

## SOIL CONSERVATION FARMING SYSTEM PRACTICES ON SLOPING LAND ON THE SOUTH-EASTERN COAST OF CHINA

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### Abstract

Soil conservation farming system has been studied in Zhangzhou Municipality of Fujian Province by following the ASOCON activities. The result has shown that intensive farming measures are available for soil conservation on sloping land in a densely populated area. Level terracing is the basic physical conservation measure in the farming system which has a high economic and soil conservation benefit. Other conservation measures include multiple cropping and rotation with different plants to increase cover and soil moisture levels to protect the soil from erosion, as dry and loose soil is easy to erode when the soil is disturbed during the harvest season. Orchard establishment with a combination of late, semi-late fruit trees and annual crops ensures farmers' early income, and improves soil fertility on the severely eroded sloping land. Contour grass barriers have also been popularly used because of their cheap cost and easy operation. Each measure shows its advantages in different situations for the farmers and their land and they need to be designed comprehensively and rationally.

Additional Keywords: soil conservation, terracing, fruit trees, contour grass barriers

### Introduction

The southeastern coast of China has suffered severe soil erosion because of dense population in relation to the available land, unsustainable land use, and the natural environment that has steep slope and high precipitation. Fujian Province lies within the subtropical zone, of southeast mainland China and is characterised by a maritime and monsoonal climate. Average temperatures are 17-20° with an average annual rainfall of 1100-2000 mm. The annual amount of runoff is 115,000 million cubic metres. The average amount of sediment transported annually is 3.86 million tons. The Province covers an area of 123000 square kilometres of which about 90% consists of mountainous and hilly land. The cultivated land area is 12400 square kilometres, or 0.043 hectare per person. In Fujian Province there are 13133.65 km<sup>2</sup> of erosion which accounts for 10.72% of the total land area. Soil erosion has resulted in farmland degradation, frequent drought, and serious waterlogging over large farmland areas. According to data analysis and current erosion rates, the soil will be all gone away in the periods between 100 and 1,000 years. Therefore, protecting the limited farmland is becoming a serious social problem that we need to address. In Fujian Province, 35 counties (including Zhao'an, Pinhe, Zhangpu, Nanjin in Zhangzhou Municipality) have serious soil erosion problems, all contributing to the more than 60 million tons of soil lost per year from the province.

### Erosion Situation on Sloping Farmland

About 80% of Southeastern China is mountainous land. In addition, rainfall is high with annual precipitation around 1,600-1,800 mm and 80% of the total precipitation is seasonal, heavy typhoon rain. Principal soils are red soil weathered from granite with loose texture and weak resistance against erosion, so the soil is easy to erode after the vegetation cover has been destroyed. Soil erosion on farmland is mainly a result from inappropriate farming systems and poverty-stricken farmers. At the same time the erosion problem is closely related to the people because the growing population needs more land for their food. Farmland development has increasingly expanded from lowland to upland areas, which tends to cause severe soil erosion problems. According to the soil erosion survey, 92% of farmland was affected by erosion in Fujian Province and the severe soil erosion resulted in land degradation, as the soil becomes depleted as shown in Table 1.

**Table 1. Effect of soil erosion on soil nutrient levels of farmland in Zhangzhou (g kg<sup>-1</sup>)**

Soil Sample Location	Soil Erosion Type	Organic Matter	Total Nutrient N	Available Nutrient		
				N	P	K
1\Pinhe County	Not Eroded	25.60	1.23	132	5.7	156
2\Pinhe County	Slight Eroded	16.70	0.81	67	3.6	59
3\Nanjing County	Medium Eroded	11.20	0.51	51	2.4	51
4\Nanjing County	Strong Eroded	9.30	0.46	36	-	50

Farmers then tend to abandon land when it becomes too degraded and exploit new sloping land for food production. In view of these problems, we are mainly taking the following measures to conserve the sloping farmland.

### **Sustainable and Productive Cultivation on Sloping Land**

The implementation of soil and water conservation programmes in the south-eastern provinces of China has involved following a policy of “combining prevention with control, with emphasis on the former”. This involves conducting a comprehensive approach to control soil erosion by using a combination of vegetative and engineering measures, to control both erosion on slopes and the formation of gullies. Equal attention is given to rehabilitation and development, as well as integrating direct short-term benefits with long-term sustainability. This approach has been developed rapidly with good results.

