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Ecological Environment Restoration and Economic Transformation in Karst Landscape Areas—Take Guizhou Province as an Example

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Abstract: *Promoting the construction of ecological civilization and building a modernization in which human beings live in harmony with nature is an important feature of Chinese-style modernization and an important element in realizing the great rejuvenation of the Chinese nation.The karst landscape area in southwest China is a typical ecologically fragile area. By analyzing the characteristics and functional features of the ecosystem in the karst region, the state of ecological and environmental quality and the achievements made in the construction of ecological civilization in Guizhou Province are introduced, and the opportunities and challenges facing ecological and environmental protection in Guizhou Province in the coming period are analyzed in the light of the current achievements and the situation faced by ecological and environmental protection work.*

Keywords: *ecological protection of the environment; green industry; pollution control; karst areas*

1. Introduction

Southwest China is one of the three major karst concentrated areas in the world, where carbonate rocks are exposed and karst development is strong. High temperature, rainfall, hot weather and rainy seasons have created a karst landscape with peaks, depressions, canyons, caves and underground rivers (Meng et al., 2018; Ran et al., 2023; Tian et al., 2023) [1]. Karst areas are characterized by high sensitivity to environmental interface variability, high degree of ecosystem competition, low environmental capacity, and poor stability (He et al., 2010)[2], and are typical fragile ecological function areas.Guizhou's ecology is beautiful but fragile. Statistics show that the exposed karst area in Guizhou accounts for 61.92% of the total area of the province. As one of the regions with the most typical karst landscapes development in the world, Guizhou was once the province with the largest rocky desertification area, the most types, the deepest degree and the most serious damage in the country.[3]

Southwest China is an important ecological barrier in the upper reaches of the Yangtze River and the Pearl River, and its ecosystem service functions are extremely important, accounting for about 2/3 of the country’s total area. It’s main ecological service functions include water conservation, biodiversity protection and soil conservation. The soil layer in this area is shallow and discontinuous , with poor water and fertilzer retention capacit and poor vegetation habitat conditions (Wu et al., 2021)[4], there are few species of suitable plants, simple community structure, and low stability of ecosystem resilience (Wang et al., 2002)[5]. Due to the joint influence of natural conditions and human activities, the zonal native vegetation has evolved from evergreen broadleaf forests and mixed evergreen deciduous broadleaf forests to shrub communities and grass communities, which directly affects the biodiversity of the region (Zhong et al., 2018; Li et al., 2023; Zhong et al., 2023)[6].Guizhou Province is located in a karst region, the distribution area of carbonate rocks accounts for about 80% of the province, and the thickness accounts for 50% to 70% of the total stratum thickness. There are a large number of karst caves, which are typical and concentrated karst carbon sink resources, and it has a great potential for the development of karst carbon sinks, and the sustainability of the ecological stability has been further enhanced[7] , as shown in Figure 1.

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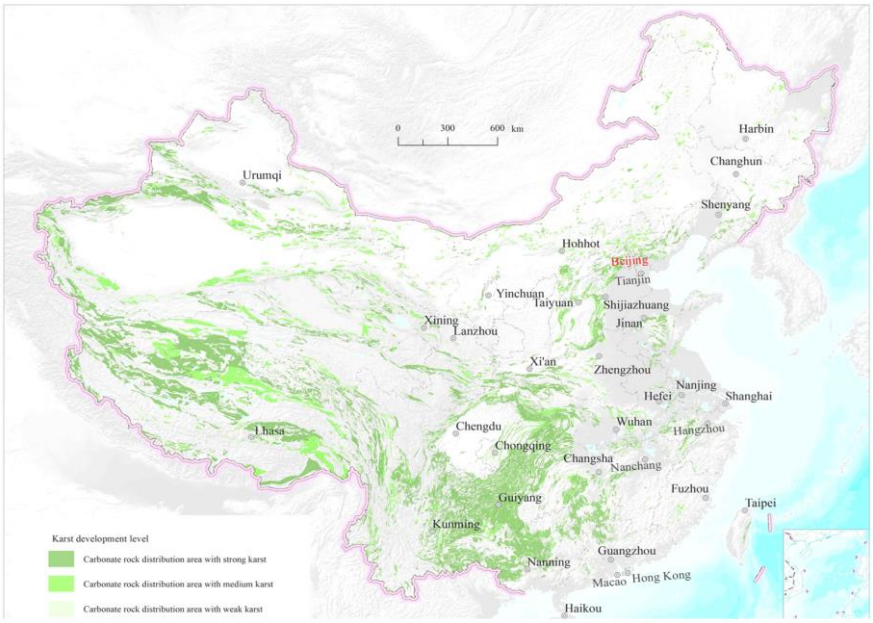

