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ECONOMIC ASSESSMENT OF SELECTED RESOURCE MANAGEMENT TECHNIQUES IN MARGINAL UPLAND AGRICULTURE:

Case Studies of China

Ni Hongxing Gu Shuzhong

The CGPRT Centre Working Paper Series, September 1998

The CGPRT Centre

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In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

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ECONOMIC ASSESSMENT OF SELECTED RESOURCE MANAGEMENT TECHNIQUES IN MARGINAL UPLAND AGRICULTURE:

Case Studies of China

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WORKING PAPER 31

ECONOMIC ASSESSMENT OF SELECTED RESOURCE MANAGEMENT TECHNIQUES IN MARGINAL UPLAND AGRICULTURE:

Case Studies of China

Ni Hongxing Gu Shuzhong

CGPRT Centre Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific

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Foreword

Recognizing the importance of sustainable development in upland agriculture, the CGPRT Centre has been implementing sustainability-related projects since 1993. The Centre completed a project "Sustainable Upland Agriculture in Southeast Asia - A Study of Constraints and Prospects for its Development (SUASA-1)" in 1995, and started a follow-up project "Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture (SUASA-2)" in February 1996.

The SUASA-2 project has been implemented in collaboration with partner organizations in China and India, the two biggest countries in Asia, where a considerable number of farmers are cultivating marginal uplands. Two case studies were conducted in each country to identify constraints to and prospects for sustainable resource management in marginal upland areas, with emphasis on economic effects of technologies. The case studies also aimed to characterize the transfer or adoption mechanism of resource management techniques and to suggest directions of sustainable resource management.

I am pleased to publish Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture: Case Studies in China. I believe that readers of the report can understand the importance of resource management for future development of sustainable agriculture in marginal upland areas.

I thank Dr Gu Shuzhong and Mr Ni Hongxing for their enthusiastic participation in the project and for preparing this report and the Commission for Integrated Survey of Natural Resources of the Chinese Academy of Sciences and the Ministry of Agriculture of the People's Republic of China for allowing them to work with us and providing continuous support. My special thanks go to Dr Vute Wangwacharakul, Kasetsart University, Thailand, for his valuable advice. I would also like to express appreciation to the Government of the republic of Korea for funding the project.

September 1998

Haruo Inagaki Director CGPRT Centre

Part I: Terracing in Qinghai Province

Ni Hongxing

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Official Exchange Rate

Currency Unit: Yuan (¥)

US\$ = 8.30¥	¥ 0.120 US\$
US\$ = 8.32 ¥	¥ 0.121 US\$
US\$ = 8.31 ¥	¥ 0.120 US\$
US\$ = 8.62 ¥	± 0.116 US\$
US = 4.72 ¥	¥ 0.212 US\$
	US\$ = 8.30 ¥ US\$ = 8.32 ¥ US\$ = 8.31 ¥ US\$ = 8.62 ¥ US\$ = 4.72 ¥

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This study, initiated and supported by UN ESCAP CGPRT Center, was designed as an economic assessment of selected resource management techniques for marginal upland agriculture to suggest direction for sustainable resource management. For this case, it was to economically assess the effect of terracing - the most important technology for improving productivity and managing resources in Huangyuan County of Qinghai Province. First of all, I would like to thank CGPRT center for its excellent organization of and support to this study.

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People's Republic of China Beijing, 1998 Ni Hongxing Senior Policy Officer Department of International Cooperation Ministry of Agriculture

Executive Summary

In recent years, sustainable resource management has been recognized as one of the most important issues in marginal upland agriculture in Asia, particularly in areas where CGPRT crops are predominant. In this region, upland agriculture is a major source of household income and is usually characterized by a fragile environment, inferior infrastructure and difficult access hampering development. As a result, low income and poverty still prevail among the rural population in these areas. Population pressure on the already limited arable land has resulted in cultivation of marginal lands and farming is practiced in fragile resource conditions; farmers experience problems in land conservation efforts and in increasing land productivity with proper farming technology. The adoption of appropriate resource management techniques is crucial to ensure the sustainability of agricultural development in these regions.

Qinghai Province of P. R. China is a typical marginal upland agricultural area characterized by harsh climatic conditions, a poor natural resource base, fragile environment, backward economic development and low income level. Agriculture in Qinghai is characterized by its subsistence and is carried out in very poor and harsh environments. Farmers there totally rely on their limited resource base; they are not only short of purchasing power to buy products from outside of the region, but also have many limits to move out of this region to seek jobs. Therefore, sustainable agricultural development in this region means improving agricultural productivity while enhancing the resource base. Techniques which can improve agricultural productivity and enhance the natural resource base should be regarded as sustainable.

In order to ensure sustainable agricultural development and to meet the challenge of feeding its ever-increasing population with very limited land and water resources, Qinghai developed a series of farming and resource management techniques to increase agricultural productivity, particularly, grain productivity. Among these technologies, the most significant and effective one is terracing. Based on an review of Qinghai natural conditions and resources, social and economic development and agricultural performance, this paper identifies the constraints to and prospects for sustainable resource management of marginal upland areas in Qinghai Province of P. R. China and economically assesses the effect of terracing, the most important technology for improving productivity and managing resources in Huangyuan County of Qinghai Province.

It could be concluded from this case study that there are many constraints to sustainable agricultural development in Qinghai Province. However, soil and water erosion, shortage of water resources and low efficiency of water utilization are decisive constraints to agricultural development. Terracing is an effective and efficient technique to overcome these constraints. It is conducive for managing soil and water erosion and improving water conservation and water utilization efficiency. Terracing plays a great role in increasing agricultural production, particularly, grain production in Huangyuan County, and has made a significant contribution to the improvement of food security in Qinghai.

Terracing is a cost-effective method for managing and utilizing agricultural resources. It can produce significant economic efficiency, particularly when combined with the construction of an irrigation system. The result of B/C analysis indicated that terrace construction is economically profitable and sustainable. The ratio of benefit to cost for transforming sloping land into terraced dryland is 1.00587, and that for transforming sloping land into terraced irrigation land is 1.34.

Terracing combined with reforestation activities is not only conducive for controlling water and soil erosion, but also facilitates improving the micro-environment. It is environmentally sustainable.

For those people who have low income and few job opportunities outside the region, terracing can be a major source of income and will contribute to poverty reduction and improvement of food security.

1. Introduction and Methodology

In recent years, sustainable resource management has been recognized as one of the most important issues in marginal upland agriculture in Asia, particularly in areas where CGPRT crops are predominant. In this region, upland agriculture is a major source of household income and it is usually characterized by a fragile environment, inferior infrastructure and difficult access hampering development. As a result, low income and poverty still prevail among the rural population in these areas. Population pressure on the already limited arable land has resulted in cultivation of marginal lands and farming is practiced in fragile resource conditions, where farmers experience problems in land conservation efforts and in increasing land productivity with proper farming technology. The adoption of appropriate resource management techniques is crucial to ensure the sustainability of agricultural development in these regions. Therefore, it is important to identify the outcome of specific and variable local resource conditions in a quantitative manner over the long-term.

Qinghai Province is a typical marginal upland agricultural area characterized by harsh climatic conditions, a poor natural resource base, fragile environment, backward economic development and low income level. Agriculture in Qinghai faces a great challenge to feed its ever-increasing population with very limited land and water resources. In order to meet this challenge, Qinghai developed a series of farming and resource management techniques to increase agricultural productivity, particularly, grain productivity. Among these technologies, the most significant and effective is terracing. Based on an review of Qinghai natural conditions and resources, social and economic development and agricultural performance, this paper aims to identify constraints to and prospects for sustainable resource management of marginal upland areas in Qinghai Province of P. R. China and to economically assess the effect of terracing, the most important technology for improving productivity and managing resources in Huangyuan County of Qinghai Province, and to suggest directions for sustainable resource management.

However, sustainable development should be fully understood before the study begins. Sustainable development appears to be rather complex as can be illustrated by the large number of definitions given to it. The definition which has received the widest recognition was formulated by the Food and Agricultural Organization of the United Nations, which describes sustainable development as follows: sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development in the agriculture, forestry and fisheries sectors conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable." This definition highlights the complexity of designing operational policy and programs for agricultural development. For Qinghai Province, agriculture is characterized by its subsistence nature and it is carried out in very poor and harsh environments. Farmers there totally rely on their limited resource base; they are not only short of purchasing power to buy products from outside of the region, but also have many limits to movement out of this region for seeking jobs. Therefore, sustainable agricultural development in this region means improving agricultural productivity while enhancing the resource base. Techniques which can improve agricultural productivity and enhance the natural resource base should be regarded as sustainable.

Since resource management techniques usually have long-term implications on sustainable agricultural development, it is impossible to make an economic assessment in a

Qinghai Province

limited time without using secondary data. This paper is based on analyses of both primary and secondary data. The data collection was undertaken by a desk study and field investigation. The secondary data were obtained from statistical yearbooks, research results of upland agriculture, water and soil conservation, terrace construction and other publications related to the objectives of this case study. The primary data were obtained directly from the farmers, officers and agricultural departments concerned, including the area of terraced land, investments in terracing, methods of cultivation, total production, prices and others. Two kinds of methodologies for assessing resource management techniques are employed for this paper, i.e. qualitative methods and quantitative methods. Both are indispensable. Qualitative methods are mainly used to assess policy effectiveness and efficiency. Quantitative methods are mainly used to assess the physical economic benefits and costs, such as the income, products, revenue, investment costs, operation costs and shadow prices, etc.

In order to analyze the impacts of terracing - key resource management techniques in Qinghai Province; benefit-cost analysis was used in this study. Benefits can be divided into direct and indirect ones, and can be also divided into income growth, product growth, investment saving, increase in employment opportunities, resource appreciation, etc. In this study, three benefit components are calculated, i.e. benefit from output improvement, partial benefit from soil conservation and partial benefit from reforestation. Costs may include the following categories: investment costs, operation costs, opportunity costs, etc. In this study, five cost components are calculated, i.e. investment, investment opportunity cost, cost of land reduction, maintenance cost, and operational cost. In temporal aspects, benefit-cost analysis can be divided into two kinds: dynamic method and static method. In order to assess the long run effect of resource development and management techniques, the period from 1995 to 2010 was taken as the base period. The formulation of B/C was used to calculate the ratio of benefits to costs in resource management.

2. Agricultural Development in Qinghai Province

2.1 Location, topography and land resources of Qinghai Province

Qinghai Province is situated in the northeast part of the Tibetan Plateau bordering Tibet and Xingjiang to the west and Gansu and Sichuan to the east. Most of the province is located some 3,000 meters above sea level with the highest level at 6,860 meters and the lowest at 1,650 meters. The province covers some 72 million hectares and ranks fourth in size in China. The landscape of Qinghai Province is characterized by a very rugged and panoramic terrain, large mountain ranges, and steep valleys and gorges interspersed with relatively level and expansive intermountain grassland plateaus and basins. There are five topographical types of land: the dominant part, hilly land, makes up 59% of the total territory (Table 2.1). However, only one million hectares of the province are classified as arable land and 580,000 ha of this is under cultivation. Over 400,000 ha - about 70% - of the cultivated land is located in the mountains. In addition, there are 36.4 million hectares of grassland and 250 thousand ha of forestland. The forest coverage rate in Qinghai was only 0.35%, while the national forest coverage rate was 13.0% in 1995. The regular annual total water resource is 63.1 billion cubic meters (Qinghai Social and Economic Yearbook, Utilization of Land Resources in Qinghai Province).

Table 2.1 Lar	id topography	in Qinghai	Province.
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Туре	Area ('000 km ²)	Percent
Hilly land	425.5	59.0
Basin	222.9	30.9
Valleys	34.6	4.8
Gobi and deserts	30.3	4.2
Hills and hilly areas	7.9	1.1
Total	721.1	100

2.2 Climate and conditions for agricultural development in Qinghai Province

Qinghai Province has a continental climate and falls within the semi-arid to arid climatic zone featuring long cold winters, cool summers, wide diurnal temperature changes, low levels of precipitation and high solar radiation. The mean annual temperature for most areas is below zero degree centigrade. The annual mean min temperature is -2 to $5^{\circ}C$ and the annual mean max temperature is $7^{\circ}C$ to $12^{\circ}C$. The mean annual precipitation varies from just over 310 mm to 450 mm. The frost-free period ranges from 30 to 160 days depending upon elevation. The province experiences the four traditional seasons - summer, autumn, winter and spring, with wide variations between summer and winter. The harsh winter with freezing conditions over five months between November and March limits the potential for crop production. The arable lands are frozen which prevents plant growth. Livestock have to be largely handfed during this period, as pasture growth is burnt off by frost. They also usually receive some protection form the elements, either in the form of housing or high walled compounds. There are also large

Qinghai Province

differentials in the micro-climate due to the wide variability in topography, aspect and altitude. The cropping season begins with the onset of spring with planting being carried out in March/April and crops maturing in the autumn as the days shorten and the night temperature falls. The major crops include wheat, highland barley, pea and bean, potato, rapeseed, vegetable and fruits. The bulk of the rainfall also coincides with the cropping season and generally decreases as temperatures increase from the southeast to the northwest.

