Ecological Restoration of Rocky Desertification in Hongfeng Lake Karst Area Based on SWOT Analysis

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Abstract In order to provide a reference for rocky desertification control in karst areas, we take the case of Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in Qingzhen City of Guizhou Province, and expound strength, weakness, opportunity and challenge in its ecological restoration, using SWOT analysis method in management sciences. And we finally put forth scientific strategies for ecological restoration in this demonstration area.

Key words Rocky desertification, Demonstration area, Ecological restoration, SWOT analysis

China's southern karst area means the area with Guizhou Province in its center, connecting northern Guangxi, eastern Yunnan, western Hunan, southeastern Sichuan and other regions, which is the world's largest and most concentrated contiguous karst area, also the area with the most typical, complex karst, and the most landscape types in the world[1]. Its area is more than 550 000 km^2, making it becoming the largest karst area for the nonce. The unique geological landform types of karst, causes rocky desertification phenomenon under the stress of human activities, that is, under the fragile karst eco-environment, irrational human social and economic activities result in the obvious contradiction between human and land, destruction of vegetation, soil erosion, decline and loss of land productivity; the surface shows the landscape similar to desertification, and the rock gradually outcrops[2]. At present, although some experts have put forth a range of restoration modes[3-6], the overall rapid expanding trend of rocky desertification area in karst areas has not yet been arrested[7]. Based on this, we take the case of Qingzhen Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in Guiyang City of Guizhou Province, to explore the driving factors of ecological restoration in rocky desertification areas, in order to provide a reference for rocky desertification control in karst areas.

1 The study area and research method

1.1 Overview of ecosystem in the study area We take Qingzhen Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in Guiyang City of Guizhou Province as the study object, which is located in both sides of Maiweng River valley, upper reaches of Hongfeng Lake, a national-level scenic spot in the southwest of Qingzhen City, having jurisdiction over 10 administrative villages (Boluo Village, Minlian Village, Luojiaqiao Village, Youqi Village, Baiyan Village, Ludi Village, Maojiazhai Village, Luohai Village, Zhushan Village, Gaojiabao Village). The demonstration area has a total area of 60.44 km^2 (including the lake area of 4.29 km^2), and the karst area accounts for 95.05% of the total area, 1240 – 1450 m above sea level, with the relative height difference of 210 m. It is a typical karst hill and basin ecological environment. The total population in 2009 was 15 982, with population density of 264 persons /km^2. The remote sensing interpretation statistics of land type in demonstration area in 2010 (Table 1) show that in land types, the area of forest accounts for 6.38% of the total area; the area of shrubs accounts for 20.57% of the total area; the area of shrub-grassland accounts for 8.88% of the total area; the area of paddy field accounts for 19.41% of the total area; the area of dryland accounts for 34.13% of the total area; the area of water area accounts for 7.23% of the total area; the area of land for construction accounts for 3.4% of the total area. The area of non-rocky desertification accounts for 54.7% of the total area; the area of potential rocky desertification accounts for 18.7% of the total area. The area of mild rocky desertification, moderate rocky desertification, and intense rocky desertification accounts for 14.51%, 6.73% and 0.42% of the land area, respectively; the non-karst area accounts for 4.95% of the land area.

1.2 Research method We adopt SWOT analysis method of ecological restoration (also known as trend analysis method), to array various kinds of major internal strengths, weaknesses, external opportunities, threats, and other factors closely related to the study object; then using system analysis method, obtain a series of situation analyses of the development of the study object, thereby deriving solutions to the problem[8]. We conduct analysis from geographic location and transport, ecosystem services compensation, building basis of brand effect, income structure, population structure, irrigation and water con-

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Table 1 Land type and rocky desertification in Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in 2010

Land type	Area // km^2	Proportion // %	Land type	Area // km^2	Proportion // %
Forest	385.4	6.38	Non-rocky desertification	3 305.9	54.7
Shrubs	1 243.46	20.57	Potential rocky desertification	1 130.0	18.7
Shrub-grassland	536.49	8.88	Mild rocky desertification	876.8	14.51
Paddy field	1 173.1	19.41	Moderate rocky desertification	407.0	6.73
Dryland	2 063.00	34.13	Intense rocky desertification	25.1	0.42
Water area	436.89	7.23	Non-karst	299.1	4.95
Land for construction	205.43	3.4	Total	6 043.8	100
Total	6 043.79	100			

servancy facilities, and ecological reconstruction, to provide proposals for ecological restoration in the demonstration area.

