

KARST ENVIRONMENT AND ECO-POVERTY IN SOUTHWESTERN CHINA: A CASE STUDY OF GUIZHOU PROVINCE

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ABSTRACT: Guizhou Province is one of the least developed areas with the largest number of counties in poverty and the widest coverage of karst landscape in China. The vulnerability of its karst eco-environment seriously threatens the survival of local residents and the development of local economy. Rapid population growth results in higher demand of various resources, which leads to more intensive development activities. For example, the blindfolded development on steep slopes has caused rock desertification of local rare soil in this karst area. It has induced a vicious circle in the poverty → population growth → ecosystem degradation and so on. About 3.13×10^6 people belong to the absolute impoverished population in Guizhou Province and most of them are living in rock-desertification areas. The essential reasons for destitution are the atrocious eco-environment and the huge population stress. Degradation of mountain ecosystems in southwestern China has continued at unprecedented speed and scale in recent decades. It is necessary to control population growth strictly and prevent further expansion of rock-desertification in order to develop local economy and better living conditions for local people. The only way to ensure a sustainable, stable and harmonious development of human, nature and economy is to restore a good condition of eco-environment and resolve the conflicts between human and land use.

KEY WORDS: karst environment; rock desertification; eco-poverty; Guizhou

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1 INTRODUCTION

In the 1980s and 1990s, there was widespread belief among environmentalists that uncontrolled population growth would be responsible for environment degradation of all types. This neo-Malthusian belief originally surfaced in the publication of *The Population Bomb* in the late 1960s. In ensuing years this belief, combined with work on environment carrying capacity and a growing environmental movement, led to the seemingly commonsense conclusion that high population growth and high fertility in particular, are destructive for the environment. This belief has attracted numerous critics that there is not a definitive link between population growth and environmental decline (CURRAN *et al.*, 2002; DASGUPTA, 2002).

However, in a place poor in amiable eco-environment, for example soil productivity in Tibet Plateau and karst area in Yunnan Guizhou Plateau is much lower than that in Zhujiang Delta and Changjiang

Delta, China, and high population growth will threaten environment capacity more directly than those places with rich resources. For example, in Guizhou Province, rapid population growth results from intensive development activities, the blindfolded development on steep slopes has caused rock-desertification of local rare soil in this karst area. It has induced a vicious circle in life poverty → population growth → environment degradation and so on (TANG and XIA, 2001). About 3.13×10^6 people belong to absolute impoverished population in Guizhou Province in 2000 and most of them are living in rock-desertification areas according to *Statistical Yearbook of Guizhou Province* (Guizhou Statistical Bureau, 2000). This paper summarizes the interactions between karst environment and eco-poverty in Guizhou Province, examines the reasons of economic poverty and puts forward some approaches to guarantee a sustainable, stable and harmonious development of human, nature and economy.

The objectives of this paper are to 1) identify the e-

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co-environment problems of karst area in Guizhou Province; 2) illustrate the socio-economic conditions of local stakeholders' living standards; 3) analyze the primary reasons contributing to utmost poverty in karst regions; 4) develop perspectives and countermeasures to fight destitution and challenges for maintaining the balance between protection and development in frail ecosystems.

2 KARST IN SOUTHWESTERN CHINA

China is one of the countries with the largest karst landscape, with an area of more than $2 \times 10^6 \text{ km}^2$, accounting for 5% of carbonate coverage in the world (CHE and YU, 1985). In the southwestern China, the coverage of karst landform is about $540 \times 10^3 \text{ km}^2$, administratively including Guangxi, Guizhou, Yunnan, Sichuan, Hunan, Hubei and Chongqing (Fig.1).