2.3 Social and economic development in Qinghai Province

Qinghai Province is one of the most underdeveloped regions in China. In 1995, its total GDP was about 2 billion US dollars (in current prices), of which the GDP for agriculture was 450 million dollars, accounting for 23.47%. Its per capita GNP in 1995 was only 413 dollars, while the national average level was about one thousand dollars in the same year. The per capita income in 1995 for farmers was 951 Yuan in RMB or 115 dollars; that for a herdsman was 1491 Yuan in RMB or 180 dollars; and that for urban dwellers was 2,538 Yuan in RMB or 306 dollars. In 1995, Qinghai Province had a population of 830 thousand living under the poverty line, which accounted for 17.3% of total population. This province is also one of the regions with a high percentage of ethnic minorities. Of the total population of 4.812 million, 57.9% are Han nationality, and 42.1% are comprised of minority communities numbering some 42 ethnic nationalities including Tibetans, Mongolians, Hui, Tu and Sale. The composition of minority ethnic population is as follows: Tibetan 48.5%; Hui, 34.0%; Tu, 8.6%; Sala, 4.0%; Mongolian, 3.8%; other minorities, 0.7%. The illiteracy and semi-illiteracy rate in Qinghai was quite high, about 40.04% in 1995. The natural growth rate is 1.512%.

The capability for technology generation and technology dissemination at a formal institutional level is severely constrained by large extension ratios - 500 to 1,500 farmers per extension agent, poor mobility of staff, and complete lack of extension aids and extension material. There is no research of any nature being carried out within the prefecture, and no ongoing demonstrations. Extension staff have not been trained in communication techniques or in the latest developments which have been identified by technology generation elsewhere in China.

2.4 Agricultural development in Qinghai Province

The province of Qinghai is divided into two areas by the Riyue Mountain range with the agricultural area to the east and a pastoral area to the west. Arable agriculture and the bulk of the population are concentrated in the east of the province on the fertile valley bottoms where Huangyuan County is located. Qinghai is one of China's main pastoral areas and over 33 million hectares are used for free-range grazing, supporting some 23 million head of livestock. In accordance with the objectives of the study, this study will mainly focus on agricultural production in agricultural areas in Qinghai Province.

Agricultural development in Qinghai is limited due to low rainfall, sub-zero winters, limited areas suitable for arable crop production, lack of vegetation, and in more recent times a serious depletion of the resource base through sheet, till and gully erosion. Farming systems in Qinghai have remained much the same for centuries and the inefficiencies within the various production systems and low productivity of crops are evidence of this. The arable crops are limited to several varieties of wheat, highland barley, pea, broad bean, potato, rapeseed, oats, fruit and vegetables.

In 1995, the total agricultural product value of Qinghai Province was 340 million US\$ (in constant 1990 prices) and the per capita agricultural product value was only 96.4 US\$

(Table 2.2), far blow the national average level. Of the total agricultural product value, that for crop production was 164 million US\$, accounting for 48.25%; livestock production was 166 million US\$, accounting for 48.84%; forestry was 8.9 million US\$, accounting for 2.61% and fishery was only 1 million US\$, accounting for 0.3%. Crop production and livestock are two important sub-sectors of agriculture in Qinghai Province.

1 u v v u u u u u u u u u u u u u u u u	tural product value of Qinghai Province (1991-1995
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	1991	1992	1993	1994	1995
Total APV (million dollars)	316	328	329	341	340
Farmers' per capita APV (dollars)	95.7	98.2	96.3	98.1	96.4
	· V 1 1				

Source: Qinghai Social and Economic Development Yearbook.

In Qinghai Province, the major agricultural products are grain, rapeseed, meat and fruits. In 1995, the total output of grain was 1,141 thousand tons with per capita grain production of 362.3 kg and the total output of rape seed was 162.1 thousand tons with per capita rape seed production of 51.4 kg (Table 2.3).

Table 2.3 Output of major agricultural products ('000 tons) of Qinghai Province.

	Gains	Rapeseed	Meat	Fruits	Aquatic Products
1991	1,146.3	132.1	157.4	21.4	3.9
1992	1,185.0	140.3	163.4	26.0	4.0
1993	1,186.3	152.1	159.1	27.2	3.9
1994	1,168.4	184.4	178.4	25.7	3.6
1995	1,141.9	162.1	183.7	26.8	2.4

Source: Qinghai Social and Economic Development Yearbook.

2.4.1 Grain production in Qinghai Province

Qinghai is a low income and food deficient region in China. Agricultural production including livestock production is basically subsistence and mainly for home consumption. As a result, the grain production and its self-sufficiency have been regarded an important foundation for sustainable social and economic development. In 1995, the total crop sown area was 568.81 thousand hectares in Qinghai, of which the food crop area was 384.25 thousand ha accounting for 67%, cash crops mainly including rapeseed and broad bean covered 149.88 thousand ha, accounting for 26% (Table 2.4).

Year	To	tal	Whe	at	Pota	atoes	Oth	iers
	Area	Output	Area	Output	Area	Output	Area	Output
1991	401.95	1146.3	217.62	769.2	35.33	83.0	149.01	294.1
1992	401.26	1185.0	220.74	749.0	37.31	121.9	143.21	314.1
1993	389.83	1186.3	209.92	739.2	36.68	120.2	143.23	326.9
1994	386.85	1168.4	204.99	686.4	38.31	146.1	143.55	335.9
1995	384.25	1141.9	205.98	694.9	37.71	147.8	140.56	299.2

Table 2.4 Grain sown area ('000 ha) and output ('000 tons) in Qinghai (1991-1995).

2.4.2 Land productivity in Qinghai Province

In general, agricultural arable land productivity in Qinghai is relatively poor. Except for potato and bean, the unit yield of grain and other crops was much lower than the national average level. For instance, the yield of wheat is 5% lower than that of China, and the yield of cereals is 30% lower than the average level of China.

Qinghai Province

Table 2.5 Grain yield (kg/ha) in Qinghai Province and Chir
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	Total	Cereals	Wheat	Beans	Potatoes
Qinghai	2,971	3,045	3,374	2,079	3,926
China	4,240	4,659	3,542	1,591	3,428
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Source: Qinghai Social and Economic Development Yearbook, Agricultural Yearbook of China.

However, the average yield of beans and potatoes in Qinghai Province is higher than the national average level. This means agricultural natural resources and conditions are suitable to producing beans and potatoes. These two crops are water-saving ones, suitable to the local dry land and drought conditions. The sown areas of these two crops should be expanded in the future.

2.4.3 The state of food security in Qinghai Province

Per capita grain output is a very important indictor for food security, particularly in regions where the economy is less developed and peoples' purchasing power is very limited. Per capita grain output of Qinghai Province was much lower than the national average level. From 1991 to 1995, per capita grain output in Qinghai was 254.2, 258.9, 255.7, 248.4, 239.1 kg respectively; while that for China was 376, 378, 385, 371 and 385 kg respectively (Figure 2.1).

Figure 2.1 Per capita grain output of (kg) Qinghai Province and China in 1991-1995.



2.4.4 Agricultural development policies in Qinghai Province

As mentioned above, Qinghai is a low-income and food deficient region in China. Agricultural production in Qinghai is substance-based but is a very important sector in its economy (accounting for 23.62%). Therefore, the sustainable development of agriculture has been regarded as top priority by the Qinghai Provincial Government. According to the Ninth Five-year Plan for Social and Economic Development in Qinghai Province (1996-2000), the orientation of agricultural development policies in Qinghai are as follows:

- Increasing the effective supply of agricultural products and improving food selfsufficiency. By 2000, the grain output should reach 1.35 million tons, the output of oilbearing crop should be 225 thousand tons and the output of meat should be 220 thousand tons.
- Relying on agricultural technology progress to improve agricultural productivity.
- Increasing farmer's and herdsmen's per capita income up to 1,310 Yuan RMB by 2000 and basically solving the problem of absolute poverty.
- Saving water resources and improving water resources utilization efficiency. In order to ensure the above objectives are achieved, Qinghai Government will take the

following measures:

- Accelerate integrated agricultural development to improve sustainability of agricultural development, including upgrading lower- and middle-yield cultivated land and reclaiming wasteland.
- Improve agricultural infrastructure to strengthen agricultural productivity, including developing irrigation systems, upgrading pasture and grassland, etc.
- Accelerate commercialization of agricultural development, including developing county-level bases for marketable grains and other agricultural products.
- Optimize rural industrial structure to increase economic efficiency of rural business.
- Pay more attention to application of agricultural technologies.

2.5 Agricultural natural resource management in Qinghai Province

Protecting and conserving agricultural natural resources play an extremely important role in improving sustainability of agricultural development in Qinghai Province due to its fragile environmental and ecological system. Therefore, Qinghai Provincial Government attaches great importance to the management of agricultural natural resources and well established various institutions to be responsible for agricultural natural resource management.

- Agricultural Resources and Zoning Office. The comprehensive organization managing agricultural natural resources is the Provincial Agricultural Resources and Zoning Office under the Provincial Planning Commission. Its predecessor was the Provincial Agricultural Resources and Zoning Commission directly under the provincial government, with one deputy governor in charge of agricultural authorities as the director of the commission. The main members of the commission were more than ten directors or deputy directors from agricultural, forestry, animal husbandry, fishery, land management, financial, planning, water conservancy and other bureaus. This commission had overall coordination and powerful rights and responsibilities in agricultural zoning, agricultural resources surveys, and played an important role in agricultural and rural economic development in 1982-1990.
- Land Management Bureau. Land Management Bureau was founded in 1986, in charge of land registration, protection of cultivated land, land tenure changes, etc.
- Water Conservancy Bureau. In charge of water resources surveys, planning for water utilization, water resources distribution, organizing water conservancy construction, etc.
- Forestry Bureau. In charge of reforestation, management of forestland resources, protection of forestland and forests, soil and water preservation, etc.
- Agricultural Bureau. Formulating agricultural production plans, extending agricultural sciences and technologies, supervising quantity and quality changes of soil and water resources in agricultural production, monitoring agricultural production, etc.

3. Terracing - Significant Technology for Sustainable Development in Qinghai Province

In order to achieve the objectives of agricultural development for Qinghai Province and to meet the challenge of feeding the ever-increasing population with limited land and water resources, terracing is regarded by the Qinghai Government as a significant technology for sustainable development due to the specific conditions of Qinghai Province. These specific conditions determine the main constraints to and potential for sustainable agricultural development in Qinghai Province.

3.1 Main constraints to sustainable agricultural development in Qinghai

The agricultural sector in Qinghai Province plays a very important role in its overall social and economic development. Agricultural production is the main source of income for most farmers and provides employment opportunities for 70% of the population. However, with the rapid growth of population and the deterioration of the environment and agricultural resources, agricultural development in Qinghai faces great challenges with its already limited agricultural natural resources.

There are a number of climatic constraints and these relate to the meteorological extremes and latitude of the study site. The harshness of the winter limits crop production to one crop per year, or 100% cropping intensity. The insufficient rainfall does not fully satisfy crop water requirements. The altitude also determines the length of the crop growing period in Huangyuan County, so varieties must be selected according to elevation as the available days decrease markedly with altitude. The timing of rainfall is also critical in rainfed crop production. The most reliable rains occur in late summer and planting is often delayed due to insufficient soil moisture. In most cases, climatic constraints are beyond human control.

Because most of land in Qinghai is located in mountain areas, the topography of Qinghai is a major constraint to crop production and limits development possibilities. Where development opportunities exist, they are associated with high environmental risks and high investment costs. In addition, the erosion potential of the soils in the agricultural areas of Qinghai Province is high because the loess soils have a poorly developed structure, are generally low in organic carbon (on arable areas at lower altitudes), lack cohesiveness, and have poor consistency. The soils are very prone to the erosive forces of wind, water, and the physical impact of man and livestock. The potential for erosion is exacerbated by the cultivation of slope land. In relation to the latter, all crop residues are removed from the field with the crop at harvest which leaves the surface of the soil bare and unprotected between September and April. Soil erosion is becoming a more and more serious constraint to sustainable agricultural development.

