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Soil and Water Conservation Strategies on the Red and Yellow Soils of South China

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ABSTRACT

The red and yellow soils of South China stretch over the tropical and subtropical regions, covering 2.20 million km^2 in 13 provinces. Due to mismanagement and inappropriate land uses, the loss of soil and water has been serious. This paper discusses the impact of human factors on soil and water loss, and presents the laws, regulations, principles, and approaches to soil and water conservation in South China.

INTRODUCTION

The red and yellow soils (Oxisols) of South China stretch over the tropical and subtropical regions between latitude 18°19'N and 32°42'N, longitude 91°24'E and 121°48'E, covering 2.20 million km^2 in 13 Provinces-Hainan, Guangdong, Guangxi, Fujian, Jiangxi, Hunan, Guizhou, Taiwan and parts of Yunnan, Sichuan, Zhejiang, Hubei and Anhui (Figure 1). There are about 410 million of agricultural population and 26 million ha of arable land in this region. This area is China's important production base of grain crops and is regarded as having great potential for tropical and subtropical cash-crop production and animal husbandry development, because the warm, wet season favors crop production and rapid biological cycling. However, due to mismanagement and inappropriate land use, the area of soil erosion increased from some 600,000 km^2 in the 1950s to about 740,000 km^2 in the early 1990s, with about 0.06 ha of arable land per capita. Therefore, loss of productive land is a serious problem in South China today.

FACTORS CAUSING SOIL AND WATER LOSS

Among the factors causing soil and water loss, expanding population, irrational reclamation and utilization, capital construction and mining without soil and water conservation measures are the main human factors. These factors, in addition to the great number of hills (about 90% of the total land area) in this region and the plenty but concentrated rainfall (annual precipitation 1200-2500 mm, mainly between April and September), result in soil erosion.

Population factor

In the past 50 years, population-land contradiction has become more serious because of increasing population. For

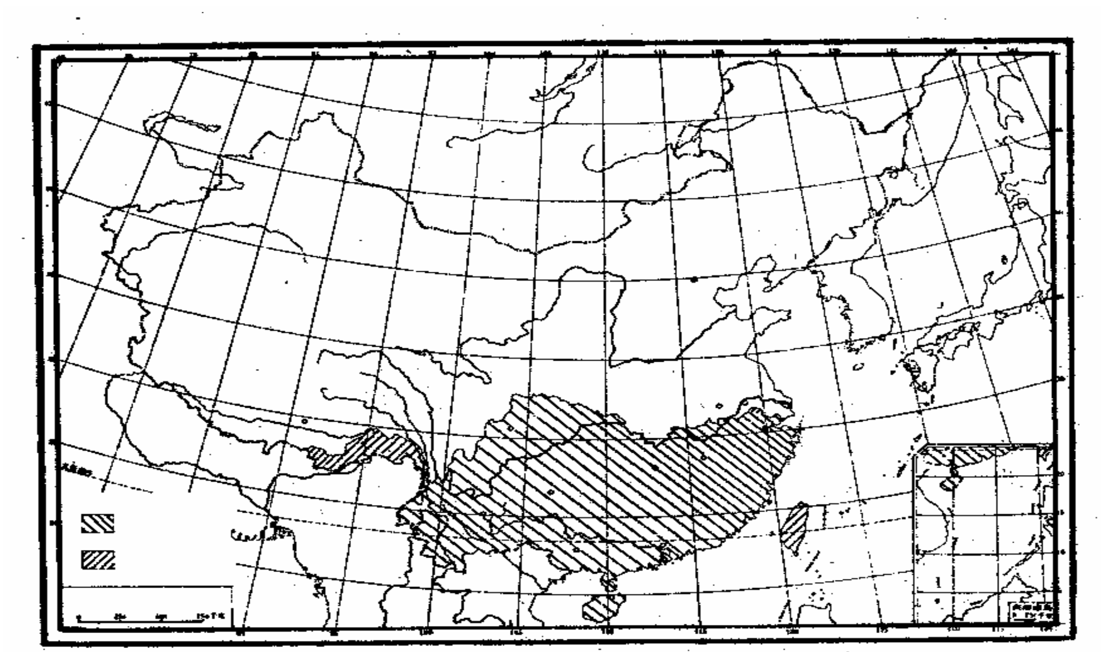

Figure 1 The red and yellow soil (Oxisol) areas in South China. Source: Liu, J., 1994. Note: The shaded region shows the areas.