Figure 1: Distribution of landform types in China, 2004

Due to over-exploitation of land, primary vegetation has been destroyed, water and soil erosion, rocky desertification are prominent, and resource and environment carrying capacity is poor (Lan et al., 2021)[8]. Meanwhile, due to the relatively sloppy economic growth mode, relatively limited development space, obvious resource and environmental constraints, land resources, are scarce, and the ecological environment is fragile which restricts the economic and social development of the region (Wang et al., 2016; Ding et al., 2016) [9-10]. With the implementation of the national strategy of ecological civilization construction, scientifically promoting the control of rocky desertification and soil erosion in karst areas will help improve the self-healing ability and stability of ecosystem, enhance regional biodiversity, and construct an ecological security pattern.

Guizhou Province is located in the karst region, the distribution area of carbonate rocks accounts for about 80 per cent of the province, and its thickness accounts for 50 to 70 per cent of the total thickness of the strata, with a large number of caverns in existence, which is typical of a more concentrated karst carbon sink resource, and it has a greater potential for the development of karst carbon sinks, and the sustainability of ecological stability has been further enhanced.Today's Guizhou is guided by market demand. While accelerating green technological innovation it is orderly eliminating outdated production capacity unswervingly following the high-quality development path that gives priority to ecology, green and low-carbon, and striving to promote the green transformation of the production and way of life.[11]

2. Progress and current status of ecological environment restoration in Guizhou Province

2.1. Greatly improves soil and water conservation

Guizhou Province is located on the eastern slope of the Yunnan-Guizhou Plateau, with broken terrain, undulating mountains, and an average altitude of 1100 meters. The karst landscape accounts for 73.5% of the province's land area. Due to the extensive distribution of karst landscapes and the large slopes of the mountains, the soil is highly susceptible to erosion after the destruction of oringinal vegetation and turning into bare rocky mountains, which seriously threatens the sustainable use of land resources (Huang et al., 2019; Sheng et al., 2018) [12]. In 2021, the total area of stone desertification land in the province is 1,551,400 km^2， the area of soil erosion is 46398.23 km^2 , and all erosion types are hydraulic erosion and soil erosion mainly occurs on sloping arable land, barren hills, slopes, low-coverage forest land, and other land types and areas with concentrated production and construction activities. Soil erosion is most serious in the western, northwestern, and northeastern parts of Guizhou Province, the southwestern, central, and eastern parts are the second most serious, and the southern and southeastern parts are mainly lightly eroded. Through the implementation of key soil and water conservation treatment, sloping arable land treatment, stone desertification treatment, returning farmland to forest and grass, and mine remediation and restoration projects, the soil and water erosion

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area has been reduced by 2.393.64 km^2 compared to 2015, and the soil and water conservation rate has increased to 73.32%.[13]

In 2016, Guizhou Province became one of the first pilot ecological civilization construction zones in China. Guizhou Province has always adhered to the two bottom lines of development and ecology, implemented the ecological strategy, and actively created the "model benchmark" of ecological civilization. 10 counties (districts and cities) were named "National Ecological Civilization Construction Demonstration Zones". The new National Development Document No. 2 gives Guizhou the strategic positioning of "the pioneer zone of ecological civilization construction ", which is conducive to the construction of Guizhou as a national ecological civilization pilot zone, and effectively grasps the inherent requirements of upgrading from "pilot zone" to "early zone"[14]. "Guizhou should consolidate and improve the quality of the ecological environment, guard the bottom line of both development and ecology, try first in the construction of ecological civilization, and explore replicable and extendable experiences, as shown in Table 1a and Table 1b.

