign investments have also been increasingly involved. The private

1 See Chapter I for details on rehabilitation terminology.

2 There is no official term "degraded forest land" in China. We calculated degraded forest land to be the sum of five categories of forest land cover in the national inventory: barren land suitable for planting trees, burnt-over forest areas, logged-over areas, barren sandy land suitable for planting trees and *sparse forest*.

3 Private sector here refers to farmers afforesting and managing their allocated lands, and individual investors and private enterprises afforesting and managing leased or subcontracted forest land for their own income. There is no strict recognised definition of private sector in China and many mixed public-private sector institutional arrangements exist in practice.

sector rehabilitates degraded forest lands for commercial purposes, particularly in South China, with enhanced opportunities and policy support through liberalised timber markets and land reforms (Lu *et al.* 2002).

Rehabilitation activities have thus differed widely in the actors involved, their objectives, scale, and funding sources. They have also differed in approaches, institutional arrangements and incentives offered. This chapter provides an historical review of forest rehabilitation in China over the last 56 years based on an assessment of the literature and national forest resource inventories. We look at the development and outcomes of past rehabilitation efforts, the factors driving degradation and rehabilitation including the main policies and identify some key constraints and challenges that China faces to ensure the sustainability of its ongoing and future efforts.

2. Biophysical and socio-economic characteristics

China has a land area of 960 million ha and is administratively divided into 23 provinces, five autonomous regions, four centrally administered municipalities, and two special administrative regions. Within each province are prefectures and cities that are in turn made up of counties, towns and villages. High mountains (with elevations of > 2000 m), plateaus and deserts in the west give way to hills, plains and deltas in the east (Zhang *et al.* 1992). China's population in 2000 was 1.29533 billion, 64 percent of which was rural and 36 percent urban. Average population density was 132 per km^2 in 2000, but distribution is uneven with more people in the east (> 300 people per km^2) and fewer in the west (about 40 people per km^2). The population growth rate is 0.758 percent. Han Chinese make up 91.59 percent of the population and the remaining 8.41 percent is made up of 55 ethnic minority groups. Ethnic minorities occupy some 66 percent of the country's land area, mainly the remote upland forest areas.

The climate is extremely diverse. Most of the country falls within the temperate and subtropical zones with a small tropical zone in the south (Figure 1) (Zhang *et al.* 1992). Minimum winter temperatures range from –27°C in northern Manchuria to 4°C along the middle and lower valleys of the Yangtze River and 16°C farther south. Summer temperatures are more uniform in southern and central China, with a July mean of about 27°C, but northern China has a shorter hot period and the nights are much cooler. Annual precipitation also varies greatly from as high as 1500 mm in the south and southeast, to 600 mm in the north and < 50 mm in northwest China. Approximately 31 percent of the total land area is classified as arid, 22 percent as semiarid, 15 percent as subhumid, and 32 percent as humid.

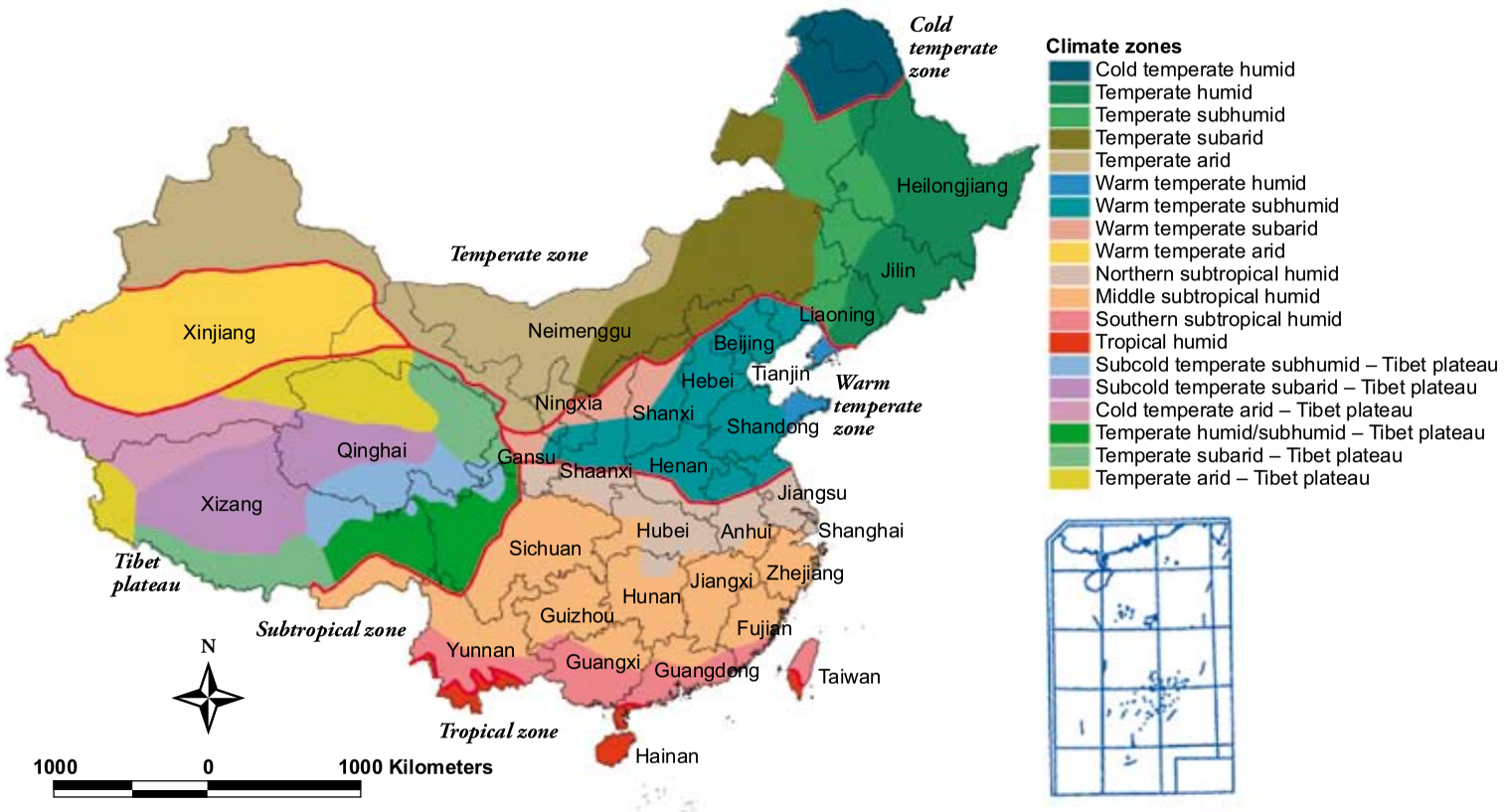

Figure 1. Climatic zones and provinces of China. Source: Geographical Sciences and Natural Resources Research Institute, Chinese Academy of Science, Beijing.

The Chinese economy has been growing rapidly since the reform policy was implemented and the nation opened up to the outside world in 1978; in recent times, the Gross Domestic Product (GDP) has grown 8-9 percent per year. GDP has risen from RMB[4] 362.4 billion in 1978 to RMB 13.7 trillion in 2004 (both figures at current prices) (National Bureau of Statistics 2004). Annual GDP per capita has also risen from RMB 379 to RMB 10,502. The relative GDP contribution of the agriculture, industry and service sectors was transformed from 28:48:24 in 1978 to 15:53:32 in 2004. Forestry is a part of the agricultural sector and an important income source in poor regions. According to Xu *et al.* (2004), forestry accounts for less than one percent of the GDP but meets 40 percent of rural energy needs and provides almost all the timber for construction. It also provides other important commercial products such as bamboo, fruits, spices, resins, edible oils and medicines.

The forest products industry has expanded rapidly since the 1980s with market liberalisation and private investment. Much of the wood (about 44 percent in 2003) is imported due to timber shortages and logging restrictions within the country (Sun et al. 2004). Ten percent of forest product consumption and 50 percent of all timber imports by volume were exported as finished products in 2003. Furniture, paper and plywood were the main forest product exports.

Economic conditions are, however, disparate across the country with eastern China and particularly the coastal areas being well-developed with good transport infrastructure, industry, and intensive agriculture. The southeastern provinces rank among the richest in China. The western region with its high mountains and vast arid areas, rich in natural resources and home to a large share of China's minority cultures, is less developed (Glantz *et al.* 2001). The area has large environmental concerns related to water and soil conservation, desertification and sandstorms. The last Five-Year plan (2001-05) focused on developing the western region and included both infrastructure development and improving the ecological environment (Hou *et al.* 2002). The area is the target of two major forestry programs at present – the natural forest protection program and the sloping land conversion program (Glantz *et al.* 2001).

The general regional land use plan officially designates 257 million ha or 27 percent of the national land area for forestry (Table 1). In 1994-98, forest land was composed of 153.7 million ha of forest, 64.2 million ha of degraded forest land, and the remaining area in shrub land, young plantations and seedling nurseries. Collectives hold and manage 58 percent of the forest land while the state manages the rest through state forest farms and enterprises. From 1981 to 1983, collective

4 Roughly 8.27 Chinese Yuan Renminbi (RMB) per US dollar (USD) in June 2005. The exchange rate was 100 USD to 153 RMB prior to 1981, 100 USD to 320 RMB from 1981 to 1985, 100 USD to 370 RMB from 1986 to 1989, 100 USD to 870 RMB in 1994, and 100 USD to 828 RMB after 1995.

Household forest farm in Guizhou Province. (Photo by Alexander Hinrichs)

forest land was partially reallocated to local farmers or village households to manage and use the resources for roughly 50-70 years. More than half the forest area and 75 percent of the standing timber volume are in the state-owned forest provinces/regions in the northeast and southwest, mainly Heilongjiang, Jilin, Inner Mongolia, Yunnan and Sichuan (Yin 1998). Another 31 percent of the forest area and 15 percent of the timber volume are found in 10 collective-managed forest provinces in the south: Zhejiang, Anhui, Hubei, Jiangxi, Fujian, Hunan, Guizhou, Guangxi, Guangdong and Hainan.

State forests mostly in the northeast and southwest supplied most timber in the past but the yields declined with over-cutting in what were primarily natural forests (Sun *et al.* 2004, Xu *et al.* 2004). Collective forests mainly in the south have increasingly contributed to timber supplies since the 1980s by developing plantations. Of the 7.8 million ha of plantations established in 2002, 81.3 percent were on collective land; overall, 73.6 percent of all China's plantations are on collective land (Miao and West

Table 1. Forest land and ownership in China (Fifth national forest resource inventory 1994-1998, SFA 1994-1998).

Tenure	Forest Land[1]	Total forest[2]	Standing timber volume
	million ha		million m³
State	105.9	63.9	7641.0
Collective	151.1	89.7	3665.3
Total	**257.0**	**153.6**	**11,306.3**

[1] Forest land is the sum of forest, sparse forest, shrub land, young plantations, seedling nurseries, logged-over and burnt-over forest areas, and all other land suitable for planting trees as designated by the different levels of government (Regulations for implementation of the State Forest Law issued in 2000). The total area varies due to forest cover outside state and collective forest lands being included, such as planting along roads and in farm land shelterbelts.

[2] Actual forest cover includes natural and artificial forest with more than 20 percent tree canopy cover (> 30 % prior to 1996). It includes timber, shelterbelt, fuelwood, *economic* (non-wood products) and special purpose forests, as well as bamboo groves and some shrub lands specially prescribed by the State. It also includes tree shelterbelts in farms and trees planted around roads, rivers, houses and villages. Artificial forest is formed through planting and aerial seeding.

2004). In 2002, household forest farms in the south and north plain regions accounted for 43 percent of total timber production, collective forest farms in the south for five percent and state forest farms and enterprises for 52 percent (Sun *et al.* 2004). Many non-timber products (dominated by fruit) and much of the fuelwood also come from collective forests (Miao and West 2004).

China is very rich in biodiversity given its large land area and wide range of climate conditions. There are 599 terrestrial ecosystem types and 32,800 higher plant species, of which, 17,300 are unique to China. This includes more than a 1000 valuable native tree species suitable for timber production and other economic purposes. China has a wide range of forest types stretching from the north to the south (MOF 1949-1993):

- Conifer and mixed conifer and broadleaved forests with tree species such as Faber fir (*Abies fabri*), Chinese spruce (*Picea asperata*), pine (*Pinus*), larch (*Larix*) and Chinese fir (*Cunninghamia lanceolata*) are found in the Da xing an ling to Himalayan mountains and from Taiwan to Artai mountains in the Xinjiang Uigur region.
- Deciduous broadleaved forests with *Fagaceae, Betulaceae,* willows (*Salix*), *Corylaceae, Ulmaceae, Aceraceae* and *Tilia* species are found in the middle to high mountains and sub-alpine zones of the temperate and subtropical regions.
- Evergreen broadleaved forests with genus such as *Cyclobalanopsis, Castanopsis* and *Lithocarpus* are mostly found in lower hills and middle-high mountains of the mid-subtropical region.
- Monsoon evergreen broadleaved forests with *Lauraceae, Magnolia, Theaceae, Myrtaceae* and *Caesalpiniaeceae* as well as *Cyclobalanopsis, Castanopsis* and *Lithocarpus* species are mainly found in the lower hills in the southern subtropical region.
- Sclerophyllous forests with species such as *Quercus semicarpifolia* and *Quercus aquifolioides* are found in middle-high mountains, the sub-alpine zone and dry and hot river valleys of the western subtropical region.
- Monsoon rain forests and rain forests with species in the families *Dipterocarpaceae, Moraceae, Sterculiaceae, Guttiferae, Meliaceae* and *Anacardiaceae* are found in the tropical region in southwestern and southern China as well as Taiwan.
- The tropical coasts in the far south have mangrove forests with tree species such as *Kandelia candel, Rhizophora* and *Bruguiera gymnorhiza.*
- The coral islands of Hainan province also have evergreen forests with species such as *Guettarda speciosa* and *Jatropha curcas*.
- Bamboo forests with 40 genus and more than 400 species are mostly found in the subtropical region. The most common bamboo species is *Phyllostachys pubescens.*

3. Historical review of forest rehabilitation

3.1 Early efforts (1949-1980)

In general, over the past 50 years, China has put in substantial effort to rehabilitate its forest lands. In the early 1950s, wood production was the forestry department's priority; forest rehabilitation was limited and had little funding support. The limited rehabilitation activity from 1949 to 1952 established 889,333 ha of shelterbelt forest in northern China. The focus was on some key areas in northern Shannxi, north to central Hebei, eastern Henan, the western part of the northeastern region and the northern coast of Jiansu Province that were affected by severe runoff, soil erosion, drought and sandstorms. After 1954, timber development was prioritised, and plantations were established in the southeastern provinces. For example, in 1955, a total 1.71 million ha of forest land was rehabilitated, of which timber forest accounted for 55 percent (MOF 1949-1986).