Qinghai Province is a typical dry land and desert province in China. Its regular annual rainfall is only 280 mm, in contrast to the national average annual rainfall of 648 mm. In addition, the spatial distribution of rainfall is uneven with the distribution range of 155 mm-540 mm; the temporal distribution of rainfall is also uneven and the rainfall in May-September is 84.6% of the annual rainfall (Table 3.1).

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Table 3.1 Temporal distribution of rainfall in Qinghai Province.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.4%	0.5%	1.3%	5.6%	12.4%	14.0%	21.8%	21.7%	14.7%	6.3%	0.9%	0.4%

The capacity for utilizing water resources is poor. The annual water resources used makes up only 4.5% of the total quantity of water resources, in contrast to the national average level of 30%. The total pooling capacity (capacity of reservoirs and ditches) is only 212 million cubic meters, only 0.58% of the total runoff and 12.8% of the total available water resources. In contrast, the national average level is 10% and 70%, respectively. Furthermore, the irrigation infrastructure in Qinghai is poor. The percentage of effective irrigated cultivated land in total area of cultivated land in Qinghai Province is only 30% while that for all China is 52%.

The capability for technology generation and technology dissemination at a formal institutional level is severely constrained by large extension ratios - 500 to 1,500 farmers per extension agent - poor mobility of staff, complete lack of extension aids and extension material, and questionable recommendations especially for crop husbandry packages. There is no research of any nature being carried out within the prefecture, and no ongoing demonstrations. Extension staff have not been trained in communication techniques or in the latest developments which have been identified by technology generation elsewhere in China. There are also no effective formal linkages between the various technical institutions - research, extension, universities, agricultural educators - farmers and government departments.

The final major constraint to improved productivity in the project area is the availability of credit to small-scale resource-poor farmers for financing livestock and crop inputs, on-farm capital investments, and the acquisition of breeding stock.

3.1.1 Potential for improved sustainable agricultural development

Although a number of barriers exist, as noted above, there is still considerable untapped potential for increasing production through sustainable exploitation of the natural resource base, maximising the effectiveness of the existing support services and institutions, improving the existing production systems, and capitalising upon existing market opportunities for farm surpluses.

The un-used available reserve farmland resource is about 500 thousand ha, of 86% of the present cultivated land area. This means the cultivated land can be expanded nearly 86% if conditions become suitable for reclamation. However, the main restriction to reclaiming this reserve available land is water shortage. The plentiful land resources and scarce water resources are the main characteristics of agricultural natural resources in Qinghai Province.

Precipitation over the highland watersheds is sufficient to produce run-off which feeds a myriad of water courses, streams and river flows. Where conditions are suitable, farmers have exploited natural resources to develop small-scale gravity irrigation schemes based on stream diversion. Larger streams with assured water are available in agricultural areas for harnessing, which would permit rainfed cropland to be converted into irrigation areas. It should also be noted that spring cereals, oilseeds and potatoes have a high water response factor - over 1.2, i.e. they respond quickly to additional soil moisture in terms of yield increases.

Great margin means great potential. There is great margin in agricultural productivity between dry land agriculture and irrigated agriculture (Figure 3.1). In addition, the margin of water efficiency between flat and sloping cultivated land is also great (Figure 3.2).

Figure 3.1 Productivity of rainfed agriculture and irrigated agriculture.



Figure 3.2 Water use rates of flat and sloping land.



The greatest untapped potential in Qinghai is the large rural population who are solely dependent upon farming and grazing for survival. Farmers appear ready to contribute labour to development programmes if they do not impinge upon farming operations. Furthermore, the labour cost in Qinghai is relatively low due to low incomes. The great margin of per capita income between Qinghai Province and other regions of China is shown in Figure 3.3.

Figure 3.3 Farmers' per capita income in Qinghai and China.



3.2 Terracing in Huangyuan County of Qinghai Province

In order to overcome the major constrains mentioned above and to fully tap the potential for agricultural production so as to meet the formidable challenges of feeding the everincreasing population, great efforts were made to develop and apply new techniques for sustainable resource management and production. At present, major techniques applied in Qinghai Province include terracing, irrigation, interpolating techniques (wheat-maize interplanting model, bean-potato interplanting model), plastic film coverage technique,

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protection planting of potatoes, protection planting of wheat, balanced application of nitrogen and phosphate fertilizers, and rainfed farming techniques. Among these, irrigation and terracing techniques were used several decades ago and played the most important role in increasing agricultural production. They also had greatest implications for resource management and sustainable development. Due to difficulties in collecting data on irrigation, this paper will focus on economic assessment of terracing in Qinghai Province. In light of the time and human resources available in this study, Huangyuan County was selected as this case study site.

There are two major reasons for selecting Huangyuan County as the study site of this project. First, Huangyuan County is one of the 150 model experimentation and demonstration counties for ecological agriculture in China. This kind of experimentation and demonstration started in 1985, and great progress was made in developing ecological agriculture in Huangyuan County. The main principles for developing ecological agriculture are as follows: a) integrity principle, i.e. taking farming, forestry, animal husbandry, fishery and even rural industries as an integrated and interdependent system; b) harmony principle, i.e. realizing harmony between human activities and natural resource capacity, between every sector of agriculture; c) circulation principle - paying great attention to energy circulation and nutrient circulation in agricultural systems, and d) regeneration principle - making best use of renewability and regeneration characteristics of agricultural resources and agricultural production. The main components of ecological agricultural development in Huangyuan County include terracing and erosion control, appropriate fertilization and irrigation, realizing balance of materials and nutrients; reforestation and forest management aiming at realizing balance between harvesting and planting; and pasture improvement. Therefore, the experiences gained in Huangyuan County will surely be useful for this case study. Secondly, Huangyuan County clearly represents agricultural development and natural resource management in eastern Qinghai agricultural areas. Agricultural development in Huangyuan County represents Qinghai's agricultural development level. Huangyuan County has a population of 131,000, of which the rural population is 104,700, accounting for 79.9%. The topography of Huangyuan County is typical of Qinghai, featuring very rugged and panoramic terrain, large mountain ranges, and steep valleys and gorges. The environment and resource composition in Huangyuan County is typical and characterized by vast land areas with small portions of arable land, low forest coverage, and harsh climatic conditions. The total area of land is 150,000 ha, of which farmland is 27,000 ha, accounting for 18.5%; grassland is 850,000 ha, accounting for 56.3%; and forest land is 23,700 ha, accounting for 15.7%. Of the 27,000 ha of farmland, 20,000 ha is cultivated at present.

3.2.1 Overview of terracing in Huangyuan County

Terracing is regarded as a major sustainable resource management technique in Huangyuan county because it can improve efficiency of utilizing rainfall through improving water conserving and pooling capacity, improve irrigation conditions through leveling land and saving water in irrigation, control water and soil erosion, and increase output of agricultural products. In short, it not only can increase current agricultural productivity to meet the needs of the present generation, but it can also improve the agricultural resource base and environment by controlling soil and water erosion so as to meet the needs of future generations.

The practice of terracing progressed through three stages in Qinghai Province. The first stage was from 1950 to 1967 when terracing was done on a small-scale and wholly by farmers. The second stage was from 1968-1981 when terracing in Qinghai was encouraged by the government-launched Movement of Agriculture Learning from Dazhai. The investment needed was wholly provided by collectives (townships and villages). The third stage started in 1982 when large-scale terracing began combined with water-shed management, funded mainly by governments at various levels and farmers and this phase continues now.

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3.2.2 Total area of land suitable for terracing in Huangyuan County

Due to its typical landscape, most cultivated land in Huangyuan County is located in the mountains. The slope of the land is an important factor for terracing. According to the Land Bureau of Huangyuan County, the total area of cultivated land in Huangyuan is 19,813 ha, of which that with slope of less than 5° accounts for 32.1% of total cultivated land (Table 3.2).

Slope	Area (ha)	%		
<50	6,360	32.1		
5°-15°	6,400	32.3		
15 [°] -25 [°]	4,834	24.4		
25°	2,219	11.2		
Total	19,813	100.0		

 Table 3.2 Slope composition of cultivated land in Huangyuan County.

Based on experience gained in the past several decades, terracing on land with relatively higher slope is more cost-effective with better economic and environment results. Therefore, the terracing selection order in Huangyuan County is that the first priority goes to land with slope over 25° ; the second priority is land with slope between $15-25^{\circ}$; and the last priority is land with slope $10-15^{\circ}$.

In light of the priority standard mentioned above, the area of land most suitable for terracing (with slope over 15°) in Huangyuan is about 12,300 ha. However, the total terraced area by the end of 1996 in Huangyuan County was around 11,133 ha, making up 56.2% of total area of farmland, and accounting for 90% of total land area of suitable for terracing. There are two main types of terracing in Huangyuan County. One is changing sloping dry land into terraced irrigated field; another is changing sloping dry land into terraced dry field. Generally, the former involves most of the total terraced area. Of the total terraced land in Huangyuan, the area of terraced irrigated field is 9,240 ha, accounting for 83%; the area of terraced dry field is about 1,893 ha, accounting for 17%.

3.2.3 Funding mechanism for terracing

With the evolution of agricultural production systems from the People's Commune System to the Household Responsibility System, the funding mechanism for terracing in Huangyuan also evolved. Before 1982, there was no government investment in terracing. The funds needed for terracing all came from the collectives - the peoples' communes and production bridges (later reformed as townships and villages). Since 1982, investment for terracing has been encouraged from many sources, and terracing investment has come from governments at various levels, collectives, farmer households and even foreign investors. The terracing investment structure at present is as follows: investment from governments at various levels accounts for 56% of the total, investment from collectives accounts for 28%, and household investment accounts for 16%.

3.2.4 Technical requirements for terracing

In order to ensure the success of terracing and to achieve the expected economic and environmental results, some technical requirements for terracing in Huangyuan were set up by the agricultural departments concerned. First, terracing should be combined with other activities. There are a lot of factors effecting agricultural production. If the expected role of terracing is to be fully realized and terraced fields well maintained, terracing must be

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accompanied by other activities such as reforestation, construction of checks and dams, construction and reconstruction of ditches, construction of water harvesting wells or cellars, etc.

Secondly, terracing should be combined with the development of irrigation schemes. The practice in Huangyuan shows that the actual efficiency of terracing is greatly affected by irrigation conditions after terracing. Whether terracing is successful depends mainly on whether the terraced land is irrigated. Therefore, terracing should be combined with the construction of irrigation schemes so as to maximize the environmental and economic returns.

With the view of rationally utilizing human resources and ensuring no negative effect on current agricultural production, the timing of terracing should be as follows:

- construct more in spring and less in autumn. Spring is the most reasonable season for terracing when the temperature is warming up, the frozen soil is melted, and most important, there is not much other agricultural activity. Since autumn is the optimal crop-growing season, farmers are busy with various farming activities then.
- construct by machines in spring and by humans in autumn. Spring is the best season to construct terraces and large scale terracing usually needs to be done by machines. However, in autumn, farmers are allowed to do some maintenance work for distorted terraced lands and using plentiful rural labor force is more cost-effective.
4. Benefit-cost Analysis of Terracing in Huangyuan County

Due to the limit of time and the availability of data, benefit-cost analysis in this paper is conducted only for terracing projects completed in 1995. The analyses will focus on direct economic benefits and cost and accompanied by assessment of environmental effects. The base period for analysis will be from 1996 to 2010. Because there are two types of terracing in Huangyuan County with different economic results (one transforms sloping land into terraced dry land and the other transforms sloping land into terraced irrigation land), analyses will be conducted separately for these two types of terracing. Since wheat is the major important grain crop in Huangyuan County, wheat will be taken as an example in assessing cost and benefit of terracing. All data used in this section are provided or estimated by the Agricultural Bureau of Huangyuan County and the Bureau of Water Conservancy of Huangyuan County.

4.1 Cost for terracing in Huangyuan County

The cost for terracing in Huangyuan County consists of three components, i.e. investment in terracing and related activities, cost of land reduction and maintenance/operation costs.

4.1.1 Investment in terracing and related activities

According to the Bureau of Agriculture and the Bureau of Water Conservancy of Huangyuan County, the work of terrace construction and related activities completed in 1995 was as follows:

- Terraced area: 1,283 ha, of which 207 were transformed into dryland and 1,076 was transformed into irrigated land.
- Reforestation area: 553 ha.
- Earth checks and dams: 367 thousand cubic meters.
- Stone checks and dams: 32 thousand cubic meters.
- Ditches: 24 thousand meters.