Table 1a: Water quality of the Yangtze River Basin in the province in 2022

water column	Number of sections	proportionality(10%)						Change from 2021(%)					
		I	II	III	IV	V	poorcategory V	I	II	III	IV	V	poorcategory V
catchment area	168	30.4	61.3	6.5	1.8	0	0	10.8	-9.5	-0.6	0.6	-0.6	-0.6
outbound cross-section	15	26.7	73.3	0	0	0	0	13.4	-13.4	0	0	0	0

Table 1b: Water quality of the Pearl River Basin in the province in 2022

water column	Number of sections	proportionality(10%)						Change from 2021(%)					
		I	II	III	IV	V	poor category V	I	II	III	IV	V	poorcategory V
catchment area	54	35.2	59.3	3.7	1.9	0	0	9.3	-9.2	0	1.9	0	-1.9
outbound cross-section	8	62.5	25	12.5	0	0	0	12.5	-25.0	12.5	0	0	0

2.2. The red line of ecological protection was strictly implemented

The ecological protection red line is an important measure to implement the system of main functional areas and control the use of ecological space. In 2018, the ecological protection red line in Guizhou Province covers an area of 45,900.76 square kilometers, accounting for 26.06% of the total land area of the province, forming an ecological protection red line of "one zone, three belts, and more points". The "one area" is the Wuling Mountain - Moon Mountain area, the "three belts" is the Wumeng Mountain - Miaoling ecological belt, the Dalou Mountain - Chishui River ecological belt in the middle and upper reaches, and the South Panjiang-Hongshui River Basin Ecological Belt, and "multiple points", i.e. various types of dotted distribution of prohibited development areas and other protected areas. By delineating the ecological protection red line, it can effectively curb the disturbance and destruction of human activities, better protect the fragile ecosystem, maintain and enhancesystem services such as water conservation, soil conservation, and biodiversity maintenance, and strengthen the ability to cope with climate change and natural disasters. At the same time, it also helps to improve the supply capacity of ecological products[15].

Since 2012, the forest coverage rate in Guizhou has risen from 47% to 62.81%, and the forest area has increased from 132 M mu to 169 M mu, accounting for 64% of the national territory, as shown in Table 2.

ISSN 2616-5872 Vol.5, Issue 8: 16-24, DOI: 10.25236/AJEE.2023.050803

Table 2: Guizhou Province Ecological Protection Red Line Classification Statistical Table

Type of red line for ecological protection		Number (pcs)	Area of red line for ecological protection(KM2)	Proportion of the total land area of the province(%)
Heritage Geology Category	World Natural Heritage site	3	1286.75	0.73
	National Natural Heritage Site	4	624.59	0.36
	National Natural and Cultural Heritage Site	1	518.80	0.29
Scenic and Historic Areas	National Scenic Spot	18	3416.10	1.94
	Provincial Scenic Spots	53	5037.73	2.86
Nature reserve category	State-level nature reserve category	9	2593.54	1.47
	Provincial Nature Reserve Category	6	1049.33	0.60
	Municipal nature reserve category	16	2752.52	1.56
Geopark category	World Class Geopark	1	170.00	0.10
	National Geopark	9	1658.02	0.94
	Provincial Geopark	2	346.00	0.19
Forest park category	National Forest Park	25	1606.94	0.91
	Provincial Forest Park	32	936.73	0.53
Wetlands of National Importance category	Wetlands of National Importance	2	151.80	0.09
National Wetland Park Category	National Wetland Park	36	585.81	0.33
	National Urban Wetland Park	1	7.00	0.004
Centralized drinking water source protection area category for more than 1,000 people	County centralized drinking water source protection area	156	2064.44	1.17
	Protected areas for centralized drinking water sources in model small towns	114	394.30	0.22
	Establishment of township centralized drinking water source protection zones	1220	1927.50	1.10