In the 1960s, along with the continued establishment of shelterbelt forests, timber plantation development was accelerated. Shelterbelt forests were located in northeastern and northwestern China, the loess plateau, and some coastal areas suffering from typhoons and flooding from torrential rain. In 1964, a regulation was issued to fund regeneration in the collective forest region and the Ministry of Forestry planned to establish 240 patches of timber plantations primarily in the southeastern provinces. Provinces in southern China responded by establishing Chinese fir plantations. However, during the Cultural Revolution from 1966 to 1976, most forest management agencies functioned poorly and plantation establishment almost stopped. At the same time during the 1960s, aerial seeding proved effective after many trials and helped to speed up forest rehabilitation in Guangdong, Sichuan and then parts of central and northern China (Li 1985).

In the early 1970s, timber plantation establishment was prioritised over protection forest, especially in the subtropical region, to meet increasing wood demand for national economic development. In 1974, the Central Government planned to establish 6.67 million ha of timber plantations within 10 years, with Chinese fir as the dominant species. From 1976, the Government invested 20 million RMB annually in collective-owned forest farms in southern China for this purpose. A total 6.53 million ha of timber plantations were established in 528 counties across 13 provinces in the south from 1973 to 1980, almost reaching the national 10-year target in just seven years (Li 1985).

In 1971, the plain regreening project was also launched with shelterbelts established around farmland, water canals, roads, villages and houses to alleviate

frequent sandstorms and dry hot winds. By the end of 1985, a shelterbelt network of about 7.2 billion trees protected 1.07 million ha of croplands on the plains. In 1978, when the Cultural Revolution ended and the forestry administration was revived, a shelterbelt forest program in the Three-North region was initiated and integrated into the national economic development plan (MOF 1949-1986).

Overall from the 1950s to the 1970s, 23.69 million ha were afforested as shelterbelts to alleviate sandstorms, runoff and soil erosion; or for timber production. Rehabilitation was primarily funded through government subsidies and compulsory labour from local people (Li 1985). Species planted in shelterbelts included willows, poplar (*Populus*), elm (*Ulmus*), ash (*Fraxinus*), Mongolian Scots pine (*Pinus sylvestris*), Chinese arbor (*Platycladus orientalis)*, black locust (*Robinia pseudoacacia*), horsetail beefwood (*Casuarina equisetifolia)*, Japanese black pine (*Pinus thunbergiana)*, water larch (*Metasequoia glyptostroboides*), pond cypress (*Taxodium ascendens*) and various shrubs.

Species planted in timber forests included Korean pine (*Pinus korariensis*), Chinese pine (*Pinus tobulacformic*), Chinese fir, Masson pine (*Pinus massoniana*), *Paulownia*, larch and bamboo. Exotic tree species such as *Eucalyptus*, slash pine (*Pinus elliottii*), loblolly pine (*Pinus taeda*), Caribbean pine (*Pinus caribaea*), Italian poplar (*Populus canadensis*) and teak (*Tectona grandis*) were introduced from Australia, Italy, America, Cuba and India, and planted for timber in the southeastern provinces, mainly Hunan, Hubei, Jiangxi, Fujian, Guangdong, Guangxi, Sichuan, Yunnan and Hainan.

3.2 Large national forestry programs from the 1980s

In the 1980s, the launching of a series of nationwide programs accelerated forest rehabilitation. In 1980, the Government enhanced cooperation between the Ministry of Forestry and the local provinces to strengthen timber plantation development. A national compulsory tree-planting campaign was initiated in 1981 requiring all citizens over 11 years old to plant 3-5 trees annually. From 1981 to 2005, a cumulative total of more than 9.9 billion people participated and more than 47.1 billion trees were planted across China under this campaign. From 1984 to 1989, four key programs were launched: the Taihang Mountain greening program; coastal shelterbelt forest program; the national plan to establish 6.67 million ha of fast-growing, high-yielding forest plantations; and the shelterbelt forest program along the upper and middle reaches of the Yangtze River valley. The plain regreening program was also accelerated in 1988 through a new targeted national plan.

In 1989, the first national plan on *afforestation*[5] and regreening from 1989 to 2000 was approved, and this plan integrated all rehabilitation activities. A nationwide campaign to regreen barren mountains followed, with provincial and local governments encouraged to take responsibility for regreening barren mountains in their administrative regions. Guangdong Province was the first to totally regreen barren mountains where trees could be planted. Subsequently 11 other provinces — Fujian, Hunan, Jiangxi, Anhui, Jiansu, Guanxi, Zhejiang, Shandong, Hubei, Hainan and Jilin — also fulfilled their *afforestation* and regreening targets. The campaign greatly increased forest cover within a short period but most of the new forests had very poor timber quality and were vulnerable to pests and fire. During this period, rehabilitation for both timber and environmental purposes was important (MOF 1999).

In the early 1990s, five additional national programs were initiated: the program on combating national desertification; and the development of shelterbelt forests in the Huaihe River and Taihu Lake basin, and the Yellow, Liaohe and Pearl River valleys. The average annual area afforested was four million ha during the 1990s. Ten of the 11 national forest rehabilitation programs launched since 1978 were aimed at environmental security in response to frequent floods, drought, sandstorms, typhoons, water runoff and soil erosion; and one program was aimed at supplying timber. The key rehabilitation programs from 1978 to 1998 are described in Annex 1.

In 1998, the Government implemented the policy to stimulate national economic growth through enhanced government fiscal investment in infrastructure and ecosystem recovery projects. Such projects they believed could ultimately support sustainable industrial development and resource exploitation. The focus was particularly on western China where environmental and economic conditions were fragile. The original 11 forestry programs were regrouped into six key programs covering 97 percent of the country's counties and integrated into the national plan for social and economic development. Of the six programs, five focus mainly on forest rehabilitation, with plans to build 92 million ha of plantations between 2001 and 2010 with a total investment of billions of RMB. These include the natural forest protection program, the sloping land conversion program, the desertification control project, the key shelterbelt project along the Three-North region and the Yangtze River valley as well as other regions, and the forest industrial base project. The high investment level and large scale and scope of the projects are unprecedented. In recent years, approximately 6.7 million ha

5 *Afforestation* includes forest establishment through planting trees, aerial seeding or *mountain closure* on barren mountains, barren sandy land, *sparse forests*, burnt-over and logged-over forest areas, and some shrublands and grasslands. It also includes planting trees along roads and rivers, around houses and villages and as shelterbelts in farms. The term "*afforestation*" as used in China includes regreening recently deforested areas.

Area newly planted for sand control in Hebei Province. (Photo by Lu Shaobo)

have been rehabilitated to forest annually. Again, ecosystem recovery was a key driver, with five of the six programs aimed at environmental improvement and the last on establishing a forest industrial base. The five rehabilitation-related programs are detailed in Annex 2.

The national programs were each spread out over many counties and provinces (Table 2). Programs prior to 1998 had *afforestation* targets of less than four

Young mixed plantation of Poplar and Japansese pagoda trees for sand control in Hebei Province. (Photo by Lu Shaobo)

Table 2. Scale and duration of the national forest rehabilitation programs since 1978. (Sources: Zhang 1997, SFA 1998, Zhou 2001)

No	Programs/ Projects	Duration (years)	No. of counties	No. of provinces	*Afforestation* target (million ha)
	Early programs: 1978-1998*				
1	Three-North shelterbelt (1978-2050)	73	551	13	35.6
2	Yangtze River shelterbelt (1989-2010)	20	271	12	20.0
3	Coastal shelterbelt (1988-2010)	22	195	11	3.5
4	Pearl River shelterbelt (1995-2000)	5	177	4	1.2
5	Combating national desertification(1991-2050)	59	598	27	47.1
6	Taihang Mountain greening (1986-2000)	14	110	4	3.9
7	Yellow River shelterbelt (1996-2010)	15	177	6	3.1
8	Huaihe River & Taihu Lake shelterbelt (1995-2005)	10	208	7	1.0
9	Liaohe River shelterbelt (1995- 2005)	10	77	4	1.2
10	Plain regreening (1987-2000)	23	918	26	No exact figure
11	National Afforestation Project (1990-1997)	7	306	16	1.0
	Consolidated programs: 1998 onwards**				
1	Natural forest protection (2000-2010)	10	799 counties/ forest farms +102 state enterprises	17	12.7
2	Sloping land conversion (2001-2010)	10	1596	30	32 (of which, 15.3 is in Phase 1)
3	Desertification control - Beijing & Tianjing city (2001-2010)	10	75	5	7.57
4	Key shelterbelt along the Three-North region and the Yangtze River valley as well as other regions (2001-2010)	10			27.0
5	Forest industrial base (2001-2015)	15	886 + 114 forest farms or enterprises	18	13.3

* The figures are based on the original plans.

** The programs from 1978-98 were integrated into the current six programs/projects. Only the five rehabilitation-related programs are included here. These figures are based on revised plans.

million ha with three exceptions. The consolidated programs from 1998 onwards have higher *afforestation* targets ranging from 8-32 million ha. The current forest industrial base development project extends beyond the subtropical to tropical provinces with their favourable site and economic conditions, to the northern plain and the state-owned forest regions of inner Mongolia and the northeast. *Afforestation* programs aimed at protecting against natural disasters and improving environmental conditions are in the major river valleys and plains scattered throughout China, along the coastline and in the steep western mountains. Desertification and sandstorm control projects are mainly located in the northwest. The natural forest protection program (with a logging ban and a rehabilitation component) covers the remaining natural forest areas in China; including the upper reaches of the Yangtze River; the upper to middle reaches of the Yellow River; and the state-owned forest regions of inner Mongolia, the northeast, and the northern part of Xinjiang Uygur Autonomous Region.

Tree planting, *mountain closure*[6] and aerial seeding all appear to be important revegetation techniques considered in the large national programs (Figure 2). Aerial seeding is suitable for rough terrain and remote areas in regions with >

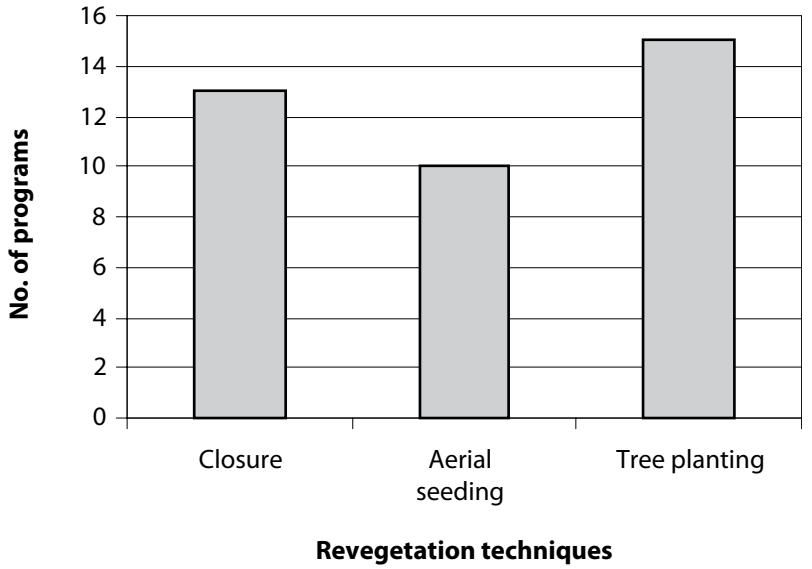

Figure 2. Revegetation techniques used by 10 national programs from 1978-98 (excluding the earlier combating national desertification program) and five consolidated programs since 1998. Sources: (Zhang 1997, Zhou 2001)

6 "*Mountain closure*" means closing public access to degraded forests and forest land with natural regeneration capacity to enable natural forest recovery.

300 mm rainfall. *Mountain closure* is an inexpensive, low-labour demanding and efficient technique of forest regeneration practiced in China since ancient times.

Pines and poplars were the most common candidate tree species spanning a range of locations. The Yangtze River shelterbelt program also included Chinese fir, broadleaf species and a mix of bamboo and cash crop trees. The coastal shelterbelt forest program, learning from experience since the 1950s, also considered hardy species such horsetail beefwood, mangrove and shrubs as well as commercial coconut and agroforestry species for local people. A mix of candidate species was listed for five programs in the northern and northeastern plains, river valleys and mountains, including cypress (*Cupressaceae*), black locust, sea buckthorn (*Hippophae rhamnoides*), shrubby amorpha (*Amorpha fruticosa*) and apricot (*Prunus armeniaca*), besides the pines and poplars. The National Afforestation Project focused on timber production with candidate species such as pines, poplars, Chinese fir, larch, black locust, *Eucalyptus* and other broadleaf species. Species like larch, *Eucalyptus* and *Acacia* are also considered in the forest industrial base project. However, listing candidate tree species does not mean that they were all planted. Only a few species are actually used in any given rehabilitation project for various reasons such as high seedling prices, lack of technical knowledge, mismanagement and limited suitable tree species for some areas with poor site conditions.

3.3 The evolution of local, private sector and foreign-funded efforts

Besides the national level programs, some provinces also adopted their own independent initiatives for ecosystem restoration and city greening with local government funding. For example, in 1998 the Yunnan Government decided to construct a shelterbelt forest along the upper and middle reaches of the Nan Ting He River in Lin Cang county with 58.6 million RMB of planned investment. The project aims to establish 13,000 ha of new forest, protect 20,000 ha of current forest, and thus increase forest cover in the project area from 28.9 percent to more than 50 percent (SFA 1999-2000). As two special economic zones, the governments of Shenzhen and Zhuhai cities in Guangdong Province actively initiated city-greening projects for environmental purposes and aesthetics (MOF 1999, Chapter III).

Forest development and utilisation have been shifting more and more from the state sector to the private sector since the 1980s with liberalised markets, investment support, technical assistance, opportunities to lease land for tree planting, longer leases and contracts, and liberty to trade and auction use rights (Lu *et al.* 2002, Xu *et al.* 2004). Different provinces and counties have adopted their own approaches based on the national reform framework. In the southeast

(Left) Small-scale timber production in Anhui Province (Photo by Alexander Hinrichs), (Right) Fragrant pear grown in Xinjiang Uighur autonomous region (Photo by Yu Yanling)

collective region, which has been traditionally favoured for wood production, private forest rehabilitation efforts are being accelerated by company-community partnerships, more flexible management allowed by governments, and reduced timber taxes and fees. However, non-timber sectors such as *economic forests* and bamboo plantations experienced greater success and expanded rapidly given less restrictive regulations, shorter-term returns and faster market development than for timber (Xu *et al.* 2000, Xu and White 2001, Cai *et al.* 2003). With economic reform and the Central Government's opening-up policy, China and particularly the southeast collective region have been the focus of international investment in commercial plantation development by some transnational corporations such as the Singapore-based Asia Pulp and Paper Co. Ltd. and Finland-based Storaenso Co. (Lu *et al.* 2002).

In the 1998 Forestry Law, the Government announced its intention to set up the forest environmental benefit compensation fund[7]. Forest lands were then classified into "ecological" and "commercial" based on their location and site characteristics. Roughly 30 percent or 57.3 million ha, were to be set aside as *ecological forests*[8] and would be rehabilitated and managed as such. Based on national financial reform and classified forestry management policies, rehabilitation for environmental purposes was to be mainly funded through government budgets,

7 The forest environmental benefit compensation fund is equivalent to the term "Payment for Environmental (or Ecosystem) Services" used elsewhere.