After the introduction of the household responsibility system, terrace construction in Huangyuan County was mainly done by individual farmers on their own contracted land in accordance with the unified plan of the collectives. The farmer did it by hand or hired a tractor to do it. Because terracing areas in Huangyuan county are mountain soil areas, the major investment for terrace construction was the labor input. The breakdown of investments for terrace construction and related activities in 1995 is as follows:

- Terracing: 354 thousand US\$, mainly labor cost (labor input: 590 thousand workdays, labor price: 0.6 dollar per workday).
- Reforestation: 111 thousand US dollars, of which the sapling cost was 42 thousand dollars; labor cost was 69 thousand dollars (labor input: 115 thousand workdays).
- Earth checks and dams: 8 thousand dollars, mainly labor cost (labor input: 13.3 thousand workdays).
- Stone checks and dams: 29 thousand dollars, of which 8.7 thousand dollars was for material input, and 20.3 thousand dollars for labor input (33.8 thousand workdays).

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• Ditches: 7 thousand dollars, of which 4 thousand dollars was for material input, and 3 thousand dollars for labor cost (labor input: 3,000 workdays, skilled labor price: one dollar per workday).

So the total investment for terracing and its related activities in 1995 was 509 thousand US\$. Assuming investment for terracing and reforestation is distributed proportionally between terraced dryland and terraced irrigated field and investment for checks, dams and ditches is mainly for terraced irrigated land, the investment for terraced dryland was 75 thousand US\$, and that for terraced irrigated field was 434 thousand US\$.

Assuming the interest rate is 7%, the opportunity cost of investment for terraced dryland was 5,250 US\$ annually, and that for terraced irrigated field was 30,380 US\$ annually.

Of the total investment for terracing in 1995, 11.9% was from government capital appropriation; 5.5% from foreign investment (mainly from the World Food Program); 9.2% from poverty-elimination special appropriation in kind; 1.4% came from grain production base investment; 7.1% came from incentive investment to underdeveloped regions; 3.1% from specified flood-control appropriation; 3.4% was from specified drought-control appropriation; 19.0% was from incentive investment for small water conservancy projects; 23.1% from village budget; and 16.3% was farmers' labor input.

4.1.2 Cost of land reduction after terracing

In Huangyuan County, the area of land was reduced due to terrace construction, which results in a decrease of sown area and output. Therefore, land reduction resulting from terracing should be regarded as a cost for terracing. According to experience gained in the past and the studies conducted by the Bureau of Water Conservancy of Qinghai Province, the decrease rates

of cultivated land after terracing are 8% for land with slope between 10° and 15° , 15% for land

with slope of 15°-25°, and 23% for land with slope of more than 25°.

According to an estimate produced by officers from agricultural department of Huangyuan County, in 1995, terraced field with slope between 10° and 15° was 135 ha, that with slope of 15° - 25° was 669 ha, and that with slope of more than 25° was 479 ha.

Therefore, the decrease of cultivated land due to terracing in 1995 was about 221 ha (Table 4.1).

10 [°] -15 [°]	15°-25°	>25°	Total	Average Decrease Rate
11 ha.	100 ha.	110 ha.	221 ha.	17.2%

 Table 4.1 Decreased cultivated area after terracing.

The average rate of land reduction after terracing is 17.2%. Therefore, of 1,283 ha of land under terrace construction in 1995, 1,076 ha were transformed into 891 ha of terraced irrigated field and 207 ha were transformed into 171 ha of terraced dryland. At present, wheat yield of Huangyuan County is 2.979 ton/ha and the price of wheat is 157 US\$/ton. Assuming wheat yield will decrease for 5 years by 2% annually due to soil erosion and will be stable after 2000, the cost of land reduction will be as follows:

For terraced dryland:
1996: 2.979 x (1-2%) x 36 x157= 16,500 US\$
1997: 16500 x 98% = 16,170 US\$
1998: 16170 x 98% = 15,846 US\$
1999: 15846 x 98% = 15,530 US\$
2000 and later: 15530 x 98% = 15,220 US\$

For terraced irrigated land: 1996: 2.979 x (1-2%) x 185 x 157 = 84,795 US\$ 1997: 84795 x 98% = 83,099 US\$ 1998: 83099 x 98% = 81,437 US\$ 1999: 81437 x 98% = 79,808 US\$ 2000 and later: 79808 x 98% = 78,212 US\$

4.1.3 Maintenance and operation cost

The maintenance cost for terraced land will occur five years after terracing. According to the findings of studies conducted by the Bureau of Water Conservancy of Qinghai Province in the past, the maintenance cost for terraced land is about 2 US\$ per hectare. In addition, for terraced irrigated land, the cost of irrigation water should be calculated in B/C analysis for terraced irrigated land. It is estimated that the water fee is 45 US\$ per hectare.

4.2 Benefits from terracing in Huangyuan County

Terracing in Huangyuan is regarded as a key technique for sustainable agricultural development to improve the agricultural resource base and increase agricultural production, particularly grain production. The direct economic benefits from terracing mainly depend on increased grain output because grain is an extremely important crop in Huangyuan County.

4.2.1 Benefits from grain yield improvement

According to studies conducted in the past, the wheat yield increase in terraced dry field is about 5% for the first year, 13% for the second year and 25% for the third year and later.

At present, the average yield of wheat on non-terraced land in Huangyuan County is about 2,979 kg/ha. Because the yield of wheat in the first two years after terracing grows at 5% and 13% respectively while cultivated land decreases at 17%, the actual grain output will decrease in the first two years after transforming sloping land into terraced dryland. Reduction in grain output is a main constraint for terracing in regions where an irrigation system is not available.

Assuming wheat yield will be decreased for 5 years by 2% annually due to soil erosion and will be stable after 2000, the benefit from yield improvement for terraced dryland will be as follows:

1996: [2.979 x (1+5%)-2.979 x (1-2%)] x 171 x 157 =5,598 US1997: $[2.979 \text{ x} (1+13\%)-2.979 \text{ x} (1-2\%)^2] \text{ x} 171 \text{ x} 157 =13,564 \text{ US}$ 1998: $[2.979 \text{ x} (1+25\%)-2.979 \text{ x} (1-2\%)^3] \text{ x} 171 \text{ x} 157 =24,649 \text{ US}$ 1999: $[2.979 \text{ x} (1+25\%)-2.979 \text{ x} (1-2\%)^4] \text{ x} 171 \text{ x} 157 =26,200 \text{ US}$ 2000 and later: $[2.979 \text{ x} (1+25\%)-2.979 \text{ x} (1-2\%)^5] \text{ x} 171 \text{ x} 157 =27,680 \text{ US}$

Agricultural output increase in terraced irrigated fields is much greater than that in terraced dryland. According to a study, Analysis and Evaluation on Project of Transforming Slope Land into Terrace in Qinghai, completed by the Bureau of Agriculture and Bureau of Water Conservancy of Qinghai Province, the grain yield increase in terraced irrigated field is 15% for the first year after terracing, 32% for the second year and 52% for the third year and later.

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Assuming wheat yield will be decreased for 5 years by 2% annually due to soil erosion and will be stable after year 2000, the benefit from yield improvement for terraced irrigated land will be as follows:

1996: **[**2.979 x (1+15%)-2.979x(1-2%))x 891x 157 =70,843 US\$ 1997: [2.979 x (1+32%)-2.979x(1-2%)²]x 891x 157 =14,9854 US\$ 1998: [2.979 x (1+52%)-2.979x(1-2%)³]x 891x 157 =24,0949 US\$ 1999: [2.979 x (1+52%)-2.979x(1-2%)⁴]x 891x 157 =24,9034 US\$ 2000 and later: [2.979 x (1+52%)-2.979x(1-2%)⁵]x 891x 157 =256,743 US\$

4.2.2 Benefit from water and soil conservation

It is known that terracing can enhance water and soil conservation and can improve water (rainfall) utilization efficiency. The results of studies completed by many researchers in Qinghai show that the rainfall utilization rate in sloping land is 18% while the rate for terraced land is 32%; the irrigation water efficiency in sloping land is 28% while the efficiency for terraced land is 57%. It is estimated that one hectare of terraced land can conserve 450 cubic meters more water each year. Therefore, 1,283 ha of sloping land terraced in 1995 can conserve 450 x 1,283 x (1-17.2%) = 477,900 cubic meters more water every year. In accordance with the investment norm for irrigation projects established by the Bureau of Water Conservancy of Qinghai Province, the annual water conservation of 477,900 cubic meters is valued at about 30 thousand US\$. The value of conserving water will be finally embodied in grain yield increase, so it should not be calculated into benefit of terracing.

The findings of studies also indicated that one ha of terraced land can reduce soil erosion by 45 tons every year. Therefore, 1,283 ha of sloping land terraced in 1995 (1,062 ha of terraced land) can conserve 47,790 tons of soil. According to the cost of silt clearance for local reservoirs, soil conservation of 47,790 tons is equivalent to 828 US\$, i.e. 0.78 US\$ per hectare. This should be calculated into the benefit of terracing.

In addition, according to the analysis carried out by the Land Management Bureau of Qinghai Province, one ton of erosion soil in Qinghai contains various fertilizers, including N=1.06 kg, P=0.72 kg and K=24.4 kg. So the conservation of 47,790 tons of soil will save 1.13 tons of N, 765 kg of P and 2.59 tons of K, which is valued at about 1,242 US\$. Since the value of conserving fertilizer will be finally embodied in grain yield increase, it should not be calculated into the benefit of terracing again.

4.2.3 Benefit from reforestation

Although it is difficult to assess the environmental impact of reforestation, it is possible to assess the economic benefit from collecting fuel wood. Fuel wood can be harvested four years after reforestation. According to an estimate of forestry experts from Huangyuan Forestry Bureau, the benefit of reforestation will be gained after year 2000 and its total annual value will be 8,295 US\$ (15 US\$ per hectare). Assuming reforestation activities are distributed proportionally between terraced dryland and terraced irrigated field, the annual benefit form reforestation for terraced dryland is 1,338 US\$ and that for terraced irrigated land is 6,957 US\$.

4.2.4 Environmental benefit of terracing in Huangyuan County

Although it is very difficult to assess the environmental impact of terracing in terms of economic benefits, the result is very positive. Terracing is conducive to improving moisture content and granular structure of soil and helpful to increase the number of microorganisms and fertility of soil. In addition, reforestation after terracing will help control wind erosion and improve the environment and micro-climate. Terracing, as a key technology of resource management, will help improve the natural resource base and is environmentally sustainable.

4.3 Total economic benefit and its ratio to total cost

Based on the above breakdown calculation, the total economic benefit gained from transforming sloping land into terraced dryland from 1996 to 2010 was 391,240 US\$, and the total cost was 388,978 US\$ (Table 4.2). The ratio of benefit to cost is 1.00587, which means total benefit is very close to total cost. Considering the environmental effect, construction of terraced dryland is economically feasible and environmentally sound. However, due to its less profitable nature, farmers are reluctant to construct terraced dryland and should be encouraged by local government.

The total economic benefit gained from transforming sloping land into terraced irrigation land from 1996 to 2010 was 3,621,805 US\$ and the total cost was 2,700,198 US\$ (Table 4.3). The ratio of benefit to cost is 1.34, which means total benefit is 34% higher than total cost, and the construction of terraced irrigated land is economically profitable and environmentally sound. However, the construction of terraced irrigation land should be accompanied by the construction of irrigation schemes.

		Costs			Benefits	
Year	Invest.	Mainten.	Land	Soil	Forestry	Output Increase
	Interest	Fee	Reduction	Conserv.	•	*
1995	75,000					
1996	5,250	-	16,500	133	-	5,598
1997	5,250	-	16,170	133	-	13,564
1998	5,250	-	15,846	133	-	24,649
1999	5,250	-	15,530	133	-	26,200
2000	5,250	342	15,220	133	1,338	27,680
2001	5,250	342	15,220	133	1,338	27,680
2002	5,250	342	15,220	133	1,338	27,680
2003	5,250	342	15,220	133	1,338	27,680
2004	5,250	342	15,220	133	1,338	27,680
2005	5,250	342	15,220	133	1,338	27,680
2006	5,250	342	15,220	133	1,338	27,680
2007	5,250	342	15,220	133	1,338	27,680
2008	5,250	342	15,220	133	1,338	27,680
2009	5,250	342	15,220	133	1,338	27,680
2010	5,250	342	15,220	133	1,338	27,680
Sub-total	153,750	3,762	231,466	1,995	14,718	374,491

Table 4.2 Cost and benefit of terraced dryland from 1995 to 2010.

B-C Ratio = 391,240/388,978=1.00587.