Some 35% of China’s total cultivation, equivalent to an area of 33.3 million ha, takes place on sloping land in mountainous and hilly regions. Within the tropical and subtropical parts of the provinces of Southeastern China cultivation occurs on an area of 8.6 million ha of sloping land. Because of the steep slope of the cultivated land, heavy rains, shallow soil depth and serious soil erosion, grain yields are low and fluctuate from year to year. In places the soil has been washed away from areas of sloping land, leaving behind unproductive exposed rock. Such severe erosion threatens the living conditions of the people, therefore, the improvement of the cultivation of sloping land is an important soil conservation activity in the Southeastern region.

The major control measures used on sloping land are terracing, contour ridging and construction of drainage channels. In places with limited water resources, the use of level bench terracing decreases surface runoff, while improving soil permeability and water storage capacity, at the same time soil erosion is reduced and land productivity increased. Terracing has been completed on 2 million ha of sloping land in the Southeastern region. This has resulted in organic matter and total nitrogen levels in the soil increasing by 1.5-2 times. Likewise, yields per unit area have been increased by 100-200%.

**Table 2. Comparison of soil conservation efficiency between terrace and sloping land runoff test plots under pineapple in Longhai**

<b>Treatment</b>	<b>Sediment Loss (t km<sup>-2</sup> yr<sup>-1</sup>)</b>	<b>Runoff (t ha<sup>-1</sup> yr<sup>-1</sup>)</b>	<b>Soil Moisture (%)</b>
Terrace+Pineapple	18.0	569.1	22.67
Slope+Pineapple	1,722.0	2,931.0	20.92
Bareland 5-30 cm layer	2,274.8	4,413.1	20.19

Level terraces have been used as a basic conservation measures for more than two thousand years. From Table 2 you can see that runoff and sedimentation under terrace conditions is evidently less than that for sloping plantation, and that soil moisture content is also slightly higher. Standard level terraces caused soil erosion to within the permitted range. Level terraces have three advantages: maintaining soil fertility; raising crop yield, generally by more than 100%; and prolonging the period of land use. By fitting into farmers’ intensive production practices, it can provide surplus land to interplant other crops because of the favourable water and fertility conservation. Level terraces have a significant capacity to increase food production in a densely populated area. The large population also has solved much of the labour needs for terrace establishment. New terrace systems have been designed with contour grassed waterway used for both runoff interception and access tracks. In Fujian, valuable practical experience has been obtained with the planning, design, building, maintenance and planting of terraced fields as well as in the utilization of contour ridges.

With the implementation of the “agricultural production responsibility system”, farmers became entitled to expand the area of land they were responsible for managing. It encouraged farmers to invest, on their own initiative, in constructing terraces on the land contracted to them. The state has developed a series of economic policies to encourage farmers to undertake terracing. Specifically the State provides a financial incentive (state subsidy) for terraces built by farmers. The subsidy for terraced fields with earth banks is 750 yuan (RMB) per ha. In addition, farmers are provided with chemical fertilizer and State purchase quotas are reduced as appropriate for the first 3-5 years of cultivation in new terraced fields. The policy was clearly formulated to enable the person who built the terraces to reap the benefits for the decades ahead.

### **Integrated Planning for Conservation Farming System: Multiple Cropping with Rotation**

Integrated planning for conservation farming system is undertaken in Zhangzhou Municipality of Fujian Province. Multiple cropping with rotation originally came from the farmers' search for higher yields. It is also a traditional farming system, and popularly used as a soil conservation measure which is recommended by soil scientists and agronomists. It is considered to have a high economic benefit and to maintain soil fertility. Farmers can harvest different crops in small fields and multiple cropping with rotation can improve soil fertility because different crops provide ground cover at varying times, which can reduce soil erosion and runoff. Meanwhile, plant residues provide a source of organic matter to improve soil structure, fertility and the activity of soil microorganisms. Therefore, multiple cropping with rotation has many advantages for soil conservation.