8 *Ecological forests* or non-commercial forests are for the purpose of maintaining and improving the ecological balance and the environment, conserving biodiversity, and providing non-timber forest products.

while commercial forests were to be developed more and more by the private sector through market mechanisms. Discussions are also ongoing regarding ways to fund *ecological forest* management through market mechanisms. End users of forest services such as water, biodiversity, carbon, tourism and hydropower and other actors could possibly share the costs. Several *afforestation* projects under the Clean Development Mechanism are under preparation and one will be registered soon.

Also since 1978, more than 20 foreign countries and international organisations have set up cooperative relationships with Chinese national and provincial forestry departments. The partners include Italy, Australia, America, Canada, Germany, France, Japan, South Korea, Sweden, Finland, Netherlands, United Nations Development Program (UNDP), Food and Agriculture Organization of the United Nations (FAO), International Tropical Timber Organisation (ITTO), Global Environment Facility (GEF), World Bank and World Wide Fund for Nature (WWF). Besides the World Bank loan for the National Afforestation Project from 1990 to 1997, by 2003, 822 million USD (6.8 billion RMB in 2005) in foreign grants had flowed via various channels to support Chinese forestry development (Liu 2004). At present, 122 projects with 230 million USD (1.9 billion RMB in 2005) in foreign grants are being implemented. Of the 122 million USD (450 million RMB in 1986) in foreign grants from 1981 to 1986, around 78 percent was used in forest rehabilitation activities (i.e. *afforestation* and forest cash crop development) (Table 3) (MOF 1949-1986).

Table 3. Focus of foreign grants for forestry from 1981 to 1986 (MOF 1949-1986)**.**

Focus of foreign grants	Funding amount (USD)	Percentage
Afforestation	78,982,480	64.7
Forest for special use (fruits, nuts, etc.)	15,859,000	13.0
Forest resource management	7,691,000	6.3
Forest protection	6,314,880	5.2
Comprehensive wood utilisation	5,061,903	4.1
Study of main tree species planted	3,567,117	2.9
Management and protection of wildlife	2,912,000	2.4
Study and application of new techniques	794,116	0.7
Other	881,816	0.7
Total	**122,064,362**	**100.0**

Two examples of foreign-funded rehabilitation projects are described in the boxes below. Most foreign-aided projects were managed independently, although some were implemented in domestic project areas.

Forest rehabilitation projects funded by the German Government

The German Government has supported Chinese forest rehabilitation since the start of the Sino-German forest rehabilitation program in 1993. The program covered some 90 counties in 14 provinces (autonomous regions and municipalities) in the Yangtze and Yellow River valleys which are less developed and suffer from poverty and severe environmental problems such as runoff and soil erosion. Ten of these provinces are currently implementing the project's first phase while four have moved into the second phase. Project durations average eight to 10 years, with forest rehabilitation activities being completed within four to five years. The total budget is 2.012 billion RMB, with 1.173 billion RMB in German grants and 839 million RMB in Chinese matching funds. Local farmers' labour inputs account for 218 million RMB. To date, the German Government has allocated 534.77 million RMB, the Chinese Government 490 million RMB with 174 million RMB from local farmers' labour. Up to now, 381,780 ha of forest have been established (Su *et al.* 2003).

FAO-funded forest rehabilitation project

The Chinese Government set up six forest rehabilitation projects with the help of FAO from 1982 to 1987, involving 11 counties in Ningxia, Shandong, Sichuan, Hunan, Liaoning and Hebei provinces and one nature reserve in Sichuan Province. The total investment was roughly 91.6 million USD (338.9 million RMB in 1986). The project aimed to afforest 572,900 ha, plant grass on 68,450 ha, improve and regenerate 16,000 ha of degraded Oiltea Camellia (*Camellia oleifera*) stands, build up 202 km of roads and a small scale hydropower station and 29,876 check dams for water and soil conservation (MOF 1949-1986). The seeds of the shrub Oiltea Camellia are extracted for high-value edible oil used for cooking and in making cosmetics in the mountains of the subtropical region. When the project ended, 43,000 ha of shelterbelt forest, 11,500 ha of fast-growing plantations, 45,500 ha of grassland and 16,000 ha of Oiltea Camellia had been planted and improved. Forest cover in Xiji county of NingXiaHui autonomous region had increased from 3.3 to 21.8 percent, and in Gongxian county of Sichuan Province, from 19.7 to 26.4 percent. The newly established forests protected more than 14,000 ha of agricultural land (Li 1985).

4. Achievements and impacts

4.1 Rehabilitation targets and forest cover change

Efforts from the 1950s to 1970s (23.69 million ha rehabilitated as shelterbelts or for timber production) were not visible on the ground as a net increase in forest cover (Figure 3: MOF 1949-1993, SFA 1994-1998). Considerable deforestation continued during the same period, and not much attention was paid to long-term sustainability of the rehabilitated areas. Forest cover actually declined by

6.64 million ha between 1950-62 due to improper forest management and over-cutting during the industrialisation period or Great Leap Forward movement which started in 1958 (Shen 2003). Forest cover declined again from 121.86 million ha in 1973-76 to 115.28 million ha in 1977-81 due to the Cultural Revolution (1966-76), which affected forests on a national scale.

Forest cover has been on the rise since the 1980s, mostly through rehabilitation of degraded forest land. From 1978 to 2000, roughly 41.3 million ha were rehabilitated through the 11 national rehabilitation programs according to SFA (2004) (Table 4). Project reports had higher figures for area afforested but national

Table 4. Area planted as compared to *afforestation* target in national programs since 1978 (SFA 2004).

No	Programs	*Afforestation* target (million ha)*	Area rehabilitated (million ha)**
	Early programs: 1978-1998		
1	Three-North shelterbelt (1978-2050)	35.6	27.6 (1978-2000)
2	Yangtze River shelterbelt (1989-2010)	20.0	5.0 (1989-2000)
3	Coastal shelterbelt (1988-2010)	3.5	1.1 (1988-2000)
4	Pearl River shelterbelt (1995-2000)	1.2	0.16 (1995-2000)
5	Combating national desertification (1991-2050)	47.1	1.1 (1993-2000)
6	Taihang Mountain greening(1986-2000)	3.9	3.6 (1984-2000)
7	Yellow River shelterbelt (1996-2010)	3.1	0.5 (1996-99)
8	Huaihe River & Taihu Lake shelterbelt (1995-2005)	1.0	0.2 (1995-99)
9	Liaohe River shelterbelt (1995- 2005)	1.2	0.22 (1995-99)
10	Plain regreening (1987-2000)	No exact figure	0.42 (1993-2000)
11	National Afforestation Project (1990-1997)	1.0	1.4 (1990-97)
	Consolidated programs: 1998 onwards* **		
1	Natural forest protection (2000-2010)	12.7	3.68 (1998-2003)
2	Sloping land conversion (2001-2010)	(15.3 1st phase)	12.2 (2000-03)
3	Desertification control - Beijing & Tianjing city (2001-2010)	7.5	2.16 (2001-03)
4	Key shelterbelt along the Three-North region, the Yangtze River valley and other regions (2001-2010)	27	8.2 (2001-03)
5	Forest industrial base (2001-2015)	13.3	0.65 (1998-03)

* The figures are based on the original plans.

** Also includes area rehabilitated in pilot phases prior to official commencement of projects.

***Only the five rehabilitation-related programs are included here.

statistics from a single report have been used here for consistency. Degraded forest land decreased from 101.5 to 64.2 million ha between 1973-76 and 1994-98 (Figure 3). Annually afforested area in the 1990s as a result of the national and provincial programs reached four million ha on average (MOF 1999) and a 38.35 million ha increase in forest cover was registered from 1977-81 and 1994-98. However, over-logging and degradation have continued at the same time in mature natural forests and state-run logging enterprises faced financial crises as timber volumes declined (Weyerhaeuser *et al.* 2005).

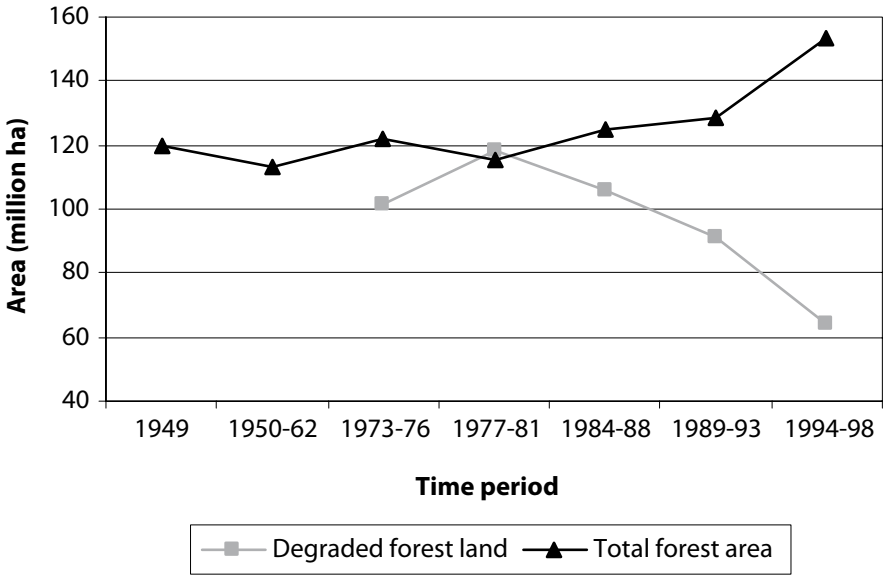

Figure 3. Trends in forest area and degraded forest land in China (MOF 1949-1993, SFA 1994-1998).

Note: The definition of forest was changed from 30 percent to 20 percent tree canopy cover in 1996 and thus the rise in forest cover from 1989-93 to 1994-98 is slightly inflated.

Rozelle *et al.* (2003) estimated that 27 million ha were rehabilitated to forest from 1980-93: timber and protection forest (14 million ha), shelterbelt (six million ha), *economic plantations*[9] (five million ha) and fuelwood forest (two million ha). However, nine million ha of natural forest were lost in the same period and seven million ha logged and converted to plantations.

However, most of the 11 programs from 1978-2000 were not on track in terms of meeting their *afforestation* targets on time (Table 4, details in Annex 1). Exceptions were the Three North shelterbelt program, the National Afforestation Project and

9 *Economic forests or plantations* are for non-wood products such as fruits, edible oils, beverages, fodder, medicines, spices and industrial materials like rubber for cash income.

possibly the Taihang Mountain greening and plain regreening programs. Detailed feasibility analysis was not undertaken at the planning stage to set realistic targets and plans were changed frequently. The Pearl River shelterbelt program was constrained by a three-year delay and low investment. Only pilot trials were implemented in the Huaihe River and Taihu Lake shelterbelt program. But as part of the nationwide campaign to regreen barren mountains launched in 1989, 12 provinces fulfilled their tasks.

The five consolidated national programs since 2000 have resulted in 6.7 million ha being rehabilitated annually (SFA 2000, 2001a, 2002, 2003 and 2004). Four programs were on track and possibly the fifth as well in terms of achieving their *afforestation* targets within the time planned (Table 4). The forest industrial base project reports a rehabilitated area of only 0.65 million ha but this is probably a vast underestimate due to data from private sector plantations not being readily available.

4.2 Survival, forest type and condition

Nationwide average survival rates one year after planting has improved from 55 percent before 1985, to 87 percent in the mid 1990's and higher than 90 percent in 2003, due to the strict quality checks undertaken since 1988. Average survival rate three years after planting was 75-80 percent in the 1990s (Xu 2003). A 40 percent survival rate of planted trees was sufficient for the area to be counted as successful *afforestation* in the national statistics prior to 1985. Now survival rates of more than 85 percent (in high rainfall areas) and 70 percent (< 400 mm rainfall areas) are required to be included.

Most of the forest area increase was in artificial forest (through planting and aerial seeding) which rose from 23.69 million ha in 1973-76 to 46.66 million ha in 1994-98 (MOF 1949-1993, SFA 1994-1998) (Figure 4). Artificial forests made up 30 percent of China's total forests in 1994-98 and China has the largest artificial forest area in the world. Natural forest showed an overall decline from 1973 to 1993, indicating that overlogging was continuing. Natural forest area increased from 1993 to 1998 with protection of existing natural forest areas and attention paid to natural regeneration.

Although rehabilitation over the past several decades has succeeded in increasing forest cover, the quality of forest resources and age structure shows a general declining trend. First, substantial areas have poor growth and timber volumes as well as stem deformities. Growth increments in planted forests are 3-3.5 m^3 per ha per annum (Bull and Nilsson 2004). Declines in yield with subsequent rotations are evident. Standing timber volume per hectare of forest and total timber growing stock was decreasing up to the late 1970s but increased thereafter,

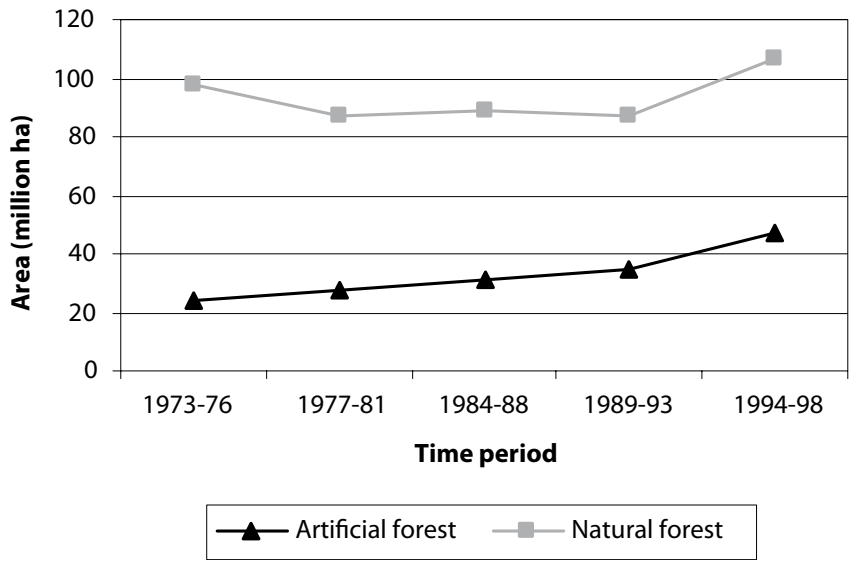

Figure 4. Trends in artificial and natural forest area from 1973-76 to 1994-98 (MOF 1949-1993, SFA 1994-1998).

though total timber growing stock declined again in 1994-98 (Table 5). Available mature forest resources for timber production continued to decrease despite an increase in forest cover. Most of the forest was very young. In 1994-98, standing timber volume was only 35 m^3/ha in artificial forest and 91 m^3/ha in natural forest.