Studied areas ▧ ▨ **Without inclusion in the study**

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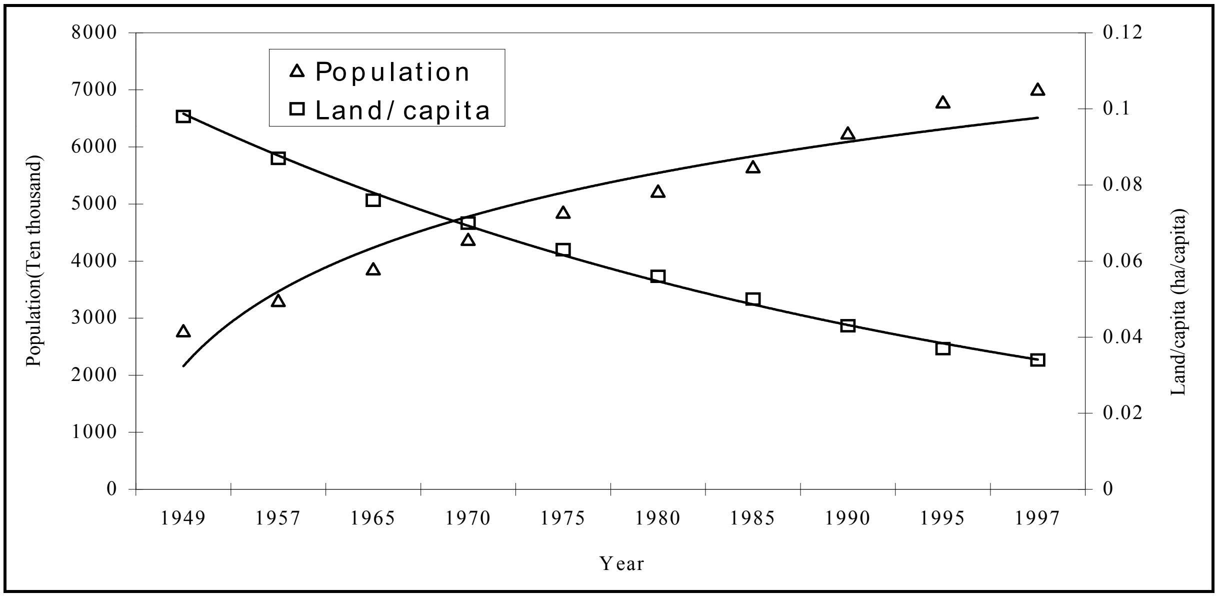

Figure 2. Dynamics of both population and land per capita in Guangdong Province from 1949 to 1997