Farmers need to adopt the system of multiple cropping with rotation, because there is only a small area of farmland for the population in the region, (< 0.043 ha per capita). Multiple cropping with rotation has become the way of survival, especially if farmers can obtain a 25-32% increase in yield per year. In addition, the favourable climate provides many options for the farmers using multiple cropping. The area has many varieties of crop in each season with different harvesting times. For instance, peanut is planted in early March, corn in mid March and sweet potato in late May. These can be planted progressively row by row. This pattern not only increases yield but the later sweet potato growing period can raise vegetation coverage levels and increase the amount of soil-fixing root system, which prevents soil erosion. In addition, the amount of biomass has a significant effect on improving soil fertility. Experimental results from runoff plots in different intercropping show that legume plantation provides better protection than fallow land (see Table 3). Therefore, intercropping is a target for future soil conservation because legumes produce vegetative material for protection from soil erosion. The question is how to manage it.

**Table 3. Soil and Water Conservation Effect on Intercropping Legume in Young Longan Orchard of Nanjing, Zhangzhou (From June to July)**

<b>Treatment</b>	<b>Runoff Index (%)</b>	<b>Soil Erosion (kg ha<sup>-1</sup>)</b>
Intercropping:		
Indonesia Green Bean	8.31	686.9
India Cowbean	4.06	112.8
Sensitive Plant	2.92	112.2
<i>Stylosanthes gracilis</i>	4.90	243.0
<i>Indigofera ennecephylla</i>	2.97	104.6
CK (Check)	10.38	1,724.7

\* Rainfall: June 193.5mm, July 269mm

Table 3 shows that legume has a soil and water conservation benefit, which is favourable to fruit growth in orchards. The combination of late fruit trees, semi-late fruit trees and annual cropping is another multiple-planting system for soil conservation in the region. Farmers can obtain early benefits to make up for orchard management costs, and can improve poor, eroded soil through multiple plant growth. Fruit tree varieties suitable for severely eroded poor land are varieties of litchi, longan and red bayberry. Semi-late varieties include plum, peach and pineapple. Annual crop for planting with fruit trees in the field are mainly peanut, soybean, watermelon and vegetables.

### **Combining Environmental Sustainability with Productivity: Fruit Tree-Pasture Comprehensive Conservation Work**

In the southeastern provinces of China, soil and water conservation activities include both soil erosion control and the rational use of land. In Fujian Province, there is a proposal to transform an area affected by soil erosion into economic orchards, fuelwood plantations and areas for the production of forage grasses. Through a rehabilitation programme, land productivity is increased in the eroded area ensuring the farmers' basic needs for food to be met.

In undertaking the conservation activities within the Minjiang and Jiulongjiang rivers in Fujian Province, attention was paid to rehabilitating the eroded areas, while at the same time considering planting fuelwood trees to meet rural energy needs, creating farmland with high productivity to overcome farmers' food problems and developing fruit orchards and livestock farming so as to increase farmers' income. In summary, the emphasis was on incorporating conservation concerns into recommendations for the development and land use requirements in the conservation recommendations. Only if the short-term benefits are combined with long-term sustainability concerns, can soil conservation and development activities be carried out on a continuous basis.

In most counties of Zhangzhou Municipality, few grasses can establish themselves as large-scale pasture because of the advanced local weeds and steep slopes. As the natural grass resource has low quality and yield, the pasture problem is a constraint for developing animal husbandry in these areas. Young orchards in areas with erosion problems can be established by the use of grass of legume pastures, combined with the fruit trees. In view of this pattern, different points have been raised because farmers usually kill weeds in orchards and believe that grass will remove fertility from soil. However, conservationists' experimental results show that not only legume, but also grass growing, can improve soil fertility as well as the activity of soil organisms in the orchard. The growth of grass does not reduce fruit growth under rational pasture management (See Table 4 ).

**Table 4 Soil fertility improvement after intercropping legume for 3 years in young Longan orchard of Nanjing County**

Treatment	Organic Matter (%)	Total N (%)	Available P mg kg <sup>-1</sup>	Available K mg kg <sup>-1</sup>
Clean cultivation (CK)	0.880	0.0269	2.97	17.41
Intercropping Legume Y1	0.946	0.0416	12.14	35.30
( <i>Indigofera ennecephylla</i> ) Y2	1.106	0.0750	23.57	57.19
Y3	1.372	0.0924	34.56	80.13

### Comprehensive Control Programmes of Small Watershed Development

In Zhangzhou Municipality, a small watershed is defined as a watershed with an area of between 5 and 30 square kilometers. By utilizing the natural resources of an area to satisfy economic interests, and in a manner that combines erosion control with the realization of benefits to farmers it has been possible to improve the ecological environment while at the same time obtaining an economic benefits have been taken into consideration, farmers have been able to obtain an income from their conservation activities, and it has therefore been possible to mobilise their enthusiasm for the work. For instance, outstanding results were obtained in the key Hanjiang and Beijiang watersheds in Guangdong Province where after 3 years of activities, 1,495 square kilometers of formerly eroded areas are already under control. Soil and water losses have been reduced, soil permeability increased and because the water levels in the rivers dropped, flooding and waterlogging disasters have been diminished.