Second, the structure and composition of the forest stands was also very simple with more conifers and fast growing species, and fewer broadleaved and high value timber species (Li 2004). The proportion of mixed forest was low and diversity

Table 5. Standing timber volume per hectare of forest, total timber growing stock and area in mature forest.

Period	1949	1950-62	1973-76	1977-81	1984-88	1989-93	1994-98
[1]Standing timber volume (m^3/ha)	90	90.12	71.03	69.21	73.3	75.8	78.06*
[2]Total timber growing stock (billion m^3)	11.6	11.0	9.5	10.3	10.6	11.8	11.3*
[3]Mature and over-mature forest area (million ha)	~ 48	42	28	22	14	13	13*

[1] Growing stock on forest land divided by forest land area. MOF (1949-1993), SFA (1994-1998).
[2] MOF (1949-1993), SFA (1994-1998).
[3] Shen (2003)
* Based on new definition of forested area (> 20 percent canopy cover). Before, it was > 30 percent.

Chinese fir plantation in Hunan Province. (Photo by Li Xiquan)

was reduced. For example, from the 1970s to 1980s, Chinese fir and Masson pine were widely selected as dominant species for timber plantations in the subtropical region, resulting in trends towards more coniferous forest in some areas (Sheng 1997). Table 6 provides statistics on artificial forest composition in five typical subtropical provinces.

Plantations with single species and simple structures were not effective in watershed protection and soil conservation. It is very common in the subtropical region that canopy cover is high but soil erosion below is still very severe. In recent years, large-scale clearing of secondary forests took place in the southern provinces to establish fast-growing and high-yielding forest plantations as well as *economic plantations*

Table 6. Artificial forest composition in six typical subtropical provinces in 1989-1993 (Sheng 1997). Unit: 100ha.

Provinces	Total artificial forest area	Conifer forest area	Broadleaf forest area	Broadleaf (%)/ Total
Fujian	13143	12591	552	4.2
Zhejiang	8077	7981	96	1.2
Jiangxi	8300	8156	144	1.7
Guangdong	14682	12571	211	4.4
Guangxi	8544	8208	336	3.9
Hunan	11957	11303	672	5.6

(Sun 2004). Site preparation activities, species planted and the presence and nature of ground vegetation and litter could have an important effect on soil properties and erodability (Huang *et al.* 2004, Jia *et al.* 2005, Wang *et al.* 2005, Yang *et al.* 2005, Zheng *et al.* 2005). For example, a lack of ground vegetation and litter could increase soil erosion (Jia *et al.* 2005) while soil compaction during land preparation could increase surface runoff (Yang *et al.* 2005). A survey in Fujian Province shows that without rotational cultivation, soil nutrients decrease by 10-20 percent in second-generation Chinese fir plantations and by 40-50 percent in third-generation plantations (Sheng 1997). Shelterbelt forests, however, did help to check soil erosion where established (Rozelle *et al.* 2003).

Monocultures also tend to be less resistant to pests and diseases and natural disasters. Poplar trees planted in the Three-North shelterbelt program were devastated by beetles and insects while diseases caused severe damage in the coastal shelterbelt forest program. Insect infestations have damaged more than 9.3 million ha of forest annually (Li 2004).

4.3 Forest production and socio-economic impacts

Rehabilitation projects have had both positive and negative impacts on production and socio-economic aspects though studies are needed to clearly identify the effects. Reviews of social impact are currently being undertaken on sample sites for the five consolidated rehabilitation projects. Specific program outcomes mentioned in the following three paragraphs are taken from project reports (details in Annex 1).

The Three-North shelterbelt program was able to harvest 5.47 million tons of fuelwood annually from 911,752 ha of fuelwood forest, and from tending and pruning. It could provide six million farmer households with fuelwood, as well as business opportunities and jobs from the forest products generated. In the coastal shelterbelt program, the output value from timber and *economic plantations* rose from 1.334 billion RMB to 8.881 billion RMB from 1987 to 1999. In the plain regreening program, timber demand eased and local incomes increased. *Economic plantations* contributed to increased household income in some areas in the Taihang Mountain greening program. In 2000, overall production from *economic plantations* in China reached more than 67 million tons, with fruit alone making up 62.25 million tons (SFA 2001a). The total output value was 12.752 billion RMB.

Besides the above, improvement in local income was also stated in the reports of the Yangtze and Yellow River shelterbelt programs, the sloping land conversion, the National Afforestation and the Pearl River shelterbelt programs. However, local incomes improved mainly through job opportunities in the rehabilitation

process in the Yellow River shelterbelt and the National Afforestation programs, and through fixed-term grain and cash subsidies for farmers participating in the sloping land conversion program. Income from the job opportunities is also limited and wages vary among regions, though wages have generally increased with increased investment in rehabilitation.

In general, many programs (Yangtze River shelterbelt, Three-North shelterbelt, plain regreening) have faced problems with rehabilitated areas being destroyed due to lack of genuine participation and stake, local needs not being considered, unstable tenure and poor economic incentives, and limited and unstable funding that impedes long-term protection and maintenance. In the desertification control project, continued over-grazing, reclaiming arable land, over-cutting for fuelwood and over-collecting herbal medicines resulted in severe damage. Some recent programs such as the desertification control and natural forest protection programs also involve relocating people from the area to be rehabilitated.

Numerous reviews suggest that the sloping land conversion program, often in combination with the natural forest protection program, is already running into many implementation and sustainability problems (Lele and Shen 2001, Colchester 2002, Xu 2002a, Shen 2003, Weyerhaueser *et al.* 2005). The program has had some negative impacts on livelihoods of mountain communities in some regions. The program aimed to improve the natural environment while increasing farmers' income, and farmers' participation was to be solicited. However, local forestry administrations find it difficult to meet the high targets with the low funding and short time available, let alone be sensitive to local farmers' needs. With tight local government budgets, they cannot provide the counterpart funds to match the Central Government investment. The target-driven approach has been imposed without considering local farmers' interests and views. Farmers have lost their current income opportunities, and compensation levels are low and only available for 5-8 years. Alternative livelihoods are not provided for beyond the compensation period and farmers are unsure about the survival and marketability of the species planted. Technical support is limited. The risk is high that farmers will revert to former land use practices once the program ends.

4.4 Protection functions

According to project reports[10], the plain regreening, Three-North and coastal shelterbelt programs have respectively protected some 32.5 million ha, 21.3 million ha and 400,000 ha of farmland (details in Annex 1). The program on combating national desertification helped improve 472,000 ha of arable land.

10 Environmental outcomes provided in project reports are based on expert evaluations in some instances but may not be very formal scientific reviews. The level of seriousness varies from province to province.

Soil erosion was reduced by 21.96 million and 0.1 billion tons per annum in the Yellow River shelterbelt and the National Afforestation programs respectively, and by 390 million tons/ha/annum in the Huaihe River and Taihu Lake shelterbelt program. However, Yin (1998) indicates that the gains in these areas were more than offset by increased erosion elsewhere, such as in the Yangtze and Haihe River basins.

According to the project report, the Yangtze River shelterbelt program enhanced dramatically the capacity to resist natural disasters such as floods and improved the functioning of the watershed infrastructure such as dams and irrigation systems (Zhang 1997). However, the reported flooding outcomes are not supported by detailed investigations.

Increases in grain yield were reported in the Three-North, Yellow River and coastal shelterbelt programs as a result of the shelterbelt protection and reduced soil erosion. In the National Afforestation Project, water shortages in some local rivers were resolved. Other authors suggest the overall environment continued to deteriorate despite the rehabilitation efforts (Shen 2003). Apparently planted forest structure was simple and often followed by degradation through grazing, agriculture and other pressures in the Yangtze River area.

According to the project reports, increased wildlife species were observed in the sloping land conversion and the Yangtze River shelterbelt programs. Sayer and Sun (2003) suggest that the natural forest losses and conversion to plantations reduce biodiversity, but beyond that the impacts of the rehabilitation efforts on wildlife habitat and biodiversity are unclear. New forests are often created on open barren land, potentially having a positive impact.

Weyerhaueser *et al.* (2005) indicates that the sloping land conversion program may fail to mitigate soil erosion and surface runoff in some areas because the lands planted are not usually the worst affected. Local administrative staff has to fulfil their allocated targets and have little time to select the areas for optimal benefit. Besides, highly-diverse landscape mosaics were converted to large-scale plantations containing few species. Monitoring was not linked to program objectives, but to the target area planted.

5. Factors driving forest land degradation and rehabilitation

The factors driving forest land degradation and its rehabilitation need to be well understood to ensure long-term sustainability of the rehabilitation efforts and prevent the recurrence of degradation and wasted money and effort. The major

deforestation episodes and expansion of degraded forest lands that followed the founding of the Peoples' Republic of China were closely linked to several political movements and transformation of forest ownership. Besides, high wood demand for economic development, subsistence needs of the rural population, fires, pests and acid rain were also important reasons for the expansion of degraded forest lands. Up to 1998, forest was still being converted to bush or barren land at the rate of 1.65 million ha per year, and forest land to other land uses such as urban development at roughly 0.44 million ha per year (Wang 1998).

Strong political resolve has driven rehabilitation of degraded forest lands to deal with environmental concerns, and timber and fuelwood shortages. In recent times, efforts to facilitate private enterprise and the opportunities for economic profit are also driving tree planting. The factors driving degradation and rehabilitation are described in detail below:

5.1 Political movements and resolve

Over the past 50 years in China, major political movements such as the Great Leap Forward and the Cultural Revolution have been responsible for substantial deforestation and expansion of degraded forest lands. The Great Leap Forward, which started in 1958, focused on rapid industrial development to keep pace with America and Britain, and resulted in forest resources being over-exploited to fuel steel and iron production. In Hubei Province, standing timber volume was reduced from 41.2 million m^3 in 1957 (not including Sheng longjia nature reserve) to 27.3 million m^3 by 1960. In Guangxizhuang autonomous region, 17.5 million m^3 of timber was harvested for steel and iron production, 10 times more than stipulated in the region's 1958 timber supply plan (Li 1985).

During the Cultural Revolution from 1966 to 1976, forest management agencies at various levels were dismissed and forestry administration was weakened nationwide. At this time, 110,000 forest fires were recorded, burning 670,000 ha of forest annually. Uncontrolled logging and forest fire reduced national forest cover by 6.6 million ha. In Fujian, Guangdong, Guangxi, Hunan and Jiangxi provinces, forests in the lower hills were completely cleared (Li 1985).

In recent decades, faced with insufficient forest resources and widespread barren areas, the political will to rehabilitate degraded forest land has strengthened, greatly speeding up rehabilitation efforts. Large national programs with billions of RMB invested have been ongoing since 1978. Political pressure was brought to bear on provincial and local governments and the masses to fulfil allocated rehabilitation tasks decided at the national or provincial level.

5.2 Tenure security

The agricultural cooperative movement from 1953 to 1958 and later the Peoples' Commune Movement which started in 1958 led to privately-owned forests being totally eradicated. Farmers lost their rights to use and manage forests. Open-access led to severe deforestation in some areas. Some forest land was allocated to local farmers under land ownership reform from 1981 to 1983 and wood markets were opened up to promote forest rehabilitation. However, open markets and experience with frequent tenure changes and unstable forestry policies in previous decades led to farmers rapidly exploiting the forest in the southern collective region for fear the policies might change again (Cai *et al.* 2003). Subsequently, over time, tenure security and rights to transfer tenure were strengthened, which did lead to substantial interest and investment in rehabilitation for commercial purposes by the private sector.

However tenure over the land does not automatically guarantee tenure over the forest resources on the land; these resources are still government-controlled. Tenure rights are often curtailed by policy initiatives and changes such as the recent logging ban under the natural forest protection program; the ban was extended to collective forest areas, even planted areas (Lele and Shen 2001, Shen 2003, Miao and West 2004). In some extreme cases, local communities' access to non-timber forest products was also cut off along with timber harvest rights. Such changes negatively affect the development and management of forest resources on collective land and increase illegal activities leading to resource degradation.

5.3 High wood demand and timber shortage

High wood demand for economic development led to heavy logging and a dramatic decrease in forest cover in many areas. In the early 1950s, the forestry department was responsible for harvesting as much wood as possible and most of the 138 state-owned forest industrial enterprises were established for this purpose. They were also responsible for rehabilitation after logging but this was rarely done. Annual timber harvests rose steadily from 1949 to 1997, and then declined when the logging ban was implemented in natural forest areas in 1998 (Figure 5). Shi and Xu (2004) based on national forestry statistics, estimate that an annual average of 19 million m^3 of wood was over-logged between the first national forest inventory (1973-1976) and the second. This had increased to 28 million m^3 by the third inventory (1984-1988). In Yunnan Province, over-logging reduced forest cover from 50 percent in the early 1950s to 24 percent in 1980 and in Hainan Province from 35 to seven percent (Zhang 1996).

On the other hand, timber shortages and increasing wood demand have driven plantation programs since the 1960s, particularly in the southeastern provinces. Earlier efforts were by the government alone but now involve the government

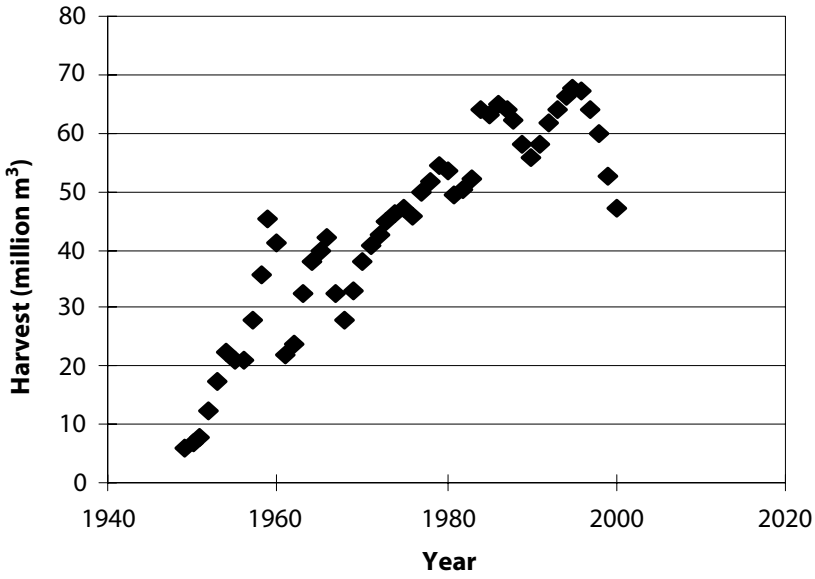

Figure 5. Annual timber harvest (million m^3) from 1949 to 2000 (SFA 2000).

and private sector. The annual gap between timber demand and supply increased at the rate of 15.9 percent from 1981 to 1990 and stood at 54.26 million m^3 in 2000 (Hong 1997). In recent years, timber demand from the wood-processing and construction industries is increasing dramatically with rapid economic development. Experts project that timber demand will continue to increase for a long time, with domestic wood demand of 345.9-350 million m^3 by the end of 2005 and 437.8-442.8 million m^3 by the end of 2015 (Table 7) (Yao 2000). At the same time, projected domestic wood supply based on present forest resources is 169 million m^3 in 2005 and 195 million m^3 in 2015, leaving shortages of 60-70 million m^3 in 2005 and 140-150 million m^3 in 2015 respectively; this does not even include fuelwood.