Guizhou Province is one of the provinces with the widest distribution and most intensive evolution of karst in China. The coverage of karst landform in the province is more than $130 \times 10^3 \text{ km}^2$, being 73.6% of total land area of Guizhou Province and 6.5% of total karst area of China (SU and ZHOU, 1995). About 94.6% of population in the province live in the karst area. Recent years, with rapid population growth and vulnerability of karst environment, soil erosion becomes so serious that it has caused the loss of surface soil in steep slopes and bareness of bedrock in large area, which directly threatens further development of economy in Guizhou Province (HE *et al.*, 1996). Naked and half-naked tor clusters have become another landscapes besides karst landforms. Therefore, Guizhou has destined to be one of the poorest provinces in China for years. How to maintain the balance between conservation and utilization of natural resources and improve

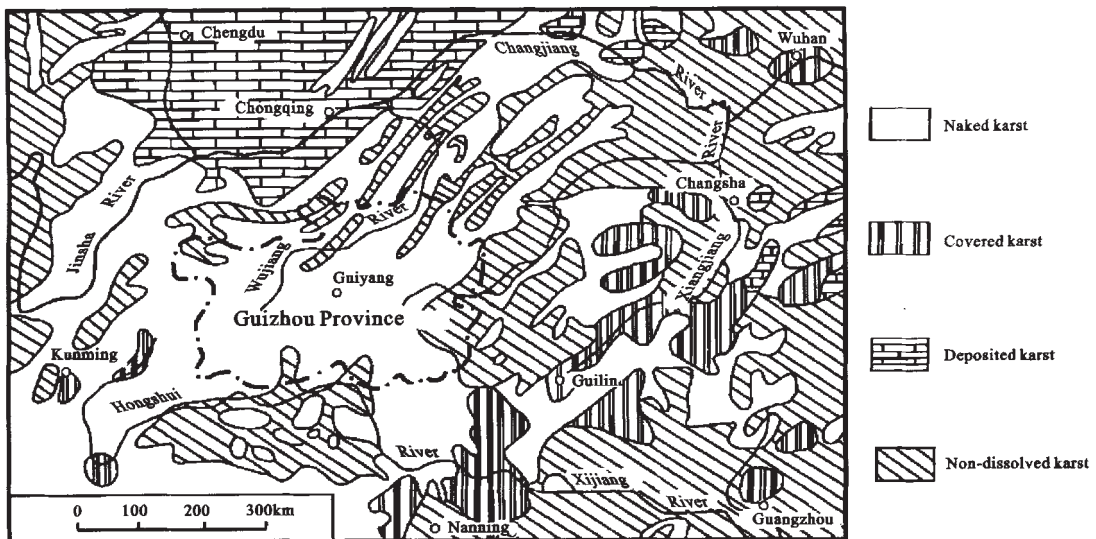


Fig. 1 Location of various karsts in the southwestern China (YAO *et al.*, 2001)

the living standards of local stakeholders in karst area is an urgent and demanding challenge for the southwestern China. In the case of Guizhou Province, with its fragile eco-environment conditions and long-term poverty in social economy, a solution of this challenge is crucial not only for further regional economic development, but also for national economic development.

3 ECO-ENVIRONMENT CONDITIONS IN KARST AREA OF GUIZHOU

3.1 Site Description

Guizhou Province is located in $103^{\circ}36' - 109^{\circ}30'E$, $24^{\circ}30' - 29^{\circ}13'N$, belonging to the Yunnan Guizhou

Plateau, with an average altitude of 1100m. The whole area is $176.1 \times 10^3 \text{ km}^2$, accounting for 1.8% of the total land area of China. Mountains and hills cover 97% of the total land area of the province, among which 73.6% is karst. The climate of the province belongs to typical subtropical plateau zone. Its average annual precipitation is about 1100–1300mm, concentrating mainly in April–September and increasing from west to northeast in space. Its average annual evaporation is 1300–1600mm, decreasing from southwest to northeast.

3.2 Soil Erosion

Based on remote sensing data of soil erosion maps of Guizhou Plateau, the area with soil erosion modulus

less than 500t/(km²·a) is 99.4×10³km², taking up 56.46% of the total land area of the province, belonging to non-distinct erosion land; while those land with soil erosion modulus higher than 500t/(km²·a) is 76.7×10³km², occupying 43.54% of the total land area of the province (AN *et al.*, 1999). Annual soil loss in the whole province is about 62×10⁶t, the average yearly soil erosion modulus is 1288t/(km²·a), and annual erosion loss is more than 190×10⁶t (HE, 2000).