In Zhangzhou Municipality, there are eight examples of such small watersheds in which the areas to be controlled exceed 667 ha and where farmers have been encouraged to take part in the conservation work. In each case the specific control measures to be used are based on the prevailing local conditions while requiring regulation of the land use pattern. Soil and water conservation work in China is not only concerned with the rehabilitation of eroded areas but also with prevention of soil erosion. Therefore through this programme small watersheds are being transformed into comprehensively protected economic land units with multiple targets, multiple functions and high benefits.

### Conclusion

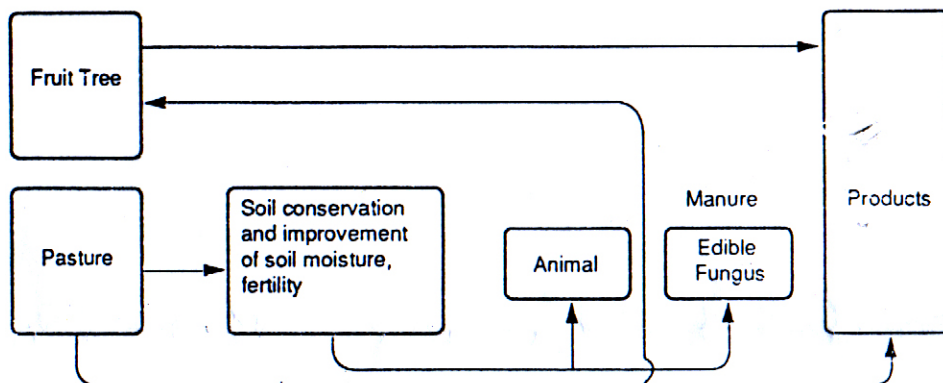
The south-eastern coast of China is characterised by a dense population, and limited land for food production. In local agriculture, there is a strong pressure for food production because of the priority given to food in the national economic plans. Farmers are also interested in intensive agriculture to increase their agricultural income, all year round. Therefore, the farming measures mentioned in this paper needs to be evaluated in regard to different land resources, and social and economic situations.

The terrace is the most popular conservation farming measure in China. These are relatively permanent and 300-year-old terraces can often be seen which is one reason why farmers are in favour of terraced farming. With increasing mechanization, many scholars are doubting the suitability of terraces in future agricultural development, especially in fruit orchards. This can be solved by new road system designs and by improvement in existing ones. The use of small machines in terraced orchards has shown promise on Taiwan island and is convenient for chemical spraying, fertilising, harvesting and transportation. Multiple cropping with rotation, fruit tree-pasture, as well as sparse forest with pasture all belong to same principle of 'returning to nature'. This not only raises productivity but also promotes a sustainable agricultural, ecological circle.

Natural forest includes a variety of species in different layers which have the greatest potential for preventing soil erosion and producing the highest biomass on a unit land. Our target for soil conservation farming system is to establish a modern but natural cropping system. The abovementioned conservation farming measures have been extended to the south-eastern coast of China according to local needs of severe soil erosion, land degradation, large population and land scarcity. Practical experience tells us that using land for high economic benefit and protecting

land from erosion damage is the only way to proceed under the macro-economic plan. Sustainable comprehensive soil conservation projects need to be designed according to the local situation to solve farmers existing problems. Consequently, soil conservation farming measures in the south-eastern coastal region of China are usually based on the following principles:

1. Soil conservation farming systems need to be combined with potential for land utilisation.
2. Land husbandry needs to be combined with an intensive, high benefit farming pattern to fit both the requirements of soil conservation and farmers' incomes.
3. Selection for soil conservation farming measures must be based on the local socioecological and economic conditions.



**Figure 1. Pasture cover under fruit trees provides a foundation for developing three dimensional agricultural production.**