Table 7. Projected wood demand in 2005 and 2015 (Yao 2000). Unit: million m^3.

Items	**2005**	**2015**
1. Production and construction	235.9-240	337.8-342.8
• construction	64.4	72
• paper	28-30	63-68
• decoration	24	33
• furniture	21	37
• panels	29-31	39
• other	69.5	93.8
2. Fuelwood	110	100
Total	**345.9-350**	**437.8-442.8**

5.4 Population growth and subsistence needs

Rapid population growth from the 1960s to 1970s increased the pressure on forest land. Even steep slopes were cultivated for food crops and the demand for fuelwood and other forest resources was high. Cultivation and overuse of these marginal lands led to severe degradation and environmental problems in the subtropical region. Population pressures also arose in the state-owned forest regions where roughly 1.3 million forestry employees were located and pressed to depend on over-logging for their basic living needs (Tang *et al.* 1998). In southern China, local villagers relied heavily on forest products for both cash income and domestic use (Cai *et al.* 2003). Fuelwood extraction often included removing all branches, logging residues and understory shrubs thus denuding hillsides, altering soil properties and increasing erosion and surface runoff (Yin 1998).

Increasing population in Karst region of Guizhou Province worsened degradation

The population growth rate was 2-3 percent per annum in the Karst region of Guizhou Province, and the province's population density was 200 people per km^2 in 1993. Both the growth rate and population density were much higher than the national averages of 1.14 percent per annum and 124 persons per km^2 in the same year. Reclaiming steep forested land for cultivation led to severe soil erosion and exposure of the underlying rock. Further cultivation or rehabilitation is difficult. The area of such degraded Karst land increased by 62,400 ha from 1974 to 1979, and is expected to expand further (Lan 2002).

(Left) Household fuelwood stock for pigfeed in Xinfu village, Guizhou, (Right) A day's fodder collection, Xifeng village, Guizhou. (Photos by Alexander Hinrichs)

The same high dependence on forest resources is stimulating local governments to rehabilitate forests for fuelwood. People in many rural areas rely mainly on fuelwood for their daily cooking and heating needs. Official statistics indicated that national fuelwood consumption was 8.84 million m^3 in 1993 (Zhang 1996) while Hou and Wang (1998) estimate that it was closer to 173 million m^3. Annual fuelwood consumption decreased by 3.7 percent from 1988 to 1993 due to improved cooking equipment; the development of methane gas, mini hydropower and wind energy in rural areas; and decreasing rural population. However, fuelwood demand is still expected to equal 110 and100 million m^3 in 2005 and 2015 respectively (Yao 2000).

5.5 Forest fires, pests and acid rain

Forest fires result in substantial deforestation in China, with 947,242 ha being severely burnt annually from 1950 to 1987. Fires were particularly frequent and widespread during the Cultural Revolution when forestry management was weak. The largest forest fire occurred in Daxinanling region of Heilongjiang Province in 1987, burning 890,000 ha, with 23,300 ha completely deforested (SFA 2001b). With a strengthened fire control system, fires declined drastically in the 1980s. In 1998, fire totally destroyed 27,424 ha of forest nationwide.

Since the 1980s, pest incidence has been increasing with 6.67 million ha of forest severely infested annually. At present, some native and exotic forest pests such as pine caterpillars, fall webworm, spring cankerworm, nematodes, pine greedy scale and rodents destroy large areas of plantations. These plantations, the result of past rehabilitation efforts, are mostly monocultures and often composed of exotic species. They are often poorly matched to site conditions and very vulnerable to pest and disease outbreaks. In 1998, 7.01 million ha were badly infested, with pine caterpillars damaging 695,000 ha and rodents 719,000 ha. By the end of 1999, nematodes had infected 72,400 ha of pine plantations and killed about 15 million trees (Li 2002).

Acid rain also degrades forests in certain areas, including in Sichuan, Guizhou, Hunan, Hubei, Jiangxi and the coastal areas of Fujian and Guangdong provinces. Field investigation shows that acid rain with pH < 4.5 greatly affects the growth of Masson pine, Huashan pine (*Pinus armandii*) and firs, and can ultimately kill such forests. The most severely affected area is in the Sichuan basin where approximately 280,000 ha is damaged annually, of which roughly 15,000 ha was totally destroyed and then clear-cut in the province (WOSMOC website).

5.6 Frequent natural disasters and deteriorating environment

Large natural disasters such as floods, droughts and sandstorms have been occurring with increasing frequency in many areas and have been associated with

deforestation and forest land degradation in China (Zhou 1997, Liu and Diamond 2005). For example, in the Yangtze River valley, forest cover of 22 percent in 1957 dropped to 10 percent after 30 years of exploitation. The area affected by runoff and soil erosion increased from 36 million ha in the 1950s to 73.4 million ha in the 1980s, covering 41 percent of the valley's land area. Annual soil loss reached 2.26 billion tons with 530 million tons ending up directly in the Yangtze River (Zhang 1997). Such natural disasters and environmental objectives have driven the bulk of the national programs, particularly since 1978.

The key environmental objectives of the programs were:
- Reduce runoff and soil loss in some river valleys and mountains.
- Reduce desertification, sandstorms and direct onslaught of dry hot winds on crops growing on plains, the northern dry zone and some river valleys.
- Avoid severe flooding and landslides in the mountains, lake basins and river valleys.
- Reduce typhoon and storm damage and stabilise shifting dunes along the coast.

The type of rehabilitation and management activities adopted could well influence local soil properties, surface flow and flooding on a small-scale. However, it should be noted that the influence of forests and tree planting activities on massive flood and landslide events is increasingly questioned (FAO and CIFOR 2005).

5.7 Facilitation of private enterprise and pursuit of economic profit

In recent years, the policy to develop private forestry has encouraged rural farmers and some private enterprises to invest in forest rehabilitation, especially in fast-growing and high-yielding timber plantations and *economic plantations* for profit. In 2003, the private sector rehabilitated approximately 5.317 million ha or 58.3 percent of the total national *afforestation* area. Government incentives for private investment include lowering timber taxes and fees and liberalising markets.

In conclusion, political pressures and demand for timber and fuelwood are common driving factors in both directions. They could promote forest land degradation or rehabilitation, and care should be taken in devising policies and programs to be sure they inhibit degradation while promoting rehabilitation and sustainable management for timber production. Additional factors driving rehabilitation efforts are frequent natural disasters and pursuit of private profit particularly after 1998. Socio-economic and technical causes of degradation such as insecure tenure, local livelihood needs and pest susceptibility will have to be addressed to ensure long-term sustainability of the rehabilitation efforts for both environmental and commercial objectives.

6. Overview of policies influencing forest land rehabilitation

During the past 50 years, under the centrally-planned economic system, governments at all levels played a leading role in facilitating forest land rehabilitation. Policies influencing rehabilitation in that time can be summarised as follows:

6.1 Financial policies

The forest rehabilitation funding system was adopted in some state-owned forest regions in the northeast and inner Mongolia in the 1950s, and extended to collective forests in the south later. In the 1960s, the Central Government formally enacted the system, which was then amended several times up to 1981. In the state-owned forest regions, 26 percent of the income from sale of timber is collected towards the forest rehabilitation fund, whereas in the collective forest region, 20 percent of the income is collected. The fee is directly levied and managed by local governmental forestry agencies to regenerate the forest.

Besides the specific income from local timber sales which provided bulk of the investments, the Central Government provided some funding for national programs and local people provided free labour. A certain percentage of the Central Government's fiscal budget has been allocated for forest rehabilitation through a financial subsidy and capital investment since 1949 (Zhao and Gao 1999) (Table 8 and Figure 6). An estimated 24.3 billion RMB of Central Government funds have been invested in forest rehabilitation from 1950 to 1999 (Zhou 2001). In general, over the past decades, the Central Governmental investment only served to subsidise seedling and seed costs, with few additional incentives. Besides, the Central Government's financial allocation for forestry was much lower than for water conservation and agriculture (Table 8). Also, capital investment declined year by year from 1980 to 1995 as a proportion of the total government budget

Table 8. Financial allocation (from Ministry of Finance) for forestry, agriculture and water conservation from the 4th to the 8th Five-Year plans in China (Zhao and Gao 1999). Unit: billion RMB (%).

Sectors	Five-Year plan periods					Total
	1971-75	1976-80	1981-85	1986-90	1991-95	
Forestry	2.48 (0.6)	3.46 (0.6)	5.53 (0.8)	9.82 (0.7)	18.03 (0.7)	39.35 (0.7)
Water conservation	18.85 (4.8)	30.05 (5.7)	23.67 (3.4)	35.35 (2.5)	63.58 (2.4)	146.51 (2.6)
Agriculture	-	11.08 (2.1)	20.77 (3.0)	36.29 (2.6)	112.30 (4.2)	180.45 (3.2)
National total	391.94	527.35	695.19	1397.82	2689.57	5699.26

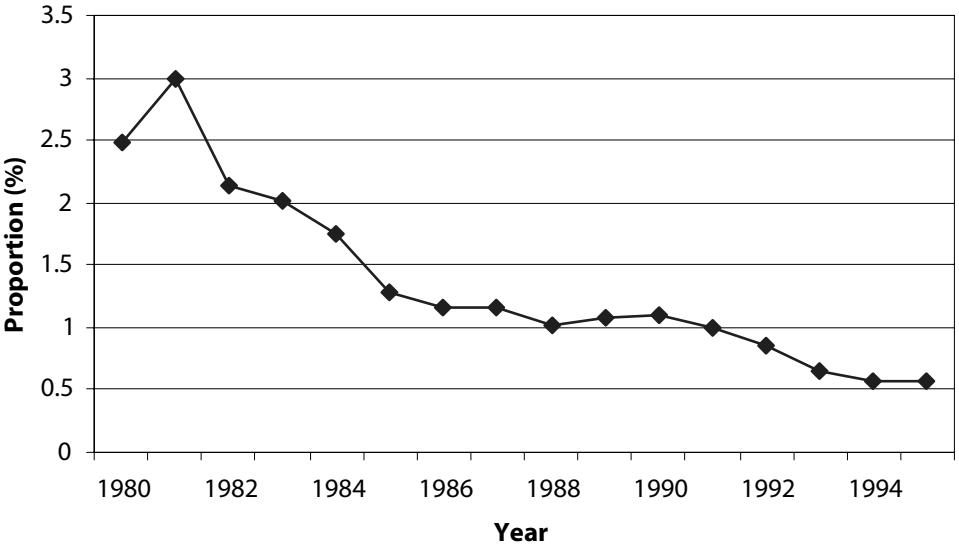

Figure 6. Proportion (%) of national capital investment allocated to forest rehabilitation from 1980-1995 (Zhao and Gao 1999).

(Figure 6) with a shift to loan-based financing of private sector and local initiatives (Xu *et al.* 2004).

In the early programs prior to 1998, much of the rehabilitation costs were borne by local governments and through free labour, with the Central Government contributing a small proportion (see Annex 1). Four consolidated large programs launched in 1998 are to be mainly funded by the Central Government with a little local government counterpart funding. The fifth program — the forest industrial base project — is to be supported through low-interest commercial loans made available to individual investors, farmers and private companies to establish *economic plantations* and fast-growing and high-yielding forest plantations. Planned investment for afforesting 92 million ha[11] through the five programs in 10-15 years is roughly 573 billion RMB: 23.13 billion RMB for the natural forest protection program, 358.43 billion RMB for the sloping land conversion program, 57.7 for the desertification control project, 70 billion RMB for the key shelterbelt project and 63.8 billion RMB for the forest industrial base project.

Investment standards have been established for the different revegetation techniques (1050 RMB/ha for *mountain closure*, 1800 RMB/ha for aerial seeding and 3000-4500 RMB/ha for planting) and for producing different types of

11 This is larger than the 64.2 m ha of degraded forest land since the programs also target areas outside the designated forest lands such as sloping cultivation lands, grasslands, lowland farms, roadsides and riverbanks for *afforestation*.

wood products (6000-7000 RMB/ha for pulp and artificial boards and 7000-8000 RMB/ha for large-diameter timber) (Zhou 2001). Under the sloping land conversion and desertification control programs, farmers are to be given cash and grain subsidies for converting their steep or poor farmlands as well as barren mountains and sandy lands into forests and grasslands. The compensation is to be paid for five and eight years respectively for conversion to *economic forests* planted with fruit trees and *ecological forests* planted with timber trees. These subsidies account for a sizeable proportion of the total 573 billion RMB estimated costs of the rehabilitation-related components of these five programs.

But how much is actually spent and achieved depends on the Central Government's budget situation and the local counterpart funding which varies from region to region and year to year. Sustaining such large Central Government investment will depend on the general economic situation of the country and the formulation of effective income generation and re-investment mechanisms by Chinese forestry agencies. Local governments are finding it difficult to raise the necessary counterpart funds given tight budgets and reduced revenues in natural forest areas arising from the logging ban. Free labour is also not forthcoming anymore.

6.2 Forest ownership

Before 1949, three major categories of forest ownership existed: national, public and private. Private forestland was owned by millions of landlords and a few feudal clans. In 1950, the land law of the People's Republic of China was enacted and forest lands were seized and distributed to local farmers. In 1953, the cooperative movement of agriculture regrouped the forest lands into elementary agricultural producers' cooperatives at first and then into advanced agricultural producers' cooperatives. In 1958, the Peoples' Commune Movement further increased the degree of public ownership with total eradication of private forest. This resulted in just two ownership types: a) state-owned forest (central or local government) located mainly in northeastern, northwestern and southwestern China; and b) collective-owned forest (local township, administrative village or natural village). In the southern and southeastern provinces, most forest land is collective-owned.

Under this system, individuals and private entities had no real tenure rights despite the stipulation that whoever planted the trees also owned them. Land ownership reform from 1981 to 1983 allowed some collective and state-owned forest lands to be partially reallocated to local farmers to manage and use the forest resources. Up to 1984, a total of 71.3 million ha of collective forest land was reallocated to more than 57 million households nationwide (MOF 1949-1986).

In the 1980s, wood markets were opened up to promote forest rehabilitation by farmers. Under a new policy in 1992, barren mountains and sandy areas were

auctioned to local farmers and private entities for *afforestation* and long-term management and use (Miao and West 2004). The Forestry Law of 1998 made use rights over timber, economic and fuelwood forest lands transferable. Farmers and collectives were allowed to transfer, lease or contract their land holdings but conversion to non-forest use was prohibited. The Law further extended use rights for up to 70 years and made them renewable. These improved tenure rights along with other financial incentives are resulting in more and more civil and private sector actors rehabilitating degraded forest land for commercial purposes. However, private ownership rights still need clarifying and strengthening to ensure sustainable rehabilitation.