Qinghai Province

		Cos	ts			Benefits	
Year	Invest.	Mainten.	Water	Land	Soil	Forestry	Output
	Interest	Cost	Fee	Reduct.	conserv.	-	Increase
1995	43,4000						
1996	30,380	-	40,095	84,795	695	-	70,843
1997	30,380	-	40,095	83,099	695	-	149,854
1998	30,380	-	40,095	81,437	695	-	240,949
1999	30,380	-	40,095	79,808	695	-	249,034
2000	30,380	1,782	40,095	78,212	695	6,957	256,743
2001	30,380	1,782	40,095	78,212	695	6,957	256,743
2002	30,380	1,782	40,095	78,212	695	6,957	256,743
2003	30,380	1,782	40,095	78,212	695	6,957	256,743
2004	30,380	1,782	40,095	78,212	695	6,957	256,743
2005	30,380	1,782	40,095	78,212	695	6,957	256,743
2006	30,380	1,782	40,095	78,212	695	6,957	256,743
2007	30,380	1,782	40,095	78,212	695	6,957	256,743
2008	30,380	1,782	40,095	78,212	695	6,957	256,743
2009	30,380	1,782	40,095	78,212	695	6,957	256,743
2010	30,380	1,782	40,095	78,212	695	6,957	256,743
Sub-total	8,89,700	19,602	601,425	1,189,471	10,425	76,527	3,534,853

 Table 4.3 Cost and benefit of terraced irrigation land from 1995 to 2010.

B-C Ratio = 3,621,805/2,700,198=1.34.

5. Conclusions and Recommendations: Qinghai Province

5.1 Conclusions

There are many constraints to sustainable agricultural development in Qinghai Province, however, soil and water erosion, shortage of water resources and low efficiency of water utilization are decisive constraints to agricultural development. Terracing is an effective and efficient technique to overcome these constraints. It is conducive for managing soil and water erosion and improving water conservation and water utilization efficiency. Terracing has played a great role in increasing agricultural production, particularly, grain production in Huangyuan County, and has made a significant contribution to improvement of food security in Qinghai.

Terracing is a cost-effective method for managing and utilizing agricultural resources; it can produce significant economic efficiency, particularly, when combined with the construction of an irrigation system. The result of B/C analysis indicated that terrace construction is economically profitable and sustainable.

Terracing combined with reforestation activities not only controls water and soil erosion, but also facilitates improving the micro-environment. It is environmentally sustainable.

For those people who have low incomes and few job opportunities outside the region, terracing can be a main source of income and will contribute to poverty reduction and improvement of food security.

5.2 **Recommendations**

- The environmental effects of terracing such as water conservation should be advertised greatly, particularly for transforming sloping land into terraced dryland.
- Terracing should be more and more combined with improving irrigation systems so as to maximize its benefit.
- Sloping land with convenient irrigation conditions should be selected first for terracing.
- The practice of terracing combined with reforestation should be maintained so as to improve the natural resource base.

Part II: Terracing in Guizhou Province

Gu Shuzhong

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Official Exchange Rate

Currency Unit: Yuan (¥)

Effective December 30, 1996	US\$ = 8.30 ¥	¥ 0.120 US\$
Up to June 30, 1996	US\$ = 8.32 ¥	¥ 0.121 US\$
Up to October 25, 1995	US\$ = 8.31 ¥	¥ 0.120 US\$
Up to December 31, 1994	US\$ = 8.62 ¥	± 0.116 US\$
Up to November 29, 1990	$US\$ = 4.72 \$	¥ 0.212 US\$

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Executive Summary

Guizhou Province is located in the sub-tropical Yunnan-Guizhou Plateau, Southwest China. It is one of the most under-developed regions in China. Sustainable development of its agriculture faces many constraints including severe shortage of arable land resources, poor quality of farmland, frequent drought disasters, and poor capacity for utilizing rainfall and ground water. To alleviate or eliminate these constraints and to develop advantages, a series of techniques hase been adopted including terracing, irrigation, drainage, multiple cropping, and use of chemicals. Of these, only terracing can simultaneously increase land and save water. So terracing has been playing an indispensable role in sustainable utilization of agricultural natural resources and sustainable development of agriculture.

Terracing in Guizhou Province mainly aims at increasing cultivated land resources, improving quality of cultivated land, managing soil and water erosion, and growing more produce. So terracing can produce four kinds of benefits including resource benefits (increase in resource quantity or improvement in resource quality, both of which can be calculated in monetary terms), ecological benefits (improvement in the ecological situation including improvement in capacity for preserving soil and water, and in biodiversity, etc.), economic benefits (growth of rural income and agricultural products) and social benefits (rural employment opportunity expansion and so on). It is concluded from detailed analyses that the terracing cost can be recovered two years after the completion of the terracing project.

Most local officials and farmers welcome terracing because of its remarkable benefits. Local officials used "five most" to illustrate the roles of terracing: the most sound project to alleviate poverty; the most basic project to improve local agricultural infrastructure and productivity; the most realistic project welcomed by poverty-stricken and grain-troubled farmers; the most all-inclusive project incorporating agriculture, forestry, water conservancy, planning, finance and other departments into the same project; and the most sustainable project that can sustainably play an active role in increasing productivity, protecting the environment and preserving the ecological balance. From the farmer's standpoint, terracing is the third most effective approach after chemical fertilizers and improved seeds. So two-thirds of farmers completly accept terracing because it can remarkably expand cultivated land and can increase production.

It is concluded that: (i) terracing is accepted by most farmers; (ii) terracing is one of the most effective and efficient ways for simultaneously realizing economic, resource, environmental, ecological and social objectives; (iii) terracing is one of the most feasible ways for realizing sustainable agricultural development; (iv) state investment plays a catalytic role in terracing; (v) farmers play an indispensable and active role in terracing; and (vi) effective organization is insurance for successful terracing.

It is recommended that: a top-down procedure for selecting terracing project areas should be applied; terracing standards should be improved; more attention should be given to fund diversion in terracing; and supervising and auditing should be strengthened and improved.

1. Overview of Agriculture in Guizhou Province

1.1 Introduction

Guizhou Province is located in the sub-tropical Yunnan-Guizhou Plateau, southwest China. It is a typical inland province of China. Its total population in 1996 was 35.55 million. It covers an area of 176,128 square kilometers, or 1.83% of China's total territory, ranking 16th of all 31 provinces, metropolitan and autonomous regions. There are 49 ethnic groups, including Han, Miao, Bouyei, Dong, Tujia, Yi, Gelao, Shui, Hui, Bai, Yao, Zhuang and others. Ethnic minorities make up 34.7% of the total population of the province, and the Han make up 65.3% of the total. The per capita GNP in 1995 was only U\$250; the national per capita GNP in the same year was about one thousand dollars. This province is one the most under-developed regions in China.

1.2 Agricultural development situation

The agricultural gross product in 1995 was 2.27 billion dollars, of which farming, animal husbandry, forestry and fishery contributed 65.0%, 4.4%, 29.7% and 0.9%, respectively.

The farmers' per capita income in 1995 was only 118 U\$ dollars, compared with the nation average level of 176 dollars. Thus, this province is a typical poverty-stricken area with 48 state-level poverty-elimination counties, comprising 8.1% of the national total state-level poverty-elimination counties. The poverty-stricken population in 1995 was 7.89 million, or 13% of China's total poverty-stricken population, and 22% of the total population of the province.

Guizhou Province is a grain-deficit region of China. Its regional per capita grain production in 1995 was only 272 kilograms, only 72% of the national average level. In the 1990s, 34% and 80% of households had grain stocks of less than 150 kilograms and 300 kilograms, respectively. Grain production is still an important problem for local governments.

1.3 Main characteristics of agricultural natural resources

There are 8 land use types in Guizhou Province (Table 1.1). The first and the best is cultivated land including paddy field and dry field. The paddy field is used to plant rice, and the dry field is used to plant wheat, maize, cotton, potato and so on. The dry field includes irrigated fields and rain-fed fields. Horticultural land is used to plant vegetables, tea and fruits. The other land uses are forestland, grassland and pasture, residential land (including rural and urban habitats), industrial and mineral land (for industrial and mineral companies), inland waters (including rivers, lakes and reservoirs), and land for traffic uses (including roads, highways, traffic stations in urban and rural areas). The final category is non-used land (including deserts, Gobi, ice-and snow covered land, and wasteland).

Cultivated land, horticulture land, grassland and pasture, and some inland waters (especially lakes and reservoirs) are called farmland.

Land Use	Land Area ('000 ha)	Share of Total Territory (%)
1. Cultivated land	4,147	23.5
Paddy field	1,416	8.0
Dry field	2,731	15.5
2. Horticulture land	73	0.4
3. Forestland	7,679	43.6
Grassland and pasture	2,365	11.7
5. Residential, industrial and mineral uses	411	2.3
6. Waters	192	1.1
7. Traffic use	81	0.5
8. Non-used Land	2,967	16.8
Total territory	17,615	100.0

Table 1.1 Land utilization types in Guizhou Province.

Source: China Statistical Yearbook, China Statistical Publishing House, 1996.

There are three main topographies, including mountains, hills and hilly areas, and basins (Figure 1.1). The diversity of topographies provides an important basis for multi-functional development of natural resources: cultivated land in basins, hill and hills areas are farmed to produce grains, cotton, edible oils and vegetables.

Figure 1.1 Land topographic composition in Guizhou Province.



Karst area constitutes 73% of the total area. This province is one of the typical regions of karst terrain. The main characteristics of karst area are: covered with stones and gravel; with high percentage of sloping land; with fast runoff of rainfall, poor water and soil nutrient preserving capacity; and poor traffic accessibility. People in karst areas live by farming rain-fed and irrigated land with limited fertility. The northwestern karst area is one of the most typical poverty-stricken regions in China.

1.4 Main constraints to sustainable agricultural development

1.4.1 Severe shortage of arable land resources

The arable land resource per rural household in Guizhou Province is only about 0.27 hectare, compared with the national average of 0.41 hectare. As the population grows, the shortage of arable land will become more serious in the future, making it one of the most important constraints to sustainable development of agriculture in Guizhou Province.

1.4.2 Low quality of farmland

First, sloping lands make up a large portion of the total farmland area (Figure 1.2). Second, the soil depth of farmland is only about 20-30 cm and mixed with a lot of gravel.



Figure 1.2 Slope composition of farmland in Guizhou Province.

Third, low productivity farmland is a high percentage in the total area of farmland. The lower productivity farmland is 86% of the total farmland area. The grain yield of the province was 3,850 kg/ha, compared to the national average in the same year of 4,660 kg/ha. The former is only 83% of the latter.

Fourth, small-scale plots of cultivated land constitute a large part of the total farmland. The so-called "palm field" or "hat field" (the plot is as small as a palm or straw hat) is very popular in Guizhou Province. So, the local farmers sometimes do not say "land", but only say "soil." There is even a well-known joke: a farmer had ten plots of dry field to sow. When nearly completed his sowing, he could not find the tenth plot. Finally, he found his last precious plot ... under his straw hat!

1.4.3 Frequent drought disasters

The uneven temporal distribution of rainfall in Guizhou Province causes frequent droughts and floods. There is a popular saying "Nine out of ten years are drought years".





Source: China Natural Resources Series, Guizhou Vol., China Environmental Science Press, 1995.

A bumper harvest can always be obtained in years of flood disasters. Most sloping dry fields benefit from plentiful rainfall (Figure 1.3).

1.4.4 Poor capacity for utilizing rainfall and ground water

Guizhou Province is a province with very under-developed agricultural infrastructure. The characteristics of typical Karst terrain further decrease the capacity for effectively utilizing rainfall and ground water. In order to improve the effectiveness and efficiency of utilizing ground water, one research project entitled " Guizhou Utilizing Hidden River Project" was implemented in some counties with plentiful underground water resources.

Summer (June~Aug., 55%)

1.4.5 Geological disasters

Geological disasters mainly include landslides, and mud-rock flows, which occur frequently in most parts of the province, causing heavy damage to human lives, wealth, agricultural and industrial production. The direct damages included loss valued at more than 4 million dollars and death of 700 persons in 1989.

1.4.6 Other constraints

Shortage of agricultural investment, poor education of rural residents, and poor capacity for technological application and acceptation of farmers, have constrained the development of agriculture in Guizhou Province.

1.5 Potential for agricultural development

1.5.1 Plentiful reserve farmland suitable for terracing

The waste land suitable to terracing as farmland constitutes about 10% of the total land area in Guizhou province. This plentiful reserve farmland provides many opportunities for further agricultural development when China's population and grain situation change.

1.5.2 Lower agricultural productivity means great potential for further development

From a comparison between Guizhou's and China's agricultural productivity of land resources in 1995, there is clearly a large gap between Guizhou's agricultural productivity and the national average level (Figure 1.4). This means that there is great potential for increasing Guizhou's agricultural productivity. So, increasing agricultural productivity of land resources will be one of the most important measures for realizing sustainable development of agriculture in this province.