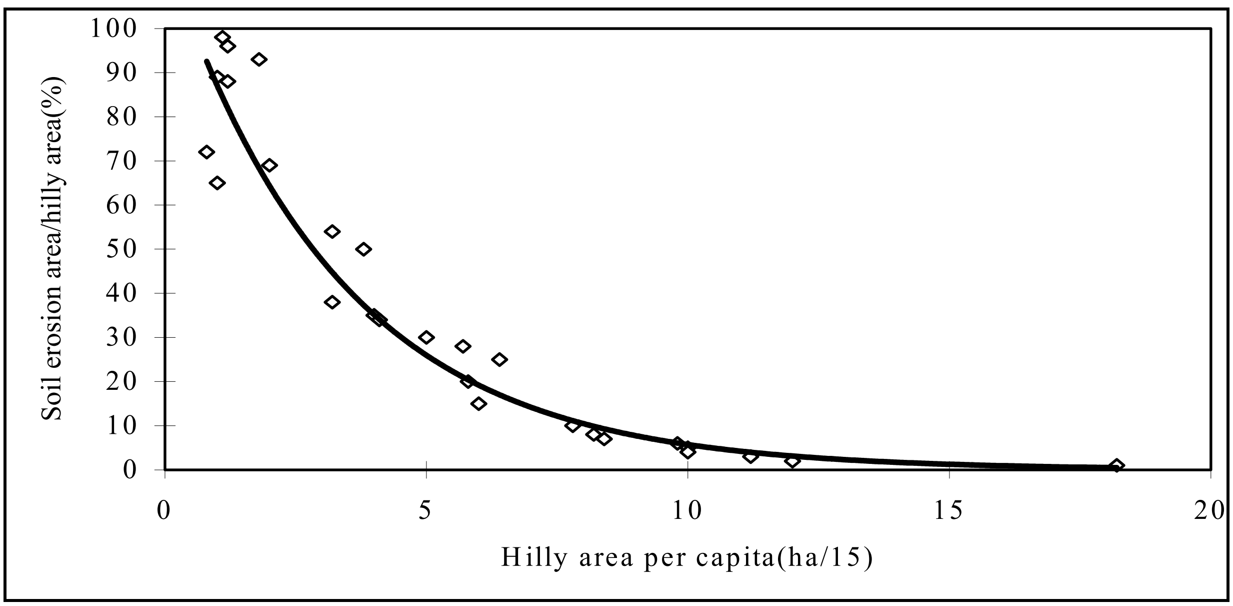

Figure 3 The relationship between hilly area per capita and soil erosion area/hilly area. Source: Tang, S. et al., 1991

example, in Guangdong Province, the population was only 27.82 million and the arable land per capita was 0.098 ha in 1949. However, in 1997 the population was 70.13 million and the arable land per capita was only 0.034 ha. The population increased by 128.9%, but the arable land per capita fell by 65.3% in 1997 compared with 1949 **(Figure 2)**. The increasing population resulted in food and fuel shortages and reduction of economic income per capita, and consequently, lead to reclamation of land by destroying forest, excessive tree cutting and the reduction of vegetation coverage, which caused heavy soil and water loss. In very hilly regions, the area of soil and water loss increased with decreasing mountain area per capita. For instance, the positive correlation between the area of soil erosion and the population density was found significant in Mexican Prefecture, where soil erosion was the heaviest in Guangdong Province **(Figure 3).** Shi (1999) and Zhang et al. (1999) reported that sharp population increase lead to the massive reclamation of forest areas, caused the reduction of forest coverage along the Yangtze River basin, and resulted in worsening soil erosion. In Sichuan Province, the aggravation of soil erosion was also reported to be closely related to population density (Chai, 1998).

Irrational reclamation and utilization

In South China, the areas with the most serious soil and water loss are located in hilly regions, where there exist generally irrational reclamation and utilization patterns, such as steep-slope reclamation, down-slope cultivation, control-burn reclamation for forestation, slash-and-burn agriculture and single cropping practice, which caused heavy soil erosion. For example, in Guangdong Province, the area of soil erosion caused by steep-slope reclamation was as great as 811.3 km^2, accounting for 29.0% of total area of soil erosion from 1986 to 1992 (Li, Z. and Guo, S., 1998). Sloping land in Nanxiong County of Guangdong Province possessed a 23cm deep soil layer at the beginning of reclamation, but was eroded to a 16.4cm deep soil layer due to down-slope cultivation after 5 years, 1.32cm of soil per year being washed away (Liu, A. et al., 1993). Zeng and Pu (1998) and Guo, T. (1998) reported that the main factors causing 1998 floods on Yangtze were steep-slope planting and unreasonable forest cutting which caused soil erosion in the upper reaches of the Yangtze River.

Capital construction and mining without soil and water conservation measures

Capital construction and mining without soil and water conservation measures are the most important causes of man-made soil erosion. For instance, in 16 cities of Guangdong Province, the area of soil erosion caused by mining and brick-kiln adites was 1802.03 km^2 (1986-1992), accounting for 62.17% of the total area of soil erosion of 2898.4 km^2 (Li, Z. and Guo, S., 1998). According to the investigation of the Three Gorges Reservoir areas and eight counties of Hubei Province and Sichuan Province, 127 initiated projects have resulted in 35.1 km^2 of soil-erosion, destroyed 36.9 km^2 of vegetation and cast as much as 100 million m^3 of soil and stone (Guo, T., 1998).

LAWS AND REGULATION

To control and prevent soil and water loss and to protect and rationally use soil and water resources, the Chinese government successively issued " Soil and Water Conservation Provisional Outlines of The People's Republic of China" (1957), "Methods of Soil and Water Conservation Practices for Small Watershed" (1980), "Soil and Water Conservation Regulations" (1982) and "Soil and Water Conservation Acts of The People's Republic of China" (1991). Besides, China has implemented family planning to relieve the pressure caused by rapid population growth.