6.3 Forest taxation and fee structures

Taxation and fee structures were not entirely favourable to forest rehabilitation in the past, particularly for establishing timber plantations. About 40 percent of the harvest earnings were to be paid directly in taxes and fees, although it varied widely between provinces and counties. In Fujian Province, the taxes and fees levied were more than 50 percent on average, rising to more than 70 percent in certain areas (MOF 1999). Taxes for forestry products were higher than taxes in other sectors (Sun 2002a). Foreign investors had more favourable terms than domestic companies.

Many provinces gradually abolished agricultural taxes (including timber harvesting taxes) to speed up agricultural and rural area development and improve farmers' livelihoods. In 2004, the Central Government announced that all taxes paid by rural farmers on special agricultural products including timber will be gradually repealed within five years, thus reducing the financial burden on farmers (Wen 2004). Forest product processing industries still have to pay taxes on value added and for their overall business operations. Timber producers still have to pay some fees to forestry agencies at the county level for the forest rehabilitation fund and related activities such as road building and fire control. It is expected that the abolition of taxes for timber producers will be a big incentive for commercial forest development.

6.4 Classified forest management policy

The classified forest management policy zoned forest land into "commercial" and "ecological" based on the main functions the forest was to play. Southeastern China was mainly classified for developing commercial forest plantations, while western China is mainly oriented towards ecosystem restoration. The policy influences rehabilitation greatly with funding for *ecological forests* arising primarily from the Central Government, and the investment for commercial forest rehabilitation depending on markets or commercial loans in most situations.

Ecological forest tenure holders were to be economically compensated to conserve the environment while combating poverty. Besides central and provincial government contributions, money was raised from local sources including part revenues from utility bill payments to cover the shortfall in compensation (Wang and Dan 2004). Numerous problems were apparent in some ongoing initial programs with compensation schemes, such as the sloping land conversion program and the Eco-fund program (Sun 2002b, Xu 2002a, Regional Development Research Centre Yunnan University 2004, Weyerhaueser *et al.* 2005). Governments at all levels were the major funding sources and the payments were inadequate at roughly five RMB per *mu*[12] and were far below the opportunity costs.

Market, local and other mechanisms for rewarding environmental services need to be explored further. Better appraisal of the services provided, and information and technical support for the providers and buyers are also needed. Currently, there is just a single compensation rate irrespective of local situations, forest quality or contribution to environmental services; and the system is not concerned with local farmers' needs or views. Lost income opportunities and inadequate compensation may act as disincentives to landholders to rehabilitate and sustainably manage their forest land, and may impoverish farmers in some cases.

6.5 Harvesting regulations

Forest resource management policies were mainly focused on protecting the remaining forest resources, with all harvesting regulated by annual quotas. The Government invested a large amount in forest resources in the past and feared rapid deforestation, hence quotas were continued despite market liberalisation and private forestry being encouraged (Xu 2002b). However, quotas do constrain tree planting because people do not have the right to dispose of the trees planted. Quotas are also insensitive to plantation conditions and market signals and do not allow for efficient resource allocation (Xu 2002b).

Bill Hyde states in Zhu (2002) that harvest regulations, with a logging ban at the extreme, have not helped to protect the environment nor succeeded financially. The private sector has been more successful in commercial forestry except where constrained by the Government. For example, Yin (1998) states that timber forestry grew rapidly in the Three-North farm forest region before 1998 compared with the state farm and southern collective regions, because this area had no harvesting quotas, timber could be sold in the open market and taxes were low. This calls for improving regulations to help the private sector practise sustainable forest management and efficient use of timber resources, while using public mechanisms to protect environmental values.

12 Fifteen *mu* = One ha

Forest resource management policy reform discussions have been ongoing since 2003 and policy reform aims to support commercial forestry development while protecting *ecological forests*. Timber logging is banned in *ecological forests* though non-timber forest products can be harvested. Since 2004, commercial foresters have been allowed to freely time their harvesting activities to suit market conditions. Further, the Central Government has decided to liberalise timber harvesting quotas for commercial plantations within the 11th national five-year plan (2006-2010) to enable tree planters to respond to market situations, particularly in southern China (http://www.forestry.gov.cn/DB1/news/content.asp?table_type=news&id=9715&pgid=1).

7. Key constraints and challenges to sustainable rehabilitation

Rehabilitating large areas in a short time has been possible in the past but there have been problems with long-term sustainability of the efforts. Concerted efforts have increased forest cover since the 1980s but the nature and quality of the forests regenerated was poor. Growth, stocking, and forest composition and structure need much improvement. There were documented production and livelihood benefits arising from the different programs. However, negative socio-economic impacts have been noted as well. Projects report improvements in soil erosion and grain yields as a result of the rehabilitation efforts while others claim that environmental conditions continue to deteriorate.

Strong political resolve has driven rehabilitation of degraded forest lands to deal with environmental concerns, and timber and fuelwood shortages. There is good experience in government programs, planning and management systems to draw from. The private and civil sectors are playing an increasing role with tenure reform and market liberalisation. Incentives offered to them at national and/or local levels include priority rights for logging licences and quotas, reduced timber taxes and fees, open timber markets, credit facilities with lower interest rates, secure and longer-term tenure, allowing tenure transfer and lease arrangements, pilot environmental service payments to landholders of *ecological forest* areas, and allowing *economic forests* or cash crop species in forest lands.

The review of past experiences suggests that the key constraints and challenges to sustainable forest rehabilitation lie in future program planning and financing; paying attention to long-term management; technical considerations; improving incentives further for private forestry; identifying effective mechanisms for enhancing environmental services; addressing timber and livelihood needs and concerns; ensuring local participation and stake; and further strengthening tenure over the land and resources.

7.1 Policy and program level

The first major challenge lies in adequately planning for and mobilising the institutional and financial resources needed for implementing the current large-scale national programs. From the mid-1980s, the Central Government adopted the responsibility system for achieving rehabilitation tasks, compelling governments at all levels to meet their respective targets in the planned period, or else the leaders stood to lose their positions. This system led to previous rehabilitation objectives being achieved. However, the system shows signs of losing its effectiveness since late 1990s with new rehabilitation tasks not being enacted in a timely manner and the Government losing its driving role in the new market economy situation. The forestry administration is stretched and funding is limited. In the 1990s, the policy requiring obligatory labour of farmers in public affairs such as forest rehabilitation and construction of irrigation facilities without pay was cancelled in order to reduce the farmers' burdens. People increasingly expect to receive direct incomes or subsidies for their efforts and it is increasingly difficult to coerce voluntary participation in forest rehabilitation projects.

Secondly, the current forestry management system was formulated under a planned economic system with governments at all levels playing dominant roles in implementing the plans. Plans often fail to reflect ground realities due to insufficient information for planning. Also the planned economic system makes managing the forest rehabilitation process less flexible. For example, in the sloping land conversion program, plans often do not suit local needs, site and market conditions. It is difficult to alter the plans handed down by higher forestry agencies, even if the weather and other conditions are unfavourable. Besides, bureaucratic procedures could mean delaying implementation and forfeiting planting at the appropriate time, which leads to poor survival rates.

Thirdly, the focus in the past was mainly on meeting targets, rather than on quality. Although a complete system to evaluate and control the quality of forest rehabilitation has been formulated since the end of the 1980s, the system focuses more on checking results and neglects guidance through the process. The quality of the forest rehabilitation process needs to be controlled, so that managers can identify, adapt to and rectify problems as and when they occur.

Fourthly, little attention was paid to managing the rehabilitated areas in the long term. The areas may be degraded after meeting afforestation targets due to fires, pests and diseases, poor survival and growth, grazing and local harvesting for domestic needs. General guidelines, concrete criteria and indicators, funding and institutional arrangements are required to sustainably manage these young and middle-aged forest stands.

Fifthly, governmental forestry agencies at different levels implemented most programs in the past, but funds and institutions are stretched and there is a new market-based economic system that could be used to mobilise more social capital for forest rehabilitation. Now, different entities such as the private sector could undertake rehabilitation using funds from the government and elsewhere. Through plantation development since the 1980s, the collective and private forestry sectors have contributed greatly to the expansion of forest cover in China. Zhou (2002) suggests that the government could focus on funding and managing *ecological forests* while commercial forestry could be left to the private sector and market-based mechanisms.

Sustaining and promoting private forestry would require that existing constraints, such as high taxes and fees and harvesting and transport controls, are addressed to make commercial forestry viable and allow the investors to manage their resources freely in response to forest conditions and market signals. However, some safeguards may be required to ensure sustainable management without land degradation and depletion of ecosystem services. Also, taxes and fees are often the main revenue source in villages and counties, especially in forest regions, and lowering these charges requires finding other funding sources to cover basic administrative expenses (Sun 2002a). The private sector would also need more technical support backed by research information and supplies of superior and diverse planting stock.

Ecological forests have more restrictions on management and use since they are meant primarily for improving environmental services. Logging is usually not allowed and landholders are to be paid economic compensation for lost opportunities. However, implementing and monitoring this scheme appropriately and providing adequate compensation over the long-term and nationwide is a serious challenge. Problems were already apparent in some early attempts. Richer provinces could afford to pay more. It is also unclear whether this strategy will actually improve environmental conditions given the choice of lands, rehabilitation techniques, consequent loss of management interest in the resources and heavy informal extraction. Alternative strategies could also be considered, such as sustainable forest management for products and services by communities or the private sector with adequate tenure security.

7.2 Socio-economic considerations

Local peoples' livelihoods and community development were hardly considered in the forest rehabilitation processes before the 1980s. Rehabilitation plans and stipulations were largely based on governmental motivations and targets. Neglecting the daily necessities of local communities and households often led to rehabilitation efforts failing and created hardships for people. For example, strict

closure of mountains without considering local farmers' basic needs for fuelwood and grazing is not implementable. Livelihood needs have to be balanced with environmental and production needs, else it ends up being a lose-lose situation.

Second, local farmers' voices remain unheard and rehabilitation processes are largely top-down and may actually harm local interests. Many programs such as the shelterbelt programs were intended to improve the local environment and enhance fuelwood, water, fodder and other resource availability. However, local people were hardly consulted and were forced to provide compulsory and mostly free labour in most past government programs. Past experiences suggest it would be wise to ensure genuine participation and consider the needs and perspectives of all stakeholders, including local communities, in designing and implementing projects. The shelterbelt program in the Three-North region was forced to integrate multiple forest types with multiple tree species and combine trees, shrubs and grasses during program implementation to cater for local livelihood needs. Participatory methods are employed in foreign-assisted projects, but they tend to bypass existing institutional structures (Liu 1999). They could more usefully try to work with the existing institutions and build their capacity for working more directly with local people.

Third, little attention is paid to program evaluation during and after project completion, particularly on the socio-economic impacts. Initial assessments suggest socio-economic problems arising from the natural forest protection and the sloping land conversion programs. Systematic methods and procedures to carry out such evaluation and synthesise the experiences and lessons would be useful. Long-term sustainability and impacts on local livelihoods should be assessed before the program is launched and after it ends.

Fourth, long-term tenure security over both the land and resources is critical for sustainable rehabilitation and management. It is important to speed up reform on tenure policies and ensure that they permit local farmers and other stakeholders to have full rights to manage their forests and dispose of any products arising from them. Any new programs and policies should be consistent and build on existing rights in order to build trust and confidence.

7.3 Technical aspects

Many technical problems continue to plague rehabilitation efforts. First, species-site matching was not effectively implemented. Some conifers or exotic species were introduced imprudently in many areas without considering the site or objectives. For example, with the boom in fast-growing, high-yielding forest plantations in southern China, *Eucalyptus* species are being introduced even in more temperate latitudes without long-term trials. If the introduced species fail to

survive extreme climatic conditions including frost, much effort and money will be wasted, and local forestry agencies who advocated the species will lose their credibility. Loblolly pine and slash pine, which were introduced in the 1960s, show weak resistance to diseases and pests. In contrast, some promising native tree species have not been given much attention. Also native species such as Chinese fir and bamboos were planted on a large scale on inappropriate sites leading to low productivity (Cai *et al.* 2003). Improper site preparation practices such as burning of the ground vegetation and not using fallows and species mixtures lead to declining soil fertility in fir plantations. Forest rehabilitation for economic purposes should be based on market trends and economic considerations, but also requires technical and social risk assessments. More natural regeneration through *mountain closure* could be used in rehabilitating forests for ecosystem services where possible, a technique that is not only cost effective but also functional.

Secondly, techniques for improving the survival and growth of trees planted in dry, sandy regions present a major challenge. This is especially important now with the rehabilitation focus moving towards dry western China with development plans for the region. Here, areas suitable for planting trees need to be identified first, as opposed to areas that should be planted to shrubs or allowed to recover naturally into forests or grasslands. Suitable tree species for the site and local needs need to be assessed before undertaking any rehabilitation action. Project implementers also need to consider the balance of water resources in site and tree species selection.

Thirdly, supplying adequate technical extension support from the top to grass-root levels is a problem due to a shortage of funds. As a result, the quality of forest rehabilitation tends to be poor. Traditional knowledge is not sufficiently used, and farmers usually only participate with their labour rather than being involved in selecting sites, tree species, and other such issues.

Fourthly, persistent and aggravated environmental problems and concerns continue to drive rehabilitation efforts, despite large increases in forest cover. The plans and techniques adopted in any program should also be based on the objectives of rehabilitation such as reducing soil erosion, while balancing other needs. A system for monitoring and evaluating progress according to the objectives should be put in place from the start.

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Annex 1. The key forest rehabilitation programs from 1978 to 1998 (Zhang 1997, Zhou 2001, SFA 2004). Planned targets and durations underwent numerous changes so initial figures are presented below.

1. **Shelterbelt forest program in Three-North region**

   The Three-North region — namely, northern, northwestern and northeastern China — contained five percent of China's forest cover and more than 60 percent of its poor counties in 1977. With annual average rainfall less than 400 mm, the region is prone to drought and desertification. The shelterbelt program was initiated in 1978 primarily to improve the environmental conditions for agriculture and local people, and also provide timber, forage, and fuelwood. The driving forces behind this program were severe top soil loss, low soil fertility, and shortages of timber, forage and fuelwood. The program covered 407 million ha or 42.6 percent of the nation's land area, and originally involved 551 counties across 13 provinces. The program was subdivided into three stages with eight phases lasting from 1978 to 2050, and an *afforestation* target of 35.6 million ha with a planned forest cover increase from 5.05 percent in 1978 to 15 percent in 2050. Revegetation techniques involved planting, closure of mountains and sandy areas to promote natural regeneration, and aerial seeding. Main species to be planted were poplars, willows, elm, pines; and shrubs such as seabuckthorn, peashrub (*Caragana*) and shrubby amorpha. Work in the first three phases was primarily done by local people providing obligatory labour (equivalent to 86 percent of the cost) with seven percent funding from the Central Government, four percent from the local government and three percent from other sources (POSFA 2001).