3.3 Rock-desertification

In 1985, the coverage of rock-desertification was 12.41×10³km², only accounting for 7.05% of the total land area of the province. While in recent years, the rock-desertification has reached such a surprising state that the annual soil degradation is about 933km² caused by the population bomb and intensive human activities. In 2000 the rock-desertification area has reached 35.9×10³km², occupying 20.27% of the total land area. Moreover, the potential rock-desertification area keeps increasing alarming which deserves much consideration: mentioned area reaches 43.7×10³km², taking up 24.81% of the total land area (LAN *et al.*, 2001). The original vulnerable land is facing another serious strike.

4 SOCIO-ECONOMIC CONDITIONS IN GUIZHOU

Guizhou Province governs nine administrative prefectures (cities): Guiyang City, Zunyi City, Liupanshui City, Anshun City, Tongren Prefecture, Bijie Prefecture, Miao-Dong Autonomous Prefecture of Qiandongnan (Qiandongnan), Bouyei-Miao Autonomous Prefecture of Qiannan (Qiannan), Bouyei-Miao Autonomous Prefecture of Qianxinan (Qianxinan) (Fig. 2), with 87 administrative counties in all. Its population has reached 37 985 100 in the end of 2001, in which

37.80% is minorities. Table 1 shows some detailed information of regional socio-economy in Guizhou Province.

As for the counties in poverty in Guizhou Province, the total area is 111 400km², and the population is 19 822 300, with a population density of about 178 persons/km². Demands for sustenance of the massive population directly induce the overuse of poor eco-environment. According to Guizhou Statistical Bureau (2001), GDP in the province is US\$ 11 992 753 623 in 2000 (the exchange rate of Chinese Yuan to US\$ is 828 to 100). The average annual income of townspeople is US\$618.60, but the average annual net income of farmers is only US\$165.94 per capita. Most of all, those people whose annual income below US\$48.31 is called people in special poverty in China, which reaches 708 000 in Guizhou Province. The number of people in poverty reaches 3.13×10⁶, most of them living in karst areas, which is an astounding number for urgent measures to improve local people's living standards (LI and SU, 2000).

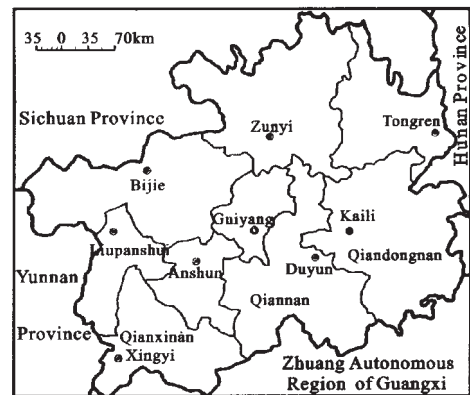


Fig. 2 Location of administrative prefectures in Guizhou Province

Economic development in Guizhou Province almost

Table 1 Main socio-economic indicators in Guizhou Province, 1999

Region	Area (km ²)	GDP (×10 ⁸ US\$)	Population (×10 ⁶)	GDP per capita (US\$)	Average annual income per townspeople(US\$)	Average annual income per farmer(US\$)
Guiyang	8 032	2.869	3.3121	872.43	734.54	242.75
Liupanshui	9 914	0.900	2.8377	320.17	550.36	155.43
Zunyi	30 753	2.729	7.0977	387.08	585.14	203.99
Tongren	18 023	0.717	3.6985	195.29	593.84	150.85
Qianxinan	16 804	0.674	2.9188	232.37	622.34	160.51
Bijie	26 853	1.456	6.7652	216.67	516.65	154.23
Anshun	9 246	0.679	2.5520	268.87	493.48	161.47
Qiandongnan	30 302	0.828	4.1714	199.76	594.93	152.54
Qiannan	26 240	1.136	3.7473	305.68	592.15	163.53
Guizhou Province	176 167	11.013	37.1007	296.86	551.33	164.61

drops behind any other province in China based on indicators provided by National Statistical Bureau (2001) (Table 2). Moreover, GDP per capita in Guizhou Province is the lowest among 34 provinces (including Hong Kong, Macao and Taiwan) and also the only province that GDP per capita is lower than 50% of national average. Average annual income of peasants is also much lower than national average for many years (Fig. 3).