PRINCIPLES

Combining engineering measures with biological measures

Appropriate engineering measures help create proper conditions for growing plants, but these measures are only a temporary solution for erosion control. Biological measures, on the other hand, can provide permanent control.

Combining erosion control with economic development

Since eroded areas are usually poorer regions, high farmer enthusiasm is not expected through controlling without economic profits. Only by combining control with local economic development, can the enthusiasm of farmers be motivated. Therefore, it is necessary to integrate with some projects, such as economic forestry, animal husbandry and fishery, which might bring local farmers economic profits and thereby promote soil and water conservation directly or indirectly.

Combining policy measures with technical measures

The leading factor in the genesis and control of soil and water loss is mankind itself. Strategic policies are mainly to control population growth rate, to implement soil and water conservation regulations, to establish and strengthen soil and water conservation institutions, to solve the shortage of energy resources and food and enhance economic development of rural areas. Tactically technical measures are mainly to take small watersheds as units and to enforce integrated biological, engineering and conservation tillage measures for controlling soil and water loss.

Classified control based on erosion types

The types of soil erosion in South China chiefly are sheet erosion, gully erosion, collapsing hill erosion and landslide erosion. Since the forms eroded and erosion intensity is different from each other, it is necessary to adopt different control measures in the light of erosion forms and local conditions.

APPROACHES TO SOIL AND WATER CONSERVATION

Engineering measures

Engineering measures to reduce soil and water loss in hilly region focus mainly on check dams, gully head protecting works, level trenches, terraces and hillside ditches. Check dams placed at the gully opening slow floodwater and trap sediments, ultimately raising the mouth of gully and creating the proper conditions for growing plants. Terraces are the main engineering measures to control soil and water loss in the hilly region of South China. For example, Sichuan Province has 72% of cultivated land in terrace form.

Biological measures

Biological measures, on the other hand, can provide permanent soil erosion control and reduce water and nutrient loss. Plant measures concentrate on planting fast growing trees, bushes and herbs. Trees, bushes and herbs are grown together in a certain proportion when revegetating. The combination of plants contributes beneficially to revegetation and can help to form a multilayer canopy, such vegetative canopies provide beneficial erosion control and soil fertility enhancement. For example, in Mexican County of Guangdong Province, the rapid plant cover technique shows that the vegetation cover reached 80-100% in the same year during which the plant were grown, and made a pronounced effect on erosion by stabilizing gully walls and reduced runoff values by 40-100% (Li, H. and Zheng, B., 1993). Contour hedgerows were also studied in recent years for controlling soil erosion and retaining water in some hilly regions and results show that it effectively decreases slope gradients and controls soil erosion (Shen, Y. 1998; Cai, Q. and Li, S., 1998).

Agronomic measures

Agronomic measures adopted in South China mainly

Table 1. The soil and water loss and economic profits under different intercropping patterns.

Patterns	Bareland	Litchi+	Litchi+vegetables	Litchi+Corn	Litchi+Graham#
Runoff &sediment (g m^{-2} hr^{-1})++	259.0	150.0	71.3	115.0	23.3
Profits (Yuan ha^{-1} a^{-1})	0	7500	14305	12250	10050

\+ Litchi *chinensis*
++ Rainfall intensity: 176.5mm/hr
\# *Stylo guianensis*

Table 2. Effects of different types of forest on soil and water conservation and temperature. Source: Zhong J., Chang B. and Tang S. (1998)

Parameters	Coniferous forest	Mixed+ forest	Broadleaf forest	Bareland
Mean temperature (ºC)	24.3	23.0	21.0	25.2
Soil water storage in 0-50cm soil layer (mm)	1648.9	1837.2	2025.1	—
Mud loss++ (kg ha^{-1} yr^{-1})	5677.5	3.0	—	19897.5

\+ Conifer-broadleaf mixed forest
++ Source: Zhang, Yao and Li (1994)

include contour tillage, ridge and furrow tillage, rotation systems, intercropping, minimum tillage and no-tillage. Contour tillage was popular in South China and the focus of soil and water conservation was mainly put on the effective intercropping and rotation system in recent years. The study on fruit (Litchi)-grass, fruit-vegetable, and fruit-corn intercropping has shown very good results by reducing soil erosion by 40-80% and significantly increasing farmer's income (Table 1).