   Area rehabilitated from 1978 to 2000 totals 27.6 million ha (SFA 2004). Shelterbelt networks have brought 21.3 million ha of farmland under protection, steadily increasing grain yield. The forest cover in priority sandy areas such as Maowusu and Keerqin has reached more than 15 percent and 20 percent respectively. Fuelwood forest of 911,752 ha has been established yielding 5.47 million tons annually. In addition, tending and pruning have provided supplementary fuelwood to meet the demand from six million farmer households. Moreover, the program has altered the rural industrial structure in some areas. More than 2600 forest products, including seabuckthorn, apricot, dates (*Phoenix*), walnut (*Juglans*), littleleaf peashrub (*Caragana microphylla*) and Mongolia willow (*Salix monglica*), have resulted in diversified business opportunities, created 63,000 jobs and generated revenue of more than 600 million RMB (POSFA 2001).

However, beetles have damaged the shelterbelt forest network, in which poplar was the dominant tree species. Beetles almost totally destroyed the poplars in Ningxia autonomous region prior to 1994. Meanwhile, farmers are losing interest in participating in the program due to insufficient investment and insecure ownership over the resources. This program has now been integrated with the new national forestry programs from 2000 and is in its fourth ten-year phase. This phase is being implemented in 590 counties in 13 provinces, and has an *afforestation* target of 9.5 million ha (Zhou 2001).

2. Shelterbelt forest program along the upper and middle reaches of the Yangtze River

The Yangtze River valley is 6300 km long and covers 18.8 percent (180 million ha) of China's land area and contains 33 percent of its population. Most of the valley is in the subtropical region. Intensive farming and fuelwood and timber extraction over a long period have led to vegetation removal, severe soil erosion, flooding and adverse socio-economic impacts.

To reverse this trend as rapidly as possible, the national Seventh Five-Year Plan (1986-1990) proposed establishing soil and water conservation forests in the Yangtze River's middle and upper reaches. The 20-year plan started in 1989 was designed to establish 20 million ha of forest in two phases in 271 counties across 12 provinces (Zhang 1997). Forest cover was to be increased from 20 percent to 40 percent, and runoff and soil erosion was to be controlled on an affected 7.4 million ha. Revegetation techniques involved planting, *mountain closure* and aerial seeding. Pines, Chinese fir, broadleaf species, bamboo, commercial fruit trees and shrubs were to be planted. The planned investment in the first phase was 3.3 billion RMB, 27.3 percent from the Central Government, 20 percent from local government and 52.7 percent as equivalent labour cost. Materialised investment equalled 38.2 percent from the Central Government and 61.8 percent from the local government and other sources.

Five million ha were rehabilitated in the first phase from 1989-2000 with forest cover in the program area increasing from 19.9 to 29.5 percent (SFA 2004). Zhang (1997) stated that the capacity to resist natural disasters such as drought, floods and sandstorms has been enhanced dramatically, watershed infrastructure such as dams and irrigation systems were functioning better, and some wildlife including the giant panda were increasing in abundance. The rehabilitation quality was high with 90 percent of the area meeting the national standards. A survey in Sichuan Province showed that local incomes had risen by 80 percent since 1989. However, limited funding meant the

forests could not be protected and rehabilitation was often followed by degradation through grazing, agriculture and other pressures. The structure and functionality of the rehabilitated forests was lower than in the natural forests.

This program was readjusted to focus on the valley's middle and lower reaches in 2001 following the launch of the natural forest protection program and the sloping land conversion program along the upper reaches of the Yangtze and Yellow River valleys (Zhang 1997). The second 10-year phase of the program is being implemented in 1039 counties in 17 provinces, and has an *afforestation* target of 6.87 million ha (Zhou 2001).

3. Coastal shelterbelt forest program

China has a long coastline of 18,000 km, stretching across 195 counties in 11 provinces. The coastal shelterbelt forest program covers 25.1 million ha of land, equalling 2.6 percent of China's land area. The region's ecological health has deteriorated following deforestation and it was very vulnerable to natural disasters such as typhoons, storms, droughts, strong winds and shifting sand dunes. These disasters caused direct economic losses of about 2.95 billion RMB per year on average and also threatened national environmental security. The coastal shelterbelt program was started in 1988 to protect against natural disasters and solve the severe local fuelwood shortage problem. It was divided into two phases, from 1988 to 2000, and from 2001 to 2010, with *afforestation* targets of 2.49 and 1.07 million ha respectively.

The program has sought to improve forest cover from 24.9 to 39.1 percent of the project area; the target for the first phase was an increase in cover to 34.8 percent. Regeneration techniques involved planting, *mountain closure*, aerial seeding, and agroforestry. Horsetail beefwood, pines, poplars, coconut, mangrove, and shrub species were to be planted. The original planned investment was 3.2 billion RMB, 22 percent from the Central Government, and 78 percent from the local government and as equivalent labour cost (Zhang 1997). Materialised investment was 2.953 billion RMB, four percent from the Central Government, 71 percent from the local government and 25 percent as equivalent labour cost (Zhang 1997).

According to SFA (2004), 1.1 million ha was rehabilitated by 2000. The project report however gives a higher estimate of area rehabilitated (Zhang 1997). According to the project report, 1.9 million ha of barren mountain land was rehabilitated in the first phase, with forest cover increasing from 24.9 percent to 35.45 percent. Shelterbelt forest covering 18,000 ha was established, which helped protect 387,100 ha of cultivated land and the total

grain output in the program area rose from 69.53 billion kg to 125.12 billion kg. With 203,600 ha of timber forest and 799,200 ha of *economic plantations* established, forestry output value increased from 1.334 billion RMB in 1987 to 8.881 billion RMB in 1999. Although a basic shelterbelt forest system has been formed along the coastal area, the forest structure is simple and some difficult planting sites need further investment.

In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions. The second 10-year phase of the program is being implemented in 220 counties in 11 provinces, and has an *afforestation* target of 1.36 million ha (Zhou 2001).

4. Pearl River valley shelterbelt forest program

This program covered the zone around the three major tributaries of the Pearl River. This zone plays an important role in the national economy. Forest cover in the valley decreased greatly with overexploitation, and the area affected by runoff and soil erosion increased from 4.1 million ha in the 1950s to 7.6 million ha in the 1990s. The land area with exposed rock surfaces following vegetation and soil removal increased at an annual rate of 3-6 percent, posing a severe threat to local people and their livelihoods.

The program was initiated in 1995 for watershed protection and for alleviating natural disasters such as drought, flood and debris flows. The program covered 40.9 million ha, about 92.6 percent of the total area of the Pearl River valley. It stretched across 177 counties of four provinces, namely Yunnan, Guizhou, Guangxi and Guangdong. Planned *afforestation* totalled 1.2 million ha with a total planned investment of 1.08 billion RMB: 12.1 percent from the Central Government, 29.3 percent from local governments and 58.6 percent being the equivalent labour cost. Targeted increase in forest cover at the end of the program is from 35.01 percent to 37.94 percent. Shelterbelt forest in particular is to be increased from 11 to 38.16 percent while timber forest is to be decreased from 72.55 to 43.88 percent. Revegetation techniques involved planting, *mountain closure* and aerial seeding (Zhang 1997). Total materialised investment in the first stage was 833 million RMB with 155 million RMB from the Central Government, 250 million RMB from the local governments and 428 million RMB as equivalent labour cost (Zhou 2001, SFA 2002).

By the end of the program's first stage in 2000, 160,000 ha were rehabilitated to forest, accounting for 13 percent of the planned task (SFA 2004). The program was constrained by a three-year delay and low investment, but

forest cover was increased in the areas where the program was implemented, improving the local environment and livelihoods in certain regions. However, severe runoff and soil erosion problems remain uncontrolled in much of the valley. The stony land needs more technical and financial inputs to speed up its recovery.

In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions. The second 10-year phase of the program is being implemented in 187 counties and 34 forest farms and nature reserves in six provinces, and has an *afforestation* target of 2.27 million ha (Zhou 2001).

5. The program on combating national desertification

The program was launched in 1991 and aimed to protect cropland and grassland from desertification and regenerate grassland for animal husbandry, as well as improve the livelihoods of local people. It covered 264 million ha of land susceptible to desertification or 27.5 percent of the national land area, and is spread across 598 counties in 27 provinces. During the first 10-year phase, the program planned to control the desertification process on 7.18 million ha through recovering 1.32 million ha of grassland, improving 376,700 ha of low-productivity cropland and increasing forest cover by 5.24 million ha. The last will involve planting 1.74 million ha, closing off 2.83 million ha for natural regeneration, and aerial seeding 673,400 ha. By the end of the program in 2050, 47.1 million ha total would be afforested, forest cover is estimated to increase to 7.6 percent, and forests will protect 3.17 million ha of cropland and 6.86 million ha of grassland. The materialised investment was 1.4 billion RMB, of which, 436 million RMB was from the Central Government (SFA 2001a).

The area rehabilitated from 1993 to 2000 was 1.1 million ha according to SFA (2004). According to the project report, from 1991 to 1995, the program established 1.42 million ha of artificial forest, aerially seeded 313,000 ha and closed 1.216 million ha of sandy land for forest and grass recovery (Zhang 1997). The report also states that 472,000 ha with low agricultural output was improved, medicinal herbs were planted on 238,000 ha, and more than 600 projects aiming at comprehensive development of the sandy region through grain and medicinal plant production, animal husbandry and tourism were established. In 2000, this program was replaced by the program "Desertification control in the vicinity of Beijing and Tianjin cities" (Zhou 2001).

6. Taihang Mountain greening program

Taihang Mountain is a natural protective barrier for Beijing and Tianjing as well as for the plains of northern China. Deliberate logging and burning during the Japanese invasion and other historical wars resulted in scant forest cover. The area was affected by severe water runoff, soil loss, and flood and mud-rock flows caused by torrential rain. The greening program was initiated in 1986 to protect the capital city and the neighbouring area. The aim was to increase the forest cover from 1.4 to 5.35 million ha, or 15.3 to 43.6 percent through rehabilitation activities from 1986-2000. The program covered 12 million ha across 110 counties in Shanxi, Henan, Henei and Beijin provinces (Zhang 1997). Revegetation techniques included tree planting, *mountain closure* and planting grass. Tree species to be planted were pines, cypress, black locust, seabuckthorn, shrubby amorpha, apricot and elm**.**

By the end of 2000, 3.6 million ha were rehabilitated, accounting for 92 percent of the planned task in the first phase (SFA 2004). According to the project report (Zhang 1997), survival rate was more than 90 percent. Confronted with poor site conditions, many new planting techniques were explored. In some areas, household income improved when *economic plantations* were established. However, insufficient investment and difficult site conditions resulted in monoculture plantations of mainly pines and cypress. Meanwhile deforestation continued during the program period with 40 percent of forest in the area converted to shrub, *sparse forest*[13] and non-forest by 1999 (Zhou 2001).

In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions. The second 10-year phase of the program is being implemented in 73 counties in four provinces, and has an *afforestation* target of 1.46 million ha (Zhou 2001).

7. Shelterbelt forest program along the middle reaches of the Yellow River

The middle reaches of the Yellow River face the most severe runoff and soil erosion problems in China, with 24.5 million ha or 78 percent of the whole river valley affected. In order to control soil loss and protect the region's watershed, the program was ratified in 1995 to rehabilitate the forests over 15 years up to 2010. A total of 177 counties across six provinces in the valley's middle reaches were involved. About 3.15 million ha of degraded forest land was earmarked for rehabilitation, with forest cover to increase from 14.9 percent in 1995 to 24.9 percent in 2010. The program planned to plant 2.7 million ha, aerially seed 300,000 ha, and protect 150,000 ha through

13 *Sparse forests* are areas with less than 20 percent tree canopy cover (< 30 % prior to 1996).

mountain closure. As a result, approximately 12 percent of the runoff and soil erosion problem area would be brought under control. Tree species to be planted were black locust, sea buckthorn, poplar, pines, cypress, apricot, *Vitex* and *Ailanthus altissima*.

By the end of 1999, 518,000 ha were rehabilitated (SFA 2004). According to the project report, 1.31 million part-time jobs created and soil erosion was reduced by an estimated 100 million tons per annum, increasing grain output by 10 percent on average (Zhang 1997). In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions.

8. Shelterbelt forest program in the Huaihe River and Taihu Lake basin

The valley of Huaihe River and Taihu Lake covers 2.75 percent of the national land area and 13.3 percent of its cultivated land. The valley produces one-sixth of the total national grain output and a quarter of the national cotton and oil output, making it a key base for commercial grain, cotton and oil production. It also supports one-eighth of the nation's population. However, the region is subject to severe flooding and drought. Following severe flooding in 1994, the program was initiated in 1995 to improve the natural environment in support of agricultural and industrial development. With a total program area of 26.4 million ha across 208 counties in seven provinces, the program aims to improve forest cover from 13.9 to 17.3 percent within 10 years. Planned rehabilitation area was 1.047 million ha, with shelterbelt forests increased from 15.7 to 30.5 percent and timber forest decreased from 50.9 to 40.3 percent. Revegetation techniques involve planting, *mountain closure*, and aerial seeding. Planted tree species are poplars, willows, pines, shrubby amorpha, black locust, *Ailanthus altissima*, cypress, elm, pond cypress and dawn redwood (*Metasequoia glyptostroboides*)**.**

From the start of the program in 1995, pilot projects were implemented in 36 counties and 200,000 ha have been rehabilitated (SFA 2004). Forest cover has been increased dramatically, covering 6.5 million ha of land affected by runoff and soil erosion. Zhou (2001) states that soil loss decreased from 93,000 to 54,000 tons per ha per year, effectively improving the environment for agriculture and industry. In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions.

9. Shelterbelt forest program in Liaohe River valley

Liaohe River valley is an important base for agriculture, industry, energy and animal husbandry. However, long-term over-exploitation of forests and

grasslands led to environmental degradation, including torrential rain and flooding, severe runoff, soil loss and desertification. By end 1996, runoff and soil erosion affected 6.115 million ha, approximately 25.9 percent of the valley. The big flood of 1985 in the middle reaches of the valley destroyed 846,000 ha of cultivated land, 30 petroleum wells and 300 petroleum stations. Desertification has severely affected animal husbandry.

The 10-year shelterbelt forest program was launched in 1995 to address all these problems. The program was subdivided into two phases, from 1996 to 2000 and 2001 to 2005. Total program area was 23.57 million ha covering 77 counties of Hebei, Inner-Mongolia, Jilin and Liaoning provinces. Planned rehabilitation area was 1.2 million ha, leading to a projected increase in forest cover from 18.6 percent to 27.9 percent at the end of the program. This would potentially help control 6.115 million ha of land affected by runoff, soil erosion and desertification; and stabilise 1.33 million ha of flowing sand dunes. Revegetation techniques involve planting, *mountain closure* and aerial seeding. Tree species to be planted included pines, poplars, sea buckthorn, cypress, and elm.

Area rehabilitated by 1999 was 0.22 million ha (SFA 2004). In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions.