Source: China Statistical Yearbook 1996, China Statistical Publishing House, 1996.

In addition, there is also a great gap between Guizhou's agricultural productivity of human resources and the national average level (Figure 1.5). This also means there is great potential for increasing Guizhou's agricultural productivity of human resources. Increasing human agricultural productivity will one of the measures for realizing sustainable development of agriculture in this province. The combination of increasing land productivity and increasing labour productivity will be the most effective measurement for sustainable development of agriculture.



Source: China Statistical Yearbook 1996, China Statistical Publishing House, 1996.

1.5.3 Plentiful cheap rural labour

There is plentiful cheap rural labour in Guizhou Province because of the high percentage of rural residents in the total population. Rural residents constitute 83% of the total population, compared to 76% in all China. The percentage of agricultural labour in total rural labour is about 86%, compared to the national average level of 71%.

Per capita income of local rural residents was only 1,087 RMB Yuan, compared with the national average of 1,577 RMB Yuan in 1995. This lower income makes plentiful cheap agricultural labour in this province. There is a heavy employment burden for local governments on one hand, but is an important advantage for sustainable development of agriculture.

1.5.4 Attention to management of agricultural natural resources by local government

First, great attention has been paid to legislation concerning management of agricultural natural resources. Up to now, there are more than eight laws related to agricultural natural resource management such as the following:

- Measure for Implementing Land Management Law of PRC in Guizhou Province;
- Measure for Implementing Water Law of PRC in Guizhou Province;
- Measure for Implementing Soil and Water Conservation Law of PRC in Guizhou Province;
- Forestland Management Measure of Guizhou Province;
- Implementing Ordinance for Basic Farmland Protection and Conservation of Guizhou Province;
- Environmental Protection Ordinance of Guizhou Province;
- Land Reclamation Measure of Guizhou Province (forthcoming).

All of these laws have had important positive effects on effective and efficient utilization of agricultural natural resources, and will also play the same role in improving sustainable utilization of agricultural natural resources.

Second, considerable work has been done by local governments to manage agricultural natural resources. The following are the major components:

- Agricultural resource surveys: soil census; agricultural natural resource investigation and agricultural zoning; land resource comprehensive survey; detailed survey of forest resources; grassland resource census; investigation and evaluation of poor-productivity land and wasteland;
- The "Population-Grain-Ecology" way of agricultural development has been espoused by the local government, which means controlling population, increasing grain production, and protecting ecology;
- Some related regulations have been published (see above);

• A series of agricultural development projects has been implemented: poverty alleviation programme; agricultural integrated development; green project; water-shed management; etc.

All of those endeavors are indispensable bases for sustainable utilization of agricultural natural resources and for sustainable development of agriculture.

1.6 Techniques adopted for agricultural resource management

There are a lot of techniques for managing agricultural natural resources. All of these techniques aim at taking full use of the existing advantages and avoiding or preventing the existing constraints to agricultural growth. These techniques mainly include the following:

- terracing of sloping farmland and waste land;
- irrigation in drought-stricken areas;
- drainage in flood-stricken and wetland areas;
- adoption of multiple cropping systems;
- use of pesticides and chemicals in agricultural production.

Almost all of these techniques are related to sustainability of agricultural development. First, irrigation can alleviate the scarcity of water in farmland and improve the effectiveness and efficiency of water in agricultural production. Thus, irrigation plays a key role in drought-stricken areas. However, its effectiveness and efficiency are always decreased in rough farmland and karst areas, as in most parts of Guizhou Province. Thus, irrigation is not the key measure for realizing sustainable use of agricultural natural resources and sustainable development of agriculture. It can only play a limited role.

Drainage can play important role in flood-stricken and wetland areas, but these kinds of farmland only make a very small part of the total farmland areas. Thus, its effect upon sustainability is also very limited.

Multiple copping is an important traditional farming technique with thousands of years of history. However, the margin for increasing the multiple cropping index has been very limited in most parts of China, especially in south China such as Guizhou Province. Thus, its effect upon sustainability is also very limited.

The use of pesticides and chemicals is very popular in China and has resulted in great soil and water pollution. Thus, this technique is not accepted by sustainable development. "Green" food is increasingly produced and consumed in China.

Only terracing directly aims at alleviating the scarcity of farmland and water resources. Terracing is one of the most reasonable techniques for increasing farmland and further increasing efficiency of water utilization in farming. Thus, terracing will be the most important technique for realizing sustainable utilization of land and water resources in agricultural production, and for realizing sustainable development of agriculture.

2. Terracing Practices in Guizhou Province

2.1. Primary objectives of terracing

Terracing has four main objectives in Guizhou Province. The first is to alleviate the shortage of cultivated land resources. Terracing in this province can remarkably increase the area of cultivated land. The increase of area after terracing is 5% to 25%.

The second is to improve the quality of cultivated land. Terracing in this province can improve the capacity for preserving soil water and nutrients to a remarkable degree. It can also improve the fertility of cultivated land.

The third is to manage soil and water erosion. Farming in sloping land, especially in land with slope over 10°, is one of the main sources for soil and water erosion. Terracing can help manage soil and water erosion in most areas of this province.

The last objective is to supply more employment opportunities for the rural labour force.

2.2 Advantages of terracing

Terracing in Guizhou Province has the following four advantages. The first is that there is plentiful sloping farmland and wasteland suitable to terracing in most parts of this province. More than half of the total cultivated land is suitable to terracing, and some portion of wasteland is also suitable for terracing.

The second advantage is that is plentiful cheap and hard-working rural labour. This is an indispensable basis for large-scale terracing. Plentiful labour implies a sustainable supply of labour for terracing. Cheap labour can greatly decrease the working opportunity cost of terracing, and decrease the cost of terracing per hectare. Hard-working labour can gradually and greatly improve the efficiency of terracing. This is an opportunity for transferring the present plentiful cheap and hard-working rural human resources into the rural agricultural infrastructure.

The third advantage is that there are plentiful stone resources for building terrace walls. Guizhou is rich in mountains and hills, stones and gravel. It is very easy to get stones for terracing in most areas, and every village has its own skilled stonemasons. Thus, the quality of terraces can be secured in almost all areas.

The last and important advantage is there is a long-term tradition of terracing. Experience and skills for terracing are very important for efficient terracing.

2.3 **Priority regions for terracing**

There are four options for identifying priority areas for terracing based on:

- land utilization situation: the first priority is presently cultivated land; second wasteland; and finally land in other use categories including forestland, grassland, etc.
- slope situation: the first priority is land with slope between 15° and 25°; second is land with slope between 10° and 15°; and finally land with slope over 25°.
- economic development level: first priority is the poverty-stricken areas; and then other areas.

 land area: first priority is the area with potential large-scale contiguous cultivated land after terracing.

In conclusion, cultivated land with slope between 15° and 25° and potential large-scale contiguous plots in poverty-stricken areas should be the first priority for terracing. Other considerations include the accessibility to terrace wall stones, the accessibility to irrigation and drainage networks, and the local farmers' willingness to terrace.

2.4 Terracing development

The terraced area from 1991 to 1995 was relatively stable (Table 2.1). This was mainly because nearly all of the terraces were planned by local governments. The terracing plans were based on allocated terracing investment.

Table 2.1 T	erraced areas in	Guizhou Pr	ovince from	1991 to 1996.
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Year	1991	1992	1993	1994	1995	1996	Total
Area (ha)	42,811	40,230	37,776	42,355	50,416	49,071	262,659

There are five main types of terraces in Guizhou Province. The first is the transfer of dry sloping field into terraced dry field, constituting the largest portion of the total terraced area. This type of terrace is irrigated or rain-fed, and is mainly used to plant maize. The second is transfer of dry sloping field into terraced paddy field, which is used to plant rice. Details are given in Table 2.2.

Table 2.2 Main types of terraces in Guizhou Province.

Terrace Type	Share in Total Terraced Area (%)
Transfer dry slope field into terraced dry field	74
Transfer dry slope field into terraced paddy field	5
Transfer slope wasteland into terraced dry field	8
Transfer slope wasteland into terraced paddy field	1.3
Restore terraces destroyed by floods	8.7
Other types	3

2.5 Administration of terracing

There are five levels of administration for terracing in this province. The top level is the Provincial Terracing Headquarters. The provincial Bureau of Agriculture, Bureau of Finance, Bureau of Water Conservancy, Bureau of Traffic and Planning Commission are the members of this headquarters. Its main functions are to design plans of terracing projects, coordinate prefecture departments in terracing, distribute terracing investments, supervise use of terracing funds and to monitor construction progress.

The second level organization is the Prefecture Terracing Headquarters. Its members come from the Prefecture Finance Bureau, Agriculture Bureau, Traffic Bureau, Forestry Bureau, Water Conservancy Bureau and Planning Commission. Its main functions are to design plans of terracing projects, coordinate related government departments, and distribute terracing investment.

The third level organization is the County Terracing Headquarters. Its members come from the County Finance Bureau, Agriculture Bureau, Traffic Bureau, Forestry Bureau, Water Conservancy Bureau and Planning Commission. Its main functions are to coordinate at the county level, design county plans of terracing, design blueprints for field construction, supervise construction progress and quality, distribute subsidies, monitor terrace quality and use of terracing investment, and train technicians and masonry workers.

The fourth level organization is the Township Terracing Headquarters. Its members are the key leaders of township governments. Its main functions are generally to organize construction, supervise field construction, and distribute subsidies to farmers.

The fifth level organization is the Village Leading Group. Its members are major leaders of the village residents' autonomous management committee. Its main functions are to physically organize and supervise field construction, to redistribute terraced cultivated land, to handle disputes in terracing, and to distribute subsidies to every participant of terracing.

2.6 Funding mechanisms for terracing

The overall funding principle for terracing is: national government subsides a little, local governments invest a little, and farmers input a little labour. There is a designated ratio for provincial, prefecture and county government terracing investments. The ratio is 4:4:2.

The terracing investment comes from five sources: state government, provincial government, prefecture government, county government and farmers or rural households (mainly in the form of labour). Farmers' labour inputs make the overwhelming weight in the total investment (Table 2.3).

Table 2.3 Investment structure for terracing in Guizhou Province from 1991 to 1996.

	Total	State	Provincial	Prefecture	County	Farmers' Labour
Money (million \$)	475.32	44.92	14.46	4.76	1.54	409.64
Percentage	100.00	9.45	3.04	1.00	0.32	86.18

The state investment was mainly in the form of government paying labour costs in local public infrastructure instead of pure relief. The National Integrated Agricultural Development Programme also provided some investment in terracing. The state funds from two sources were always combined together in terracing.

Farmers' labour input in the past six years was 680 million working days, valued at 409.64 million dollars based on 5 RMB Yuan per working day. Farmers' labour inputs made the overwhelming weight in past terracing investment structure. Farmers have played a basic, active and indispensable role in terracing.

Prefecture and county governments have played positive roles in terracing, but their investments in terracing have been decreasing. The original prefecture and county government investments should have be 14.46 million dollars and 7.23 million dollars, respectively, according to the designated investment ratio for each level of government. The actual completed investment of prefecture and county governments was only 33% and 21% of their intended investment. Nevertheless, this kind of investment shortfall did not remarkably affect the enthusiasm of local farmers in terracing.

2.7 Priority policies for terracing

In Guizhou Province and other areas of China, farmland is mainly owned by village collectives. This is one kind of public land ownership, which is the basis for China's economic mechanism. Private land ownership is forbidden in China. This public land ownership does not affect the utilization of farmland, and does not affect the ongoing terracing projects in Guizhou Province and other areas. All rural households have their own land tenure for more than 30 years. The land tenure is always obtained by signing contracts with collectives. There is a

policy that "those who contract, terrace; those who terrace, utilize; those who utilize, are benefited".

Agricultural productivity can be increased remarkably after sloping land has been terraced. In order to protect farmers' rights as beneficiaries of terracing, the provincial government has stipulated that agricultural taxes, contract fees and collective administrative costs are not permitted to increase within at least three years of land being terraced.

The government has always emphasized that terraced cultivated land should not be occupied. When requisition is not avoidable, the requested terraced land should be compensated according to the actual total predictable loss of farmers. This kind of loss should include agricultural gross production for five years and terracing costs.