2.3. The province's ecological environment quality continues to improve

In January 2022, the Opinions of the State Council on Supporting Guizhou to Break New Ground in the Development of Western China in the New Era was issued, which gave Guizhou the strategic position of "Pioneer Zone of Ecological Civilization Construction", and established new historical coordinates for Guizhou to promote the construction of ecological civilization. 2022, the province's overall ambient air quality remains excellent, with an average of 99.1% of good days. Surface water quality is generally excellent, the proportion of good water quality at provincial control sections is 97.6%, and all outbound sections reach water quality category III and above. The water quality compliance rate of central cities and county towns' centralized drinking water sources is maintained at 100%. The overall quality of the soil environment remains stable. The overall sound environment of urban areas is good, the sound environment of urban road traffic is good, and the daytime and nighttime compliance rates of urban functional area sound environment monitoring points are 99.7% and 93.8% respectively. Guizhou has taken the lead in formulating the first list of local party committees, governments and relevant functional departments for ecological environmental protection responsibilities, as shown in Figure 2.

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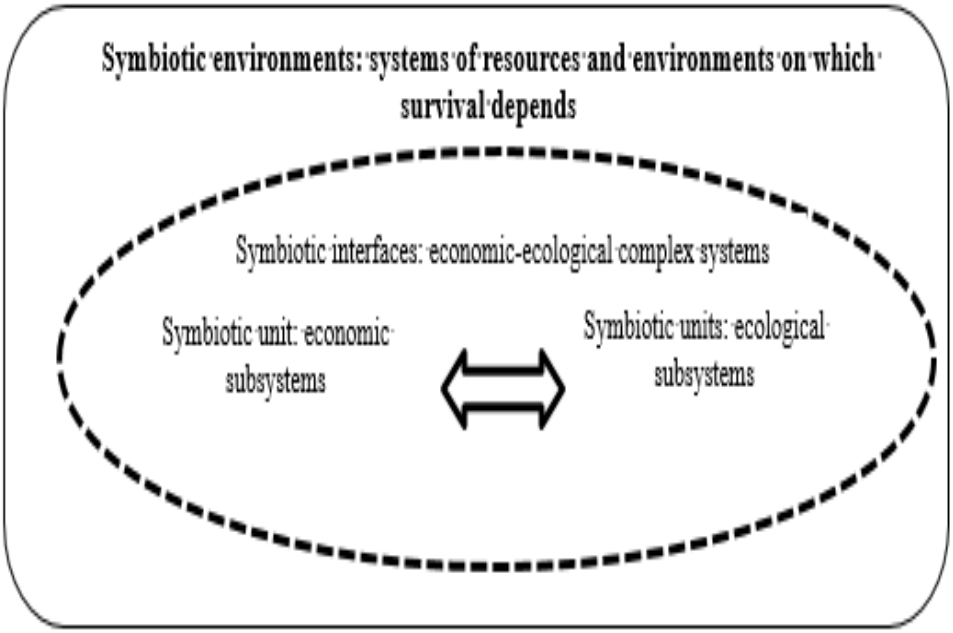

Figure 2: Relationship between economic and ecological interactions

The level of ecological and environmental protection ideology has been continuously improved. The concept of green development is gaining popularity, and more and more places are taking strengthening environmental protection as an opportunity and an important grasp to expand development space and improve the economic quality., and the awareness of the rule of law and the subject awareness of protecting the environment are increasing.In February 2023, Guizhou Province issued the Implementing Opinions on Encouraging and Supporting the Participation of Social Capital in Ecological Protection and Restoration, which encourages and supports the participation of social capital in ecological protection and restoration with 7 aspects and 21 policies.

2.4. The development of the green industry has been effective

Guizhou Province leads new industrialization, new urbanization, agricultural modernization, tourism industrialization with ecological civilization, promotes industrial ecology and ecological industrialization, establishes a green and low-carbon circular development economic system, and promotes the overall green transformation of economic and social development. The energy consumption per unit of added value of industrial enterprises above the scale will drop by more than 25% year-on-year, and industrial energy conservation and consumption reduction will be effective. 3 national green industrial parks and 17 green factories have been created in 2021. 37 provincial green factories will be built.