10. Plain regreening program

There are four plain and semi-plain areas in China, namely the northeastern plain, the northern plain, the plain along the middle and lower reaches of the Yangtze River valley and the Pearl River delta region. Scarce vegetation cover made the plains vulnerable to severe sandstorms, droughts, runoff, soil loss, hot dry winds, salinisation and alkalisation. The people here also faced severe fuelwood shortages. After the Peoples' Republic of China was founded in 1949, the Government initiated the campaign to green the plains nationwide with compulsory participation by local people. Based on the experiences and lessons learnt, the National Planning Commission in 1988 developed and approved a plan aimed at speeding up plain greening. The program covered 918 counties in 26 provinces, involving 146.7 million ha, or 15 percent of the national land area. The program aimed to green the national plain areas by forming a forest network to protect against wind, sand and drought damage. Revegetation techniques involved tree planting and aerial seeding. Planted tree species were poplars, willows, pines, cypress, elm, black locust, Chinese ash (*Fraxinus chinensis*), *Paulownia*, *Tamarix*, Pond cypress, *Ailanthus*, Chinese wingnut (*Pterocarya stenoptera*), dawn redwood, common camptotheca (*Camptotheca acuminata*), London plane tree (*Platanus acerifolia*), Chinese

spruce, camphor tree (*Cinnamomum camphora*), and Mongolian Scots pine**.** The program was mainly carried out by local people's voluntary participation. When a county has reached the nationally-set criteria for plain greening, it will receive 100,000 RMB as a kind of bonus for the local government units and individuals who contributed (Zhou 2001).

By the end of 1998, of the 920 counties in the plain and semi-plain areas, 850 counties achieved the national *greening*[14] target, placing 32.56 million ha of arable land (70 percent of the national total) under the protection of a shelterbelt forest network. The four sides of canals, roads, rivers and villages were regreened at the rate of more than 85 percent. Forest cover in the plains increased from less than two percent in the early 1950s to 19.2 percent. The program also brought about a variety of environmental, economic and social benefits to local communities and households. Zhou (2001) states that severe problems related to sandstorms, dry hot winds, floods, salinisation and alkalisation gradually reduced. The pressure of timber demand in the plains eased and local incomes as well as the natural environment improved. However, *greening* levels were still low, even in counties that had achieved the national criteria. Farmers did not take the program seriously in some places and investment was low. Between 1998 and 2000, approximately five million ha of arable land lost its shelterbelt protection and severe insect and disease outbreaks caused great damage to established shelterbelts.

In 2000, the program was regrouped into the key shelterbelt program along the Three-North region, the Yangtze River valley and other regions. The second 10-year phase of the program has an *afforestation* target of 5.52 million ha (Zhou 2001).

11. Timber plantation establishment program

Apart from the above-mentioned programs oriented towards ecosystem recovery, China also accelerated the development of its commercial forest base to meet the increasing demand for wood. In 1988, the State Council ratified the plan to establish 6.667 million ha of fast-growing and high-yielding forest plantation from 1989 to 2000. Targeted locations were in the Da xin an ling and Xiao xin an ling mountain regions, Yunnan and Guizhou provinces, as well as southeastern China where site and socio-economic conditions, local knowledge and rehabilitation practices are superior. The first phase of the plan from 1989 to 2000 covered 297 counties and 82 forest industrial bureaus. By the planned harvest time around 2010, 370,000 ha were expected to be harvested yearly on a rotational basis with annual wood output reaching 43.8 million m^3 (State Council 1990).

14 Increasing forest canopy cover to a certain percentage or above, and is expected to result from *afforestation*.

The Chinese Government applied for a World Bank loan to accelerate its timber plantation establishment program and this led to the National Afforestation Project from 1990 to 1997. The project covered 306 counties in 16 provinces in the subtropical to tropical region and central and eastern China. A total of 1.385 million ha of plantations were established by 1997 against a planned target of 985,000 ha. The main tree species planted included Chinese fir, Masson pine, slash pine, torch pine (*Pinus taeda*), larch, poplars, *Eucalyptus*, *Robinia*, *Paulownia* and other broadleaf species. Materialised investment was 557 million USD (3.763 billion RMB), 59 percent through the World Bank loan and 41% in Chinese matching funds (SFA 1998). The World Bank loan was to be repaid in 20 years with a grace period of eight years and a four percent interest rate.

At the end of the program, 1.3849 million ha of timber plantation was established, accounting for 140.7 percent of the planned rehabilitation area. The achievement exceeded the targeted area due to favourable currency exchange rates providing additional funds and previous plans being readjusted. Average survival rate was 95.8 percent (SFA 1998). Predicted production during the project's management cycle was 0.211 billion m^3 of timber and 16.96 billion tons of fuelwood. During project implementation, 192 million job opportunities were provided to participating farmers. Forest cover in targeted counties increased by 2-3 percent on average and soil loss is expected to decline by 21.96 million tons annually. Moreover, the project also provided important technical and management expertise that have since become national models. The rehabilitation quality was higher than in other domestic projects due to strict quality control.

An example of social benefits from the National Afforestation Project (SFA 1998)

In Hubei Province, 105,000 ha of timber plantations established through the National Afforestation Project were expected to help retain 19.129 million tons of water (SFA 1998). In Lenshui township of Zhongxiang city, 200 households in two administrative villages suffered from potable water shortages and had to travel up to seven km to procure supplies. After the National Afforestation Project was implemented in the two villages, 486.7 ha was rehabilitated to forest, and forest cover increased by 60 percent. One outcome was that a stream running through the village that had been dry for many years began flowing again and the local water shortage problem was resolved.

Annex 2. Five consolidated rehabilitation-related forestry programs since 1998.

1. The natural forest protection program

Natural forests covered 106.96 million ha in 1994-98 with 9.072 billion m^3 of standing timber, and have been the country's primary timber source since 1949. However, the natural forests have been over-exploited and severe environmental crises such as the 1998 flood event were attributed at least partly to their degradation. After a pilot phase from 1998 to 1999, the natural forest protection program was formally launched in 2000 to rehabilitate the deteriorating resource by 2010.

The first part of the two-part program was located along the upper reaches of the Yangtze River and middle and upper reaches of the Yellow River. It aims to stop logging in 30.38 million ha of natural forest by reducing commercial timber output by 12.39 million m^3, protecting 30.8 million ha of other forest and scrub, and relocating 256,000 redundant forest workers. Meanwhile, 12.73 million ha of forest is to be newly rehabilitated from 2000 to 2010, increasing forest cover from 25.87 to 32.26 percent.

The program's second part was located in the state-owned forest region of Inner-Mongolia, Jilin, Heilongjiang, Hainan and Xinjiang, and covers 34.179 million ha. Of this area, 14.09 and 12.06 million ha will be subject to a strict logging ban and limited logging per ha respectively, reducing timber output from 18.532 million m^3 in 1997 to 11.017 million m^3 in 2003. Meanwhile, 484,000 redundant workers will be relocated and the remaining 8.029 million ha will be developed into commercial timber forest through timber stand improvement.

During the pilot phase from 1998 to 1999, 10.17 billion RMB was invested in this program as a whole. The planned investment for *afforestation* was 23.1 billion RMB, with 80 percent from the Central Government's budget and 20 percent from local governments (Zhou 2001). Investment standards established were 1050 RMB/ha for *mountain closure*, 1800 RMB/ha for aerial seeding and 3000-4500 RMB/ha for planting. However actual investments depend on the Central Government's budget situation and could vary widely.

Under the program, commercial logging in natural forests was completely stopped in 13 provinces in the Yangtze River's middle reaches and the Yellow River's middle and upper reaches. By the end of 2003, 3.68 million ha had been afforested (SFA 2004).

2. The sloping land conversion program

More than 360 million ha or 37.5 percent of China's land area is affected by severe runoff and soil loss caused mainly by long-term cultivation and over-grazing on steep lands. It is estimated that two-thirds of the two billion tons of mud and sand flowing into the Yangtze and Yellow Rivers annually come from steep land along the river valleys. Severe desertification affects a further 174 million ha, or 18.2 percent of China's land area. To address these problems, the sloping land conversion program was formally initiated in 2002, after a pilot phase from 1999-2001. It involves 30 provinces and is to be executed in two phases from 2001 to 2005 and 2006 to 2010.

In the first phase, 6.67 million ha of cropland (of which 3.33 million ha has steep slopes >25° and two million ha are sandy land) will be converted to forest land, and 8.67 million ha of barren mountain will also be rehabilitated. In the second phase, 14.67 million ha of cultivated land including 2.67 million ha of sandy land, will be converted to forest land, and 17.33 million ha of barren mountains will also be rehabilitated. Forest cover in the program area will increase by an estimated 2.4 and five percent by the end of the first and second phases respectively. Revegetation techniques include planting trees and *mountain closure*. Although there are many candidate tree species, local people preferred planting species with high economic value such as poplar, *Eucalyptus,* bamboo, mulberry (*Morus*), *Ziziphus jujuba*, walnut, chestnut (*Castanea*), wild apricot, *Toona sinensis,* seabuckthorn, peashrub, Chinese fir, pines, *Robinia* and *Tamarix chinensis*.

Farmers who converted steep cropland into forest land in the Yellow and Yangtze River valleys were to receive 1500 kg and 2250 kg grain per hectare converted respectively, 300 RMB per hectare for their children's education and public health care, and 750 RMB per hectare for buying seedlings. The compensation is to last for five years for conversion to *economic forests* planted with fruit trees and eight years for *ecological forests* planted with timber trees. These farmers will also have to rehabilitate an equivalent area of barren mountains and will receive 750 RMB per hectare for this task.

Total planned investment in the whole project period is 358.43 billion RMB, 92 percent of it to come from the Central Government. This includes 298.5 billion RMB for grains, 34.01 billion RMB cash subsidy for education and health care, 24 billion RMB for buying seedlings, and 1.92 billion RMB for technical support and project preparation (Zhou 2001). Provincial governments will shoulder the expenses of grain transportation and other local costs amounting to roughly eight percent.

By the end of 2002, 13 million households with 53 million farmers obtained cash and grain subsidies. By the end of 2003, 5.86 million ha of sloping cultivated land and 6.34 million ha of barren land had been forested (SFA 2004). Field investigation from 1999 to 2002 indicated that various wildlife species had reappeared and increased gradually in the program area (Zhou 2001).

3. Desertification control project in the vicinity of Beijing and Tianjin

Increasingly severe sandstorms have affected the capital city of Beijing in recent years. Following up on the program on combating national desertification (1991 to 2000), this desertification control project was launched in 2001 to reduce the sandstorms and halt desertification encroaching on Beijing and Tianjin. It covers 75 counties in the Inner-Mongolia autonomous region, Hebei and Shanxi provinces, Beijing and Tianjing municipality.

The project is scheduled for 10 years, with two phases from 2001 to 2005, and 2006 to 2010. It aims to convert 2.629 million ha of cultivated land into forest land by the end of 2006, rehabilitate 4.944 million ha of barren mountains and sandy lands, improve 10.63 million ha of grassland, control runoff and soil loss on 2.34 million ha, and relocate 80,000 people living in the area who are affected by the deteriorating environmental conditions including drinking water shortages. Techniques include tree planting, aerial seeding, mountain and grassland closure and relocating local people. Species to be planted were poplars, pines, larch, *Robinia*, cypress and shrubs.

The total investment was to be about 57.703 billion RMB and includes costs of *afforestation*, establishing seedling nurseries and small-scale water conservation systems, pasture management, farmer relocation, technical support and operations (Zhou 2001). Farmers who converted poor cropland into forest land or afforest barren mountains or sandy land would receive 1500 kg grain per hectare converted, 300 RMB per hectare for children's education and public health care, and 750 RMB per hectare for buying seedlings. Investment standards established were 1050 RMB/ha for *mountain closure*, 1800 RMB/ha for aerial seeding and 4500 RMB/ha for planting.

About 2.16 million ha were afforested through this program from 2001-03, 28% of the area targeted over ten years (SFA 2004). However, over-grazing, reclamation of arable land, over-cutting for fuelwood and over-collecting of herbal medicines continue to cause severe damage.

4. **Key shelterbelt development project in the Three-North region, the middle and lower reaches of the Yangtze River, and other areas**
This program from 2001 to 2010 integrates the fourth phase of the shelterbelt program in the Three-North region; the second phase of the shelterbelt program along the middle and lower reaches of the Yangtze River valley; and the second phases of the coastal shelterbelt, the Pearl River valley shelterbelt, Taihang Mountain greening and plain regreening programs. Some counties from the earlier Liaohe River valley, and Huaihe River and Taihu Lake basin shelterbelt programs were also recombined into this shelterbelt development project.

   The total targeted *afforestation* area is 26.98 million ha for the 10 years. Planned investment is 70 billion RMB, of which more than 50 percent comes from the Central Government (Zhou 2001). Investment standards established were 1050 RMB/ha for *mountain closure*, 1800 RMB/ha for aerial seeding and 3000 RMB/ha for planting. About 8.2 million ha were afforested through this program from 2001-03, 30% of the area targeted over ten years (SFA 2004).

5. **Forest industrial base development project in key regions**
China is facing increasing wood demand due to rapid economic development. Total domestic wood demand will reach 340-350 million m^3 in 2005 and 430-440 million m^3 in 2015, but projected wood supply based on current national forest resources will be only 169 million m^3 and 195 million m^3 respectively. Even excluding fuelwood requirements, domestic timber shortage for construction and wood-processing industries will be as high as 60-70 million m^3 in 2005 and 140-150 million m^3 in 2015. In the past, the wood supply came mainly from natural forests, and the natural forest protection program has increased the domestic pressure caused by wood shortages.

   Following up on the earlier timber plantation programs, the 15-year forest industrial base development project was initiated in 2001 with the aim of meeting 40 percent of the domestic industrial wood demand by 2015. The project area is 13.326 million ha spread across 886 counties and 114 forest farms or enterprises in 18 provinces. The key areas are in the southern provinces of Guangdong, Fujian, Hainan and Guanxi; the middle and lower reaches of the Yangtze River; the middle and lower reaches of the Yellow River; and the northeastern and Inner Mongolian regions. The project is subdivided into two stages, the first stage from 2001 to 2005, and the second (with two five-year phases) from 2006-2015.

The project plans to establish 10.83 million ha of plantations for paper and panel-making industries and 2.497 million ha of plantations for large-diameter timber for furniture and construction**.** About 4.691 million ha, 4.511 million ha and 4.124 million ha of fast-growing and high-yielding plantations will be established in each of the three phases respectively. Of the total project area, 6.18 million ha will be newly afforested and the remaining 7.146 million ha will be formed by improving current forest stands.

Revegetation techniques include tree planting and improving low-yield forests. Species to be planted include poplars, *Eucalyptus*, pines, bamboo, *Acacia*, *Paulownia*, larch, mahogany (*Swietenia)*, teak, camphor, birch (*Betula*), ash, *Phellodendron amurense, Tilia tuan*, and oak (*Quercus*). Total planned investment for *afforestation* is 63.8 billion RMB of which 20 percent is a subsidy (mainly for seedlings) from the Central Government, 70 percent from low-interest bank loans and 10 percent from other sources (Zhou 2001). Investment standards for new plantations were 6000-7000 RMB/ha for pulp and artificial boards and 7000-8000 RMB/ha for larger-diameter timber.