Table 2 GDP and rank of Guizhou Province in China (×10⁹US\$)

Year	1997	1998	1999	2000
GDP	9.58	10.17	11.01	12.00
Rank	28	29	29	28

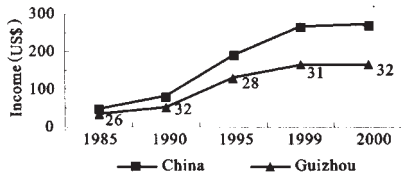


Fig. 3 Comparison of farmers' annual per capita income in Guizhou Province and China

5 REASONS OF ECONOMIC POVERTY

5.1 Atrocious Physical Environment

More mountains with large slopes and less plains for agriculture characterize the physical environment in Guizhou Province as karst landscape covers most parts of it (Table 3). The coverage of mountains and hills takes up 97% of the total land area of the province. This kind of land cover contributes much to the loss of rare surface soil along slopes and expedites the process of rock-desertification (Table 4). However, population of rural areas keeps growing rapidly in recent years. Under the conditions of shortage of arable land, more marginal and forest lands along the mountains are being reclaimed for agricultural use and in return, this activities accelerate soil erosion, loss of soil fertility, deforestation, overgrazing and degradation of the vulnerable mountain ecosystems. Further degeneration of karst environment has seriously limited the local economic development.

Table 3 Slopes distribution in Guizhou Province

Slope range (°)	<8	8-15	15-25	>25
Proportion (%)	8.64	21.96	37.50	31.90

5.2 Population Pressure and Lower Education

The population in Guizhou Province has increased sharply over the past decades. There had been a popu-

Table 4 Soil erosion rate and rock-desertification rate in different slopes (SU and ZHOU, 1995)

Slope range(°)	10-15	15-20	20-25	25-30	30-35	>40
Soil depth(cm)	120	81	86	78	71	<20
Tilled depth(cm)	20	17	15	18	<9	-
Soil erosion modulus (t/km ² ·a)	2850	-	3150	-	11700	>32000
Rock-desertification speed(%)	100(CK)	-	215.3	-	1197	>40416

lation of 32 675 300 by the end of 1990 while 37 557 200 by the end of 2000, which means a growth of 4 881 900 in the ten years. The annual rate of population increase is 14‰. Synchronously, the arable land per capita reduced from 0.088ha to 0.076ha, which is the lowest in China. The per capita land-resources decrease is an acute result of population growth, which also leads to over exploitation, and deterioration of the quality and productivity of land resources. Lower education cannot provide local stakeholders with a wise way of conserving rare surface soil and recognizing the importance of birth control in fragile ecosystems, which in return causes higher birth rate, further impedes economic development and the improvement of poorer living conditions. Considering land resources, two direct ways to mitigate population growth are reclamation and over-exploitation. Both of them can result in ecosystem degradation. A favorable local knowledge system will help to control population growth. However, low education conditions generate poor local knowledge system of wise use of resources and contribute to population growth in return, which also ended up with ecosystem degradation (Fig. 4).

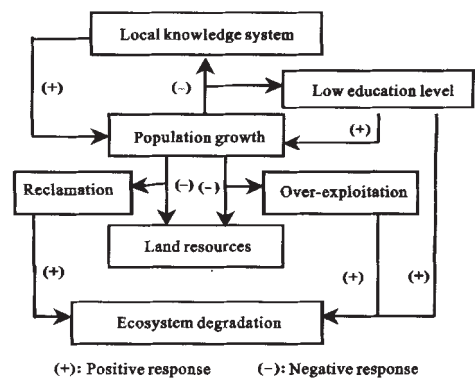


Fig. 4 Relationship among population growth, local knowledge system and ecosystem degradation

Of the 37 557 200 people in 2000, only 1.9% received a bachelor's degree or higher education and illiterates took up 13.8%, which is higher than the average rate of illiterates in China (5.7%). Low education in-

duces a higher population growth rate in Guizhou Province (LIU and LI, 2000). Recent years, natural growth rate of population in Guizhou is around 14‰ and takes the second place in China whose average rate is lower than 9‰. It is inevitable that rapid population growth generates the conflicts between human beings and food supply (AN *et al.*, 1999). Its arable land per capita is far behind the alert limit stipulated by the United Nations (SU and ZHU, 2000). However, the dimension and scale of degradation have been further enhanced by natural fragility and marginality of steep slopes. Population growth has led to deforestation, overgrazing, poorly maintained arable land, fertile surface soil erosion and decline in productivity (SHI and LI, 1999). The status quo of mountain ecosystems in the southwestern China shows symptoms of unsustainability: less land resources per capita; destruction of the biophysical resources; stagnation or decline in productivity, due to erosion and degradation; and loss of resources regenerative capability and diversity (JODHA and SHRESTHA, 1994). Activities of deforestation and de-grassland for agricultural use has accelerated soil erosion and rock-desertification on a larger scale.