2.8 General procedure for terracing

Terracing in Guizhou Province has the following nine steps:

- Selecting terracing sites: according to the slope of each cultivated plot, and the accessibility to wall stones. Priority should be given to cultivated land with slope of 15° 25°.
- Field survey of the terracing sites.
- Designing construction blueprint for terracing.
- Training of technicians, skilled masons, bricklayers.
- Organizing terracing construction.
- Physical construction: demolition, stone-wall construction, building irrigation and drainage system (if required), clearing of stone and gravel remains, field leveling.
- Supervising of construction progress and quality.
- Monitoring and auditing expenditure of terracing funds.
- Project check and acceptance by special group composed of specialists and officials. Table 2.4 is a terracing checklist.

Item	Sub-item	Possible Points	Actual Points Obtained
1. Site selection and	1.1 Site selection	10	
blueprint design	1.2 Blueprint design	10	
	2.1 Foundation quality	10	
	2.2 Wall solidity	12	
2. Construction quality	2.3 Wall thickness	5	
	2.4 Wall appearance	5	
	2.5 Scale of stones	2	
	2.6 Land even or not	10	
	2.7 Clearing remaining stones and gravel	8	
	2.8 Soil depth	3	
	2.9 Project integrity	5	
3. Project management	3.1 Project security management	3	
and efficiency	3.2 Project financial management	7	
-	3.3 Follow-up management	5	
	3.4 Project efficiency	5	
4. Total points		100	
Excellent Project: points o	ver 90; good project: 80 - 90 points; OK proje	ect: 70 - 80 points; m	arginal passable project:

Table 2.4	Ferracing	checklist.
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3. Economic Assessment of Terracing

3.1 Methodology of assessment

Data were collected through a structured survey in Pingba County. The types of data collected consisted primarily of land and soil preservation practices in the area. Among several preservation techniques, information on terracing and its effect on agriculture was intensively collected. Sources of data and information were farmers and local officials. To supplement the structured survey, direct observation was also made during the period of data collection. Steps of data collection are as follows:

- selection of study site
- secondary data collection
- primary data collection through structured survey
- observation on the existing farming practices
- observation on terracing techniques.

The benefit-cost analysis method was applied for economic assessment of terracing techniques in this project. The total benefits include the following: resource benefits (increase in resource quantity or improvement in resource quality, all of which can be calculated in monetary terms), ecological benefits (improvement in ecological situation including improvement in capacity for preserving soil and water, and in biodiversity, etc.), economic benefits (growth of rural income and agricultural products) and social benefits (rural employment opportunity expansion and so on). The costs include material costs and labour costs.

3.2 Study site selection

3.2.1 Reasons for selecting Pingba County as the specific research area

Taking into account data collection, limited time, traffic constraints and other reasons, it was decided to select a county as the specific research area for assessing terracing techniques in the whole province. Pingba County was selected as the specific research area for three reasons. The first reason is that it is representative of Guizhou Province with regard to natural resources and natural conditions, including topography, rainfall, sunshine, temperature, plant coverage, water resources, land conditions and so on. It is also representative of agricultural production methods and the agricultural development situation. Furthermore, it is representative in terms of overall economic development and social development.

The second reason for selecting Pingba County as the specific research area is that this county has been listed in the SARD Programme, or Sustainable Agriculture and Rural Development in China, organized by the Department of Agricultural Resource Management and Regional Planning under the Ministry of Agriculture. The main activities of this programme are research, experimentation and demonstration in sustainable agriculture and rural development. Its main aims are to study SARD theories, to evaluate indicator systems for sustainability, to develop policy frameworks for SARD, and to evaluate and redesign policy regarding sustainable use of agricultural resources and management systems, sustainable agricultural technologies, and SARD at the rural household level. There are 29 SARD experimentation and demonstration areas including Pingba County. SARD's basic ideas have been accepted by more

and more officials, technicians and farmers in this county. This situation has had positive effects on local agricultural development decisions and management of agricultural natural resources.

The third reason is the relatively easy traffic accessibility of Pingba County in Guizhou Province. Guizhou's traffic situation is the poorest in China. The traffic situation is very important for implementing research work in remote and rugged regions like Guizhou Province.

3.2.2 Land resource utilization in Pingba County

The total territory of Pingba County is 999 square kilometers, of which mountains, basins and waters constitute 84%, 14% and 3%, respectively. Areas of land with altitude over 1,500 meters and below 1,200 meters are 1.64% and 14.10% (mainly is basins and waters), respectively. The residual area of 84.26% has an altitude between 1,200 meters and 1,500 meters.

There are three main types of land use: agricultural land, available wasteland, and others (including residential, traffic, industrial, mineral, commercial uses and nonavailable lands). The land use structure of this county is listed in Table 3.1.

Plentiful available wasteland is very useful to sustainable development of agriculture because a large part of the wasteland can be changed into cultivated land or forested land. A high percentage of forest land in the total area provides beneficial security for agriculture against adverse factors such as floods, and droughts, so it is also very useful to sustainable development of agriculture. Furthermore, trees and bushes are usually planted on terrace walls.

Table 5.1 Land use structure in	ii i ingua County.
Land Use	Percentage in Total Area
Agricultural lands	56.5
Cultivated land	30.1
Dry field	16.1
Paddy field	14.0
Horticulture land	1.7
Forestry land	19.0
Pasture land	5.7
Available wasteland	10.7
Other uses and non-used land	32.8

Table 3.1 Land use structure in Pingba County.

3.2.3 Overview of terracing project area in Pingba County

The terracing project in Pingba County covers 7 townships, 34 villages, and 5,796 rural households. The total rural residents benefiting from the project are 30,319 persons. The duration of the project was five years, i.e. from 1991 to 1995. The total completed terraced area was 807 ha in these five years.

Table 3.2	Terraced	areas	comple	ted in	Pingba	County	from	1991 1	to 1995	5.
			· · · ·		.					

	Total	1991	1992	1993	1994	1995
Areas planned by prefecture terracing headquarters (ha)	800	130	130	130	220	190
Terraced areas actually completed (ha)	807	130	130	137	210	200
Completion percentage of planned terraced area (%)	109	100	100	105	96	105

There were two types of terraces in Pingba County. One transfers sloping dry field into terraced dry field, making up 98.27% of the total terraced area. The other transfers sloping dry field into terraced paddy field, making up only 1.73% of the total terraced area (Table 3.2).

3.3 Cost calculation for terracing

Terracing has two kinds of costs. The first is material costs: explosives and detonators; drill rods, hammers and rock drills; cubic stones, electricity, machinery, diesel oil, spades, etc. The second is labour costs: project management, blueprint design, survey, masonry, land leveling, clearing stones and gravel in field, terrace wall building, etc.

From the following general analysis, it will be seen that the total cost per hectare was 6,030 RMB Yuan or \$ 710, of which the labour cost is 71% (Table 3.3).

Total Cost	Cash Cost	Labour Cost	Working Days	Labour Fee
(¥/ha)	(¥/ha)	(¥/ha)	(day/ha)	(¥/day)
6,030	1,755	4,275	855	5

Table 3.3 Total cost per hectare for terracing.

Source: Pingba County Terracing Headquarters.

Of course, the cost depends upon the slope. In areas with slope over 20°, the total terracing cost per hectare was 12,750 RMB Yuan, twice the average level. In areas with slope below 20°, the total terracing cost per hectare was only 5,700 RMB Yuan or 94.5% of the average level.

Table 3.4	Total cost	per hectare	for terracing	areas with	different slopes.
		per needa e	Tor terracing		anner ente bropest

Slope	Total Cost	Cash Cost	Labour Cost	Working Days	Labour Fee	
	(¥/ha)	(¥/ha)	(¥/ha)	(day/ha)	(¥/day)	
Over 20°	12,750	3,750	9,000	1,800	5	
Below 20°	5,700	1,650	4,050	810	5	

Source: Pingba County Terracing Headquarters.

The total annual terracing cost in Pingba county from 1991 to 1995 was 783,900, 783,900, 826,110, 1,266,300 and 1,206,000 RMB Yuan, respectively.

3.4 Resource benefit calculation for terracing

Cultivated land resources are the indispensable base for sustainable development of agriculture, especially in regions with large population and relatively scarce farmland, such as Guizhou Province. Thus, benefits in cultivated land resources are crucial to sustainable development of agriculture. These benefits include the following:

- Area expansion. Terracing can remarkably expand the area of cultivated land everywhere in Pingba County. Nevertheless, the area expansion rate varies with slope. Generally, terracing cultivated lands with slope over 20° can increase the cultivated area by 15%. Terracing cultivated land with slope below 20° can expand the former cultivated area by 6%. Terracing variable sloped cultivated land can expand the former cultivated area by an average rate of 8%.
- Plot scale expansion. The average plot scale can be expanded from 0.03 ha to 0.9 ha after terracing. The plot scale expansion rate is usually 30 times. The scale expansion can greatly improve the accessibility to machinery.
- Thickening soil layer. The soil layer was thickened from 15-30cm to 40-60cm. The capacity for preserving soil, water and nutrients can be greatly improved, and the fertility can be greatly improved, too.

According to the local farmers, soil moisture can generally be increased greatly. However, detailed information was not available. The other benefit is the increase in efficiency of irrigation water after terracing. Unfortunately, there were no data concerning this.

3.5 Ecological benefit calculation for terracing

As the survey results (from the local water and soil conservation bureau and terracing headquarters) showed, 807 ha of former soil and water eroded sloping cultivated land had been controlled and managed. The soil erosion had been decreased by 149 thousand tons of soil, equaling increased cultivated land of 500 ha. Decease in soil and water erosion resulted in a remarkable increase in agricultural productivity (Table 3.6).

The average grain yield could be increased by 20% after terracing due solely to improvement in anti-disaster capability. The destruction from flood and drought disasters was alleviated greatly after terracing. The annual growth of grain output because of the improvement in anti-disaster capability is shown in Table 3.8

3.6 Economic benefit calculation for terracing

3.6.1 Increased grain yield

This growth of agricultural productivity can be seen in comparison between yields of terraced cultivated land and sloping cultivated land. The average grain yield per hectare of original slope cultivated land was 2,760 kg/ha, compared to the average grain yield of terraced cultivated land of 3,200 kg/ha. So, the average grain growth rate after terracing was 16% (Table 3.5). Of course, there were some differences between different years after terracing.

 Table 3.5 Growth rate of grain (maize) yield after terracing.

First Year	Second Year	Third Year	Fourth Year and Later
5%	11%	18%	22%
Source: Ping	ba County Terrac		

On the basis above, the total increased grains only because of yield increase can be calculated. From Table 3.6, it will be seen that the total increased grain (mainly maize) due entirely to yield increase was 17,940, 58,100, 124,890, 211,970, 312,430 and 397,090 kilograms from 1992 to 1997 respectively; and is projected to be 458,390, 482,680 and 482,680 kilograms in 1998, 1999 and 2000 respectively.

Table 3.6	Increased	l grain	output	(kg)	due sol	lel	y to y	ielo	d increase	.
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Year of Terracing	1992	1993	1994	1995	1996	1997	1998	1999	2000
1991	17,940	39,470	64,580	78,940	78,940	78,940	78,940	78,940	78,940
1992		18,630	40,990	67,070	81,970	81,970	81,970	81,9,0	81,970
1993			19,320	42,500	69,500	84,940	84,940	84,940	84,940
1994				23,460	51,610	84,450	103,220	103,220	103,220
1995					30,360	66,790	109,320	133,610	133,610
Total increased grain	17,940	58,100	124,890	211,970	312,430	397,090	458,390	482,680	482,680

Source: Pingba County Terracing Headquarters.

3.6.2 Increased grain output due entirely to expansion of cultivated land area

The total increased grain output due to area expansion of cultivated land was 30,140, 62,000, 98,230, 142,590, 199,140 and 210,630 kilograms respectively from 1992 to 1996; and

is projected to be 215,580, 217,350 and 217,350 kilograms respectively in 1998, 1999 and 2000 (Table 3.7).

-	_	-	-						
Year of Terracing	1992	1993	1994	1995	1996	1997	1998	1999	2000
1991	30,140	31,860	33,870	35,000	35,000	35,000	35,000	35,000	35,000
1992		30,140	31,860	33,870	35,000	35,000	35,000	35,000	35,000
1993			32,500	34,310	36,470	36,900	36,900	36,900	36,900
1994				39,410	41,660	54,710	56,570	56,570	56,570
1995					46,370	49,020	52,110	53,880	53,880
Total increased grain	30,140	62,000	98,230	142,590	199,140	210,630	215,580	217,350	217,350

Table 3.7 Increased grain output (kg) due to expansion of cultivated land.

Source: Pingba County Terracing Headquarters.