Forest measures

Forestation in soil-and-water-loss regions to increase forest coverage is an extremely important measure in preventing soil erosion and improving the ecological environment of South China. Afforestation can also provide fuel, forage, plant nutrients, lumber, fruits, and other forest by-products, and thereby accelerate the development of agriculture, forestry, animal husbandry, and commodity production. Forestry measures for soil and water conservation focus on slope shelter-forest, gully shelter-forest, gully head shelter-forest, reservoir shelter-forest, and economic forest. Forestry measures include afforestation and closing hillsides to facilitate afforestation. Different types of forest have different effects in conserving soil and water (Table 2). Comprehensive effects suggested that developing various types of mixed forest is worth extending in South China. Conifer-broadleaf trees mixed forest and arbor-bush mixed forest are the common types adopted.

In 1985, the Guangdong provincial government put forward a plan to afforest Guangdong within ten years. By 1997, the forest coverage rate had reached 56.6%, increased by 104.3% compared with 27.7% in 1985 (Figure 4). The increase of forest area can markedly reduce the area of soil and water loss. According to the statistics of 12 counties' investigation data in Guangdong Province, the correlation between forest area and the area of soil and water loss was significantly negative (Figure 5).

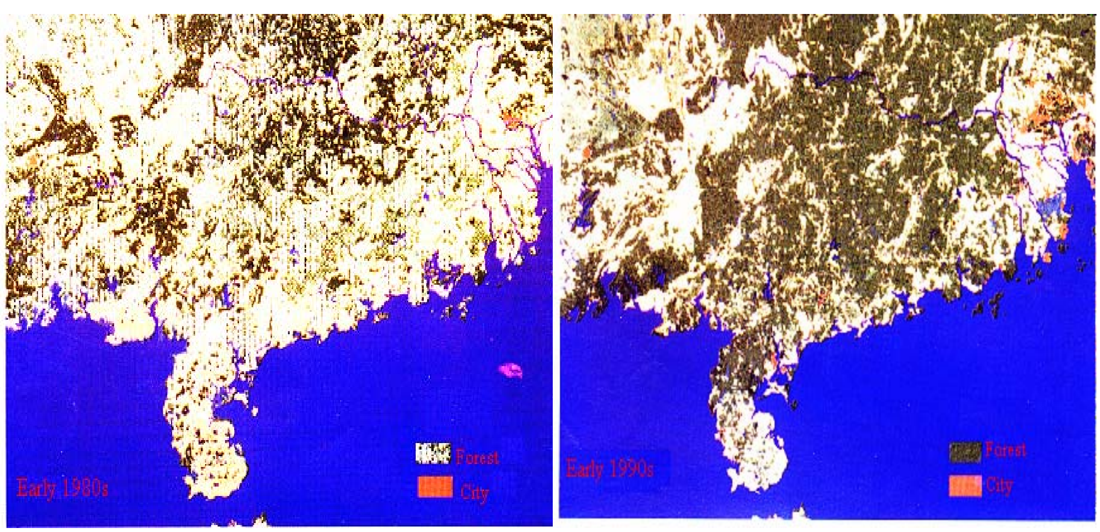

Figure 4. The satellite remote sensing image of forest cover changes. Left image: in the early 1980s; Right image: in the early 1990s. Source: Cover 2 in Review of Science and Technology, No. 8, 1997.