5.3 Shortage of Water Resources for Development

Lack of water resources is another important restrictive factor for local economic development. Many reasons contribute to water shortage though it has a higher precipitation of 1000–1300mm per year. Geologically speaking, many fissures, sinkholes, underground streams and caverns cause the leakage of rainwater and runoffs in large areas. The fall of rivers is so high, for example, the fall of the Wujiang River reaches 2036m in Guizhou Province, which causes another water loss in Guizhou highland. Heavy rain and the high fall of rivers also result in serious soil erosion, water loss and rock-desertification. Primary, secondary and tertiary industries are all in great demand of water resources. But water loss becomes the second restraint factor besides its vulnerable eco-environment to economic development in Guizhou.

All in all, atrocious physical environment, population pressure and lower education level, and shortage of water resources are the main reasons contributing to utmost poverty in Guizhou Province among other various reasons, such as inaccessibility because of poor infrastructure. However, the most important one is atrocious eco-environment indicated by sterile topsoil along steep slopes, poor productivity of sustenance, and unitary plantation without diversity in mountain areas and low carrying capacity of the land. We define this kind

of poverty caused mainly by meagre ecosystem to so-called eco-poverty demanding a sustainable and integrated approach to improve ecosystem health and carrying capacity. Karst area in Guizhou Province is a typical eco-poverty place in China.

6 ANTI-POVERTY MEASURES

The key problems facing sustainable development in karst areas in Guizhou Province are poor eco-environment and rock-desertification. The conflicts among appropriate land use, population growth and economic development are more serious than before with the forthcoming of western region development. Lacking of drinking water for human and livestock, low forestation rate and out breaking of numerous natural hazards illuminate that implementing sustainability in karst areas is a long and laborious way not only for local stakeholders, but also for government officials, managers, scientists and environmentalists.

6.1 Eco-environment Restoration

In order to meet the demand of available resources of both water and soil in karst areas, advanced technique to improve the use efficiency of resources in mountain regions are highly recommended. Economizing water by agricultural technique, engineering or management is the primary measure to improve the use efficiency of various waters in biosphere. Agroforestry is a method of ancient land use with great promise, whereby trees are combined with crops and livestock to produce diverse products. Recent years this old practice has again been used successfully as a reference base for regional development in karst areas, such as agrosilviculture, silvopastoral system and agrosilvopastoral system (SHI and LI, 1999).

Forestry restoration is another important method to improve ecosystem health of karst areas. There are two ways to reconstruct forestry systems: one is self-design theory by closing the area to local people, the other called designer theory by human activities such as trees plantation (BETH, 1999; VAN and PEDERSON, 1989). The latter should be attached much importance since most karst regions are facing massive population pressure. That is to say, self-design theory is an approach that emphasizes the ability of a site, given enough time, to organize itself around engineered components; designer theory is an approach that views the life history strategy of species as the important factor in developing vegetation on a restoration site. There are just restatements of earlier theories of Clementsian ver-

sus Gleasonian succession. Eco-economic trees and grasses, fast-growing nitrogen-fixing trees and shrubs, hedgerows are been taken into much consideration. Local governments encourage and help farmers to construct fruit farms and to plant tree and economic crops on steep slopes. Contracts are signed between governments and farmers to purchase those products. Farmers earn cash income, which is several times more than crop output, increasing their incentive to participate actively in the program of returning slope lands to forest (SHI and LI, 1999).