3. New challenges to economic transformation after ecosystem restoration

Good ecological environment quality is the foundation of economic development. The excellent ecological environment has become the biggest development advantage and competitive advantage of Guizhou, which has laid a solid foundation for promoting ecological environmental protection to a new level in the coming period and striving to make new achievements in ecological civilization construction. Several reform measures for the construction of ecological civilization have been put into effect, integrating several achievements in the system of environmental governance, releasing reform dividends, and adding strong impetus to promoting ecological environmental protection, as shown in Table 3.

ISSN 2616-5872 Vol.5, Issue 8: 16-24, DOI: 10.25236/AJEE.2023.050803

Table 3: Main Objectives of Ecological Protection and Restoration Planning for Land Space in Guizhou Province

categories	Serial No.	targets	2020	2025	2035	causality
Conservation and restoration category	1	Comprehensive soil erosion control area(ten thousand hectares)	/	[149]	National mandates	prospective
	2	Area of ecological rehabilitation of historical mines(hectares)	/	[5000]	/	prospective
	3	Area of forest protection and restoration(ten thousand hectares)	/	[120]	/	prospective
	4	Area under comprehensive management of rocky desertification(ten thousand hectares)	/	[35.5]	[98.8]	prospective
	5	Pilot integrated land management for the entire region(spot)	/	[20]	/	prospective
	6	Area of river and lake shoreline ecological protection and restoration(ten thousand hectares)	/	[1.5]	[4.5]	prospective

3.1. The level of pollution prevention and ecological protection still needs to be improved

The treatment of volatile organic compounds, ozone and fine particles is still the focus of work to improve the ambient air quality. The level of industrial pollution treatment needs to be improved, and the technology of acidic wastewater management in mines is still immature. There are obvious shortcomings in rural environmental improvement, the rate of rural domestic sewage management is only 10.2%, and the operation mode of rural sewage treatment facilities needs to be innovated, the mechanism of rural domestic garbage and agricultural waste disposal is not yet perfect. The waste disposal mechanism is not yet perfect. The resource utilization level of industrial solid waste such as manganese slag, phosphogypsum needs to be improved.

3.2. Environmental protection infrastructure still has shortcomings

Sewage treatment facilities in cities, towns, and development zones still have outstanding shortcomings. And the level of professional operation needs to be improved. The sewage collection network is not perfect, the network management is not in place, and the problem of direct discharge of sewage still exists. The degree of resource utilization of domestic waste is not high, and the collection of domestic waste classification still needs to be further promoted. Sanitary landfill is still the main method of domestic waste treatment, and the construction of incineration power generation facilities is relatively lagging behind, and the level of domestic waste treatment needs to be improved.

3.3. Agricultural surface source pollution control work is a long way to go

Due to the unclear bottom of agricultural surface sources, agricultural surface pollution is characterized by fragmentation, uncertainty, and lag, and making it difficult to control. By means of ecological environmental protection, agricultural input reduction, resource recycling, and agro-ecological restoration, etc., strengthen scientific and technological support, increase innovation and development, focus on promoting comprehensive prevention and control of agricultural surface pollution, and effectively improve the rural ecological environment, and constantly enhance the sustainable development of agriculture.

3.4. Ecological environment peculiarities are prone to multi-factor pollution

Guizhou has many rivers, lakes and reservoirs, and featured with high mountains and steep slopes,

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turbulent water flow, and a lack of ecological buffer zones along the river and lake shorelines. Karst terrain is prevalent and it is very easy to form surface water, groundwater, slag water transfer and transformation, resulting in complex pollution problems caused by the intertweaving multiple factors. With the acceleration of industrialization and urbanization in the province, water-related environmental risks continue to rise, mainly manifested in the frequent occurrence of water environment problems, prominent pollution problems in key industries such as phosphorus chemical industry, electrolytic manganese and wine making industry,industrial waste dumps, domestic garbage, etc. Systemic and derivative pollution problems such as domestic waste landfill leakage, urban domestic sewage overflow.

3.5. Biodiversity protection work still needs to be consolidated

Accelerated urbanization and industrialization threaten the habitat of species and increase the pressure on the ecosystem. The impact of overuse and disorderly exploitation of biological resources on biodiversity has intensified. Environmental pollution has affected aquatic and riparian biodiversity and species habitats. The biodiversity monitoring and early warning system have not yet been established, the investment in biodiversity conservation is insufficient, the level of management and care needs to be improved, and the ability to deal with new problems in biodiversity conservation is insufficien. Biodiversity conservation will become a difficult and key work area in the coming period.