3.6.3 Increased grain output due to improvement in anti-disaster capability

The increased grain output because of improvement in anti-disaster capability was 97,500, 195,000, 297,750, 455,250, 605,250 and 602,520 kilograms respectively from 1992 to 1997; and is projected to be 605,250 kilograms annually from 1998 to 2000 (Table 3.8).

Table 3.8	Increased	l grain	output	(kg)	due t	o improvemer	it in	anti	-disaster	capability	<i>!</i> •
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Year of Terracing	1992	1993	1994	1995	1996	1997	1998	1999	2000
1991	97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500
1992		97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500
1993			102,750	102,750	102,750	102,750	102,750	10,275	102,750
1994				157,500	157,500	157,500	157,500	157,500	157,500
1995					150,000	150,000	150,000	150,000	150,000
Total increased grain	97,500	195,000	297,750	455,250	605,250	605,250	605,250	605,250	605,250

3.6.4 The total increased grain output

The total increased grain output due to terracing from 1992 to 2000 is shown in Table 3.9. The total added value from terracing is also calculated.

Table 3.7 Total increased grain output (kg	Table 3.9	Total	increased	grain	output	(kg).
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Year of Terracing	1992	1993	1994	1995	1996	1997	1998	1999	2000
1991	145,580	168,830	195,950	211,440	211,440	211,440	211,440	211,440	211,440
1992		146,270	170,350	198,440	211,470	211,470	211,470	211,470	211,470
1993			154,570	179,560	208,720	224,590	224,590	224,590	224,590
1994				220,370	250,770	296,660	317,290	317,290	317,290
1995					226,730	265,810	311,430	337,490	337,490
Total increased grain	145,580	315,100	520,870	809,810	1,109,130	1,209,970	1,276,220	1,302,280	1,302,280
Total added value (Yuan)	232,928	504,160	833,392	1,295,696	1,774,608	1,935,952	2,041,952	2,083,648	2,083,648

3.7 Social benefits of terracing

- Improvement in local grain security: The local grain security improved remarkably after terracing. First, the total increased grain output reached 2,775 tons over 1992-1996 or 555 tons per year. Second, the per capita grain increased by 96 kilograms. The local grain security will be further improved.
- Poverty alleviation: The farmers' income growth due to terracing was 223 thousand dollars, for a per capita income increase of 63 RMB Yuan or 7.5%.
- Providing more working opportunities for local farmers: The total increased work opportunity in 1992-1996 was 690 thousand working days. This provided additional 45.5 working days per farmer per year for these five years.

3.8 Calculation of net benefit and identification of the break-even point for terracing

3.8.1 Total terracing costs and benefits

The total terracing costs and benefits are calculated in dynamic terms. That is to say the interest rate is used in calculating accumulated terracing costs and accumulated terracing benefits. Taking into account China's actual interest rates from 1991 to 1997, an average interest rate of 10% was applied here. The general formulation for calculating accumulated costs or benefits is:

$$PV_n = P_1(1+10\%)^{n-1} + P_2(1+10\%)^{n-2} + \dots + P_{n-1}(1+10\%)^1$$

where, n, n-1, n-2, ... and 1 are the years n, (n-1), (n-2), ... and 1. P_1 , P_2 , P_{n-1} and PV_n are the accumulated value (costs or benefits) in the first year, second year and the year of (n-1) and n, respectively.

3.8.2 Calculation of net benefit and identification of the break-even point

From Table 3.10, an important conclusion can be obtained: terracing did not begin to produce net benefits until 1997 and thereafter, that is to say the break-even point was around 1997. In other words, the total terracing cost can be regenerated by 1997, two years after completion of the terracing project.

Table 3.10 Net benefit of terracing.

Year	Actual Cost	Accumulated	Actual Benefit	Accumulated	Net Benefit
		Cost		Benefit	
1991	783,900	783,900			-783,900
1992	783,900	1,646,190	232,928	232,928	-,413,262
1993	826,110	2,558,529	504,160	760,380	-2,482,491
1994	1,266,300	4,166,911	833,392	1,669,810	-2,497,101
1995	1,206,000	5,789,602	1,295,698	3,132,488	-2,657,114
1996		6,368,562	1,774,608	5,220,344	-1,148,218
1997		7,005,418	1,935,952	7,678,332	672,914
1998		7,705,960	2,041,952	10,488,116	2,782,156
1999		8,476,556	2,083,648	13,620,576	5,144,020
2000		9,324,212	2,083,648	17,066,282	7,742,070
4. Sustainability of Terracing

4.1. Sustainability

Terracing in regions like Guizhou Province is one of the most effective and efficient technologies for sustainable agricultural development. It can effectively and efficiently increase the area of cultivated land on the basis of improving the natural conservation situation without destroying the ecological balance. It can remarkably increase the output of grains and other agricultural products, resulting in great improvement in grain security. It can also greatly increase the farmer's income level, and alleviate and finally eliminate local poverty. It can increase employment opportunities for local farmers. In other words, terracing in Guizhou Province can remarkably improve economic, resource, environmental, ecological and social efficiency. Agricultural development that is able to realize these five kinds of efficiency is sustainable. That is the reason why so many farmers and officials are pleased with terracing.

4.2 Views of local officials on terracing

The local government usually used "Five Most" to illustrate the roles of terracing in social and economic development of Guizhou Province including Pingba County:

- Terracing is the most sound project in alleviating poverty and integrated agricultural development.
- Terracing is the most basic project in improving local agricultural infrastructure and productivity.
- Terracing is the most realistic project welcomed by local poverty-stricken and graintroubled farmers.
- Terracing is the most all-inclusive project that incorporates agricultural, forestry, water conservation, planning, finance, traffic and other departments into one project.
- Terracing is the most sustainable project that can sustainably play an active and indispensable role in increasing production, protecting the environment and preserving the ecological balance.

4.3 Views of local farmers on terracing

The selection of farmers or rural householders to be interviewed was based on the following considerations: per capita income; per capita grain possessed; per capita contracted cultivated land; education; size, age and gender composition of the family; householder's occupation, etc. One hundred rural households were visited and questioned. Ten key questions were asked. The results are summarized here.

- What kind of agricultural technologies do you prefer?
 - Seed improvement: 86%
 - Soil fertilization: 34%
 - Water-saving irrigation: 12%
 - Produce processing: 67%
 - High-efficiency chemical fertilizer: 88%

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- High-efficiency pesticides: 52%
- Terracing: 78%
 Analysis: terracing is an approach welcomed by local farmers, ranked third only after high-efficiency chemical fertilizers and high-quality improved seeds.
- Farmers' acceptation of terracing:
 - Complete acceptation: 68%
 - Conservative acceptation: 26%
 - Rejection: 6% Analysis: two-thirds of farmers completely accepted terracing mainly because of the remarkable expansion of cultivated land area and improvement in irrigation conditions.
- What are the problems of in terracing?
 - Corruption of officials: 32%
 - Flood destruction: 52%
 - Change in land tenure after terracing: 67%
 - Change in land ownership: 0%
 - Can't obtain the deserved terracing subsidies: 18% **Analysis**: farmland is owned by the local collectives and there is little change in land ownership. That is the reason why Chinese farmers were not afraid of changes in land ownership. However, tenure changed frequently in some areas because of adjustment in the allocation of plots, especially after terracing. Strict control over terracing investment appropriation and utilization was the reason for lower corruption in terracing in Guizhou Province.
- Why do you participate in terracing?
 - To expand cultivated land area: 89%
 - To get subsidies from participating in terracing construction: 26%
 - Forced by local leaders: 3%
 - To prevent soil and water erosion: 15%
 - **Analysis:** almost all of the farmers said terracing could expand cultivated area greatly. That was the main reason for farmer participation in terracing. Nearly one-fourth of the farmers said subsidies (generally given in grain form) attracted them to participate in terracing.
- Are you satisfied with the existing terracing organizing and management system?
 - Completely satisfied: 51%
 - Conservatively satisfied: 36%
 - Unsatisfied: 13%

Analysis: the reason for the high percentage of satisfaction was that the existing terracing organizations are operating efficiently and effectively, and that corruption is under control. But some farmers were not satisfied with officials of county and township terracing organizations.

- To what degree can terracing expand cultivated land area?
 - Can expand area by 20% and over: 6%
 - Can expand area by 10-20%: 24%

- Can expand area by 5-10%: 65%
- Can expand area by 5% and below: 5% Analysis: all of the farmers said terracing could expand cultivated land area. From the answers above, the average expansion rate can be calculated as about 8%.
- To what degree can terracing increase grain yield on your cultivated land?
 - Increase by 30% and over: 15%
 - Increase by 20-30%: 28%
 - Increase by 10-20%: 48%
 - Increase by 10% and below: 8%
 - Decrease cultivated land after terracing: 1% **Analysis**: all of the farmers experienced an increase in grain output after terracing. The reason for different answers may be mainly because they planted in cultivated land with different slopes and different irrigation conditions. Farmers with sloping land with good irrigation conditions had a greater increase of grain output.
- How long did you work in terracing construction in 1995?
 - Sixty days and over: 31%
 - Fifty to sixty days: 38%
 - Twenty to forty days: 23%
 - One to twenty days: 6%
 - None: 2%

Analysis: the reason for different working time in terracing was the difference in age, gender, full-time occupation, etc. Young male full-time farmers worked longer in terracing.

- What was your family's per capita income last year (in RMB Yuan)?
 - Two thousand and over: 5%
 - One thousand five hundred to two thousand: 14%
 - One thousand two hundred to one thousand five hundred: 29%
 - Eight hundred to one thousand two hundred: 41%
 - Six hundred to eight hundred: 9%
 - Below six hundred (the local poverty-line in current prices): 2%

4.4 **Problems in terracing**

Fund shortage is very common in China, and is more serious in Guizhou Province, one of the most under-developed regions in China. Funds invested in agriculture are further limited in such a province even though this kind of investment could produce reasonable gains. This is the first reason for fund shortage.

The second reason is that the local terracing specific-use investment is usually decreased again and again. The total planned investment assumed by provincial government, prefecture governments and county governments was 14.46 million dollars, 14.46 million dollars and 7.23 million dollars, respectively, from 1991 to 1996. But the funds actually invested by the three levels of governments were 14.46 million dollars, 4.76 million dollars and 1.54 million dollars, respectively. The completed investment rates were 100%, 33% and 21%.

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Fund diversion appeared in limited places, but produced bad effects on terracing projects. Even though there was official corruption in some places, it was not too serious. As investment supervision and auditing are improved, these problems will be limited.

Not all of the selected terracing areas were optimal. The reasons for inappropriate selection of terracing areas were: official personal preference or even prejudice; technical mistakes; and fairness in allocating terracing investment.

Inappropriate selection of terracing areas resulted in negative effects such as: efficiency sacrifice in terracing including economic, environmental, social, resource and ecological efficiency loss, and more unnecessary administrative interference with farm production.

Some project areas have their own effective and efficient terracing headquarters and powerful terracing directors. The powerful organizations are the most important insurance for smooth terracing construction. Pingba County is one of the areas with a powerful terracing headquarters and directors. The regional gap between organization systems and their effectiveness results in differences in terracing progress.

There were apparent imbalances in terracing quality because of differences in terracing organization system effectiveness, technician quantity and quality, views of local farmers on terracing, and natural conditions including flood frequency. Some areas with powerful terracing directors, enough technicians, skilled farmers and suitable natural conditions always completed good quality projects more rapidly. Pingba County was one of them.

5. Conclusions and Recommendations: Guizhou Province

5.1. Conclusions

- Terracing is accepted by most farmers in Pinba County of Guizhou Province.
- Terracing is one of the most effective and efficient ways for simultaneously realizing economic, resource, environmental, ecological and social objectives in Pingba County, and possibly other areas in Guizhou Province.
- Terracing is one of the most feasible ways for realizing sustainable agricultural development in Pingba County, and may apply elsewhere in Guizhou Province.
- There is a severe shortage of terracing investment in both Pingba County and Guizhou Province.
- State investment played, plays and will play a catalytic role in terracing. State investment attracted more investment from local government and enterprises.
- Farmers played, play and will play an indispensable and active role in terracing in Pingba County and in Guizhou Province.
- An effective organization system is important insurance for successful terracing.

5.2 Recommendations

- Specific-purpose terracing investment should be increased. The local leaders should try to attract foreign investors' attention, including every kind of monetary organization.
- The selection procedure for terracing project areas should be greatly improved from provincial government officials downward to village heads.
- The recommended procedure is: organizing a special provincial technical group including officials and technicians, prioritizing counties according to their actual need for terracing; selecting key terracing project areas by county terracing headquarter.
- The terracing standard should be improved
- More attention should be given to fund diversion in terracing. Fund supervising and auditing should be strengthened and improved further.