6.2 Education Enhancement and Urban System Improvement

The moderate population carrying capacity in Guizhou Province is 150 persons/km². To add one person needs 734m² of land for reclamation (SU and ZHOU, 1995). However, the population density has reached 213.19 persons/km² in 2000, which is higher than the average not only in nearby areas such as Guangxi, Yunnan, Sichuan provinces but also in China. Population overloading contributes much to environment pressures, such as deforestation, over-grazing and rock-desertification. Birth-control enforcement, women participation in local affairs, environmental education and popularization are also urgent in many rural areas of Guizhou.

Over 80% of population in Guizhou Province are engaged in agriculture and live in rural areas with low education infrastructure. Among 87 administrative counties, only 32 of them offer a complete 9-year compulsory education, while with large loss of school-age children in other counties (ZHANG and ZHAN, 2002). The main reasons for children leaving off study are impersonal ones, such as fund shortage, teachers scarcity, schools too far away and lack of labor forces in family. Setting up core towns or cities and enhancing their driving forces, radiation and control functions to rural areas is an important approach to realize co-affluence in the long period (SHEN, 2002). Developing ecological township enterprises to employ surplus labor forces is another way to alleviate population pressure to land resources.

6.3 Bringing Natural Advantages into Full Play

Guizhou Province is famous for its opulent mineral deposits, abundant hydraulic energy, complex biodiversity and various tourism resources in China. The storage of coal, aluminum, phosphorus, manganese, zinc, gold, antimony, and barites take predominant places in China. Accessible hydraulic powers take the 6th place in China and can easily be developed furthermore. The u-

plifting of Qinghai-Tibet Plateau led to vertical mountain climate types and vertical vegetation zones along the elevation gradient. Zonal vegetation varies from tropical rainforests in the south to the temperate grasslands in the north. Combination of both induces abundant and complex flora and fauna, which deserves further development for their ecological, economic or pharmaceutical functions.

What deserve special mention are its splendid natural sights and in particular folk music, arts, costumes and customs. How to develop the two kinds of tourism resources is critical to develop local economy nowadays with less or without investments for industry at all and infertile land for agriculture. It should be a promising, shifting and environmental enterprise with eco-tourism in place of traditional agriculture.

7 DISCUSSION AND PERSPECTIVE

It has been demonstrated that atrocious ecosystem results in utmost poverty in Guizhou Province. Population density has exceeded the possible carrying capacity of environment, indicating the eco-environment is turning hostile and improper for living. Arable land per capita, GDP per capita and education level in Guizhou is always among the lowest ones in China while the rate of population growth is among the highest ones in recent years, leading to gaps from other provinces (regions) in China. It is among the places facing a serious ingenuity gap implying declination of food production, reduced economic output, and large population growth (HOMER, 1995). The relationships between population growth, education level and ecosystem degradation are the key factors in solving these problems.

The limitations facing anti-poverty measures include: 1) Disadvantage of land-tenure system. Land-tenure in China had been under the system of a *Contracted Responsibility System* since the economic reform by the end of the 1970s. The land is allocated in accordance to quality and land areas are often divided into several fragments for several households, which is a decentralized and private production system designed for direct economic utilization, and lacks of public and communal management (LI *et al.*, 1999). 2) Inaccessibility of transportation and various communication systems. The average altitude of Guizhou Province is about 1100m with much mountainous regions. Inaccessibility of transportation and communication has limited the possibility of receiving information and trade of agricultural production for marketing and eco-tourism development. 3) Shortage of financial funding. The an-

nual income per capita is even not enough for food and clothing. Funds for education fees, investments of irrigation works or other usage are impossible for local stakeholders and governments. 4) Poor infrastructure for agriculture and urban system. Rainwater storage before falling into karst fissures, sinkholes and underground streams are important to local agriculture and industry since most areas in Guizhou Province are in great desire for fresh water resources. 5) Weak links between supply and demand of education and high techniques. Poor education level and research activities hamper social-economic development in further step.

However, how to maintain the balance between conservation and utilization in vulnerable ecosystem in karst area is still a promising program not only for governments but also for local people, so the following measures are taken into consideration: 1) public participation in environment protection and management; 2) women involvement in public affairs; 3) population growth control and living standards improvement of local stakeholders; 4) infrastructure construction for agriculture, industry, education, transportation and communication; 5) 9-year compulsory education enhancement and education conditions improvement; 6) eco-tourism development based on adaptive planning and management; 7) investments and technology adoption from global level.

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