4. Conclusions and Implications

4.1. Ecological diversity in Guizhou Province enriches ecosystem service possibilities

The synergistic effect between ecological resources and industries in Guizhou Province is beginning to emerge, mainly in terms of the connectivity attributes of ecology, including the breadth and depth of connection. In practice, Guizhou Province has established a rich and solid connection between ecological resources and industrial development, obtained connection dividends, realized value creation and value acquisition, promoted ecotourism, eco-agriculture and digital industries, and established reciprocal connections between different subjects, integrated the use of diversified and heterogeneous external resources, and realised the synergistic and network effects of internal and external resources.

4.2. Turning ecological advantages into developmental and competitive advantages

Currently, the province has 570 Class A tourist attractions and 40 national and provincial tourist resorts, as well as more than 200 hot springs, providing a rich carrier platform for the realisation of the value of ecological products. In 2022, the province's growth rate of tourism receipts is comparable to the national average, the growth rate of tourism revenue is slightly higher than the national average, the per capita spending of tourists isl increase by 3.4% year-on-year, and the digital economy is account for about 40% of the Gross Regional Product (GRP).weighting of about 40%, and ecological symbiosis and synergy further improved.[16]

In 2022, the proportion of green economy in Guizhou provincel reaches 45%. At present, Guizhou is making every effort to promote a green economy that is ecologically utilized, circular and efficient, low-carbon and clean, and energy-saving and environmentally friendly throughout the province, and to promote the construction of a green economic system that includes green consumption, green production, and green circulation, so as to make excellent ecology become the biggest developmental and competitive advantage of Guizhou. In the next stage, with the goal of 'making new achievements' in ecological civilisation construction, Guizhou should make full use of its comparative advantages, tap its own potential, differentiate achieve differentiated and characteristic development, and maintain high intensity competitiveness.

4.3. The advantages of the ecological environment continue to be consolidated and enhanced

The province sticks to the ecological bottom line and promots both qualitative and quantitative improvements in green Guizhou. The ecological security barriers in the upper reaches of the Yangtze River and the Pearl River have been consolidated, the province's forest coverage rate has steadily increased, important progress has been made in biodiversity protection, and the quality of the ecological environment has continued to remain at the forefront of the country. Significant progress has

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been made in the resourceful utilisation of solid wastes, such as phosphorus gypsum, manganese slag, fly ash, etc, and the shortcomings of the environmental infrastructure have been accelerated.

4.4. Effective conversion of ecological products

Guizhou has experienced the baptism of the construction of the pilot area and the great ecological strategic action, and has constructed an organic pattern with rich diversity,of ecological advantages, stability and sustainability, and symbiosis and synergy, and has good environmental conditions. Ecological advantages will surely be transformed into development advantages and competitive advantages.The stock of ecological advantages has been transformed into the increment of economic development in Guizhou Province, the mechanism for realising the value of ecological products and the multi-level ecological product market trading system have been basically established, the ecological product value assessment mechanism has been brought into full play, and breakthroughs have been made in deepening the pilot demonstration of the mechanism for realising the value of ecological products, so that a good symphony of ecological civilisation and economic development has been played.

4.5. The system of ecological civilisation has been continuously improved

Focusing on breaking down the obstacles of relevant institutions and mechanisms, exploring and improving the value realization of ecological products, Guizhou have promoted the industrialised management of ecological resources and the market-based operation of ecological assets, utilised Guizhou's comparative advantages to the fullest extent, and strived to improve the governmental, market-based and social participation mechanisms for realising the value of ecological products, and formed a number of major systems in the areas of property rights of natural resources assets, horizontal ecological protection compensation, ecological and environmental damages, and green financial reforms and innovations. In terms of property rights of natural resources assets, horizontal ecological protection compensation, compensation for ecological and environmental damages, green financial reform and innovation, a number of major institutional achievements have been formed, taking the lead in establishing an ecological civilisation system that is systematic, smooth, effective and functional.

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