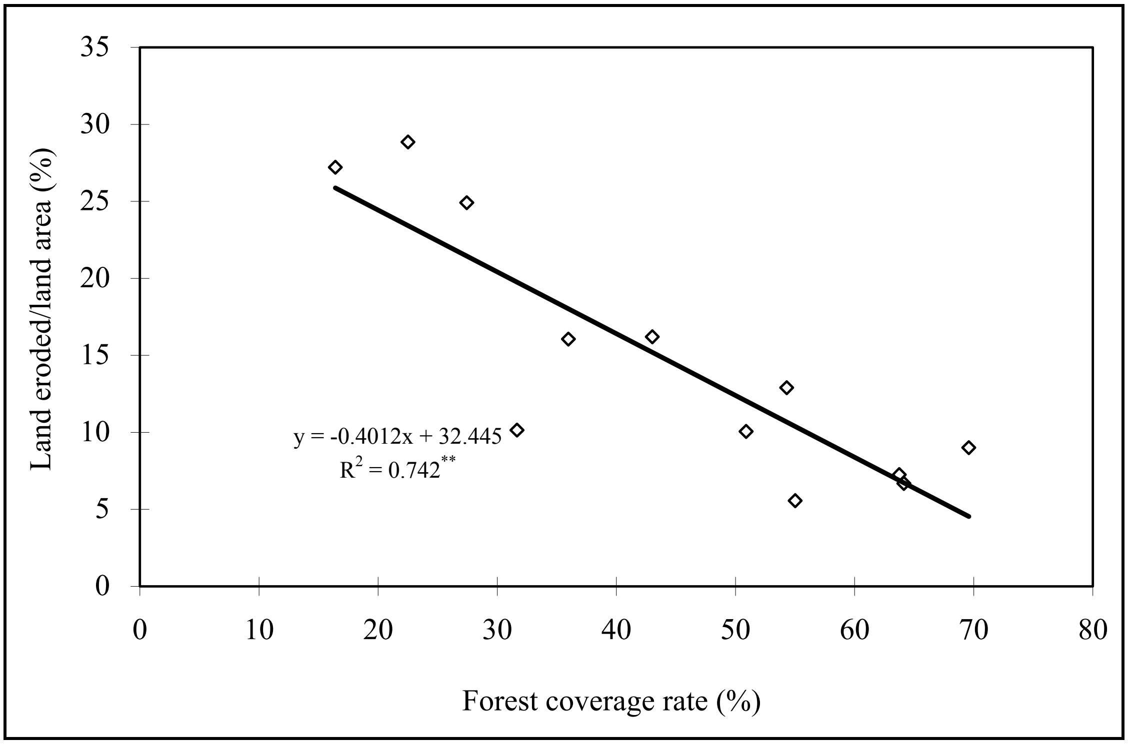

Figure 5. Relationship between forest coverage rate and soil erosion area (*P*<0.01). Source: Tang, S., 1991.

Stereoagriculture

Stereo agriculture is an important form of ecological agriculture for preventing soil erosion that is commonly practiced in hilly areas of South China. This form of agriculture is designed to generate a variety of products (i.e. foods from plants, animals, firewood, timber and medicines) from a topographically varied side.

The hilltop section is typically designed for conservation forest. Approaches have focused on identifying optimum community combinations to promote rapid growth and maximize canopy development. Multi-storied, multi-species communities have proven to be most effective.

Hillside sections are developed as a blend of conservation and economic forest (fruit trees). This type of forest focuses on different plant combinations according to the local conditions, and may be developed to satisfy local fuel, lumber and fruit demands or even be enhanced further to provide raw materials for local industries and thereby contribute additional economic benefits.

Foothill sections are focused on mixed systems of orchards, cash crops, livestock and culture. These systems, following the ecological principles of the food chain, exemplify foothill management and contribute much to economic development.

Small watershed comprehensive harnessing

The small watershed is an integrated physical and social unit, consisting of various relief structures, such as mountain, hill, basin, valley and plain. Small watershed comprehensive harnessing in South China includes the following contents: taking small watersheds as control units, rational planning and arranging conservative tillage practices, forest-grass practices and engineering measures, optimizing the land-use structure of agriculture, forests and animal husbandry, and making various practices mutually coordinated and promoted to form the small watershed integrated harnessing systems, and finally realizing the targets of controlling soil erosion with the combination of ecological, economic and social profits. Since the 1980s, provinces in South China have successively launched small watershed comprehensive harnessing as the most effective way of preventing and controlling soil and water loss and developing the local economy. For example, in the small watershed of Mianyang River in Wuhua County of Guangdong Province, the area of soil erosion was 10.78 km^2, accounting for 37.6% of the hilly area. Through continuing harnessing by integrated planning, closing hillsides to facilitate afforestation, constructing check dams, reforming irrational tillage practices, changing monoculture systems, turning crop cultivation of steep slope land into forest (mainly fruit trees) and building terrace to plant crops or fruit trees, 2/3 of loss area was controlled four years later, the river bed was lowered by 25 cm, and farmer's income was markedly raised (Tang S., Zhong J. and Zou G., 1991).

China feeds 22% of the world population with 7% of the world land area. Therefore, soil and water conservation is an extremely important but long-term and arduous task. With the advance of science and technology, the steps of soil and water conservation task in China will be faster, and the achievement of soil and water conservation will be greater.

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