2 Results and analysis

2.1 Strength analysis

2.1.1 Advantage in geographical location and transportation. Qingzhen City (106°07′06″–106°33′00″E, 26°21′00″–26°59′09″ N), is located in the middle of Guizhou Province, the satellite city of Guiyang City, east to Wudang District and Huaxi District of Guiyang City, south to Pingba County, west to Zhijin County, north to Qianxi County, northeast to Xiuwen County, 22 km away from Guiyang City. It is 42.6 km wide from east to west, 56.0 km long from north to south. The demonstration area is located in both sides of Maiweng River valley, upper reaches of Hongfeng Lake, a national-level scenic spot in the southwest, and Guiyang – Huangguoshu Highway runs across the territory, with good location strength. For the demonstration area, developing community participatory tourism (*i. e.* in the process of decision making, development, planning, management, and supervision of tourism, full consideration is given to the views and needs of the community, and the community is regarded as the major subject of development and participation, in order to achieve comprehensive community development under the premise of ensuring the sustainable development of tourism[9]), and market-oriented suburban vegetables, fruit and flowers agriculture, is very favorable to improvement in farmers' economic structure.

2.1.2 Compensation advantage in ecosystem services. The demonstration area is located in both sides of Maiweng River valley, upper reaches of Hongfeng Lake, having great driving effects on the villages within the valley, conducive to the transfer of labor forces and industrial restructuring within the valley, mitigation of the pressure of the ecological environment. In the mean time, due to the role of water conservation, through the ecological compensation mechanism[10] and Guiyang's "Two-lake and One Reservoir Project", the environmental tribunals and management bureau established, provide support of laws, policies, and funding for rocky desertification control project in the region.

2.1.3 Advantage in laying foundation for building brand effect. A brand is a "name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of other sellers"[11]. The brand effect is the value manifestation of products, the benefit and impact brought for the users of the brand. Based on its own resource conditions and geographic conditions, taking ecological environment construction and sustainable socio-economic development as target, the demonstration area introduces pollution-free cultivation techniques to grow high-quality Chinese medicinal herbs and new grape varieties, and breed milk cows and beef cattle, initially creating 143.20 hm^2 of economic forests focusing on Yingqing pear, plum and grape; establishing 1 dairy farm (breeding 263 milk cows), 1 beef cattle farm (rearing 186 hybrid cattle), 1 ecological planting demonstration base and 1 ecological farming demonstration base, which will lay the foundation for building the brand of the suburban "farmhouse".

2.1.4 Advantage in income structure. The income structure is composition, proportion and mutual relations of income sources, which reflects different sources, scales of funds, different forms adopted, as well as the proportion of various types of income to the total income, and ways to increase income. The aim of regarding income as the overall structure for analysis, is to grasp organic links between various sources of income overall, so that they keep appropriate proportional relationship, facilitating the advance of the structural optimization of income, in order to improve the overall function of the structure. For the demonstration area, it has basically gotten rid of the operation pattern simply depending on farming. As reported in Table 2, GDP in 2009 was 150.196 3 million yuan, and per capita GDP was 9 397.84 yuan, including labor income of 74.889 million yuan, accounting for 49.86% of the total income, nearly half. With the labor shortage in the eastern regions and the development of Guiyang City, the labor outflow still has great space for development. The animal husbandry income was 26.700 2 million yuan, accounting for 17.78% of the total income. The economic forest and grass income was 17.321 3 million yuan, accounting for 11.53% of the total income. With changes in the urban residents' diet habits, animal husbandry still has great potential for development. The grain growing income was 14.647 million yuan, only accounting for 9.75% of the total income. It is conducive to reduction of residents' direct pressure on the environment, and rocky desertification control. The industrial sideline income was 11.981 8 million yuan, only accounting for 7.98 % of the total income, not conducive to improving residents' income, yet to be strengthened. The transportation income was 2.814 million yuan, accounting for 1.87% of total income. Income from returning farmland to forests was 1.259 2 million yuan, accounting for 0.84% of total income. Other income was 0.583 7 million yuan, accounting for 0.39% of the total income. Overall, the income of residents in the demonstration area shows diversified development, which is favorable to consolidating the early rocky de-

sertification control achievements and the future control.

Table 2 The income of residents in Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in 2009

Income type	Income//10^4 yuan	Per capita income//yuan	Percentage of income//%
Grain growing income	146.47	916.47	9.75
Economic forest and grass income	173.21	1083.8	11.53
Animal husbandry income	267.00	1670.65	17.78
Labor income	748.89	4685.83	49.86
Transportation income	28.14	176.07	1.87
Industrial sideline income	119.82	749.71	7.98
Income from returning farmland to forests	12.59	78.79	0.84
Other income	5.84	36.52	0.39
Total GDP	1501.96	9397.84	100

2.2 Weakness analysis

3.2.1 The population structure is close to the elderly-type. According to the survey results of age structure of population in the demonstration area (Table 3), the age structure of population at the end of 2009 is as follows: the people aged 0 – 15 account for 24.55%; the people aged 16 – 40 account for 44.38%; the people aged 41 – 59 account for 22.038%; the people aged over 60 account for 9.03%. If the proportion of population aged 60 and above to total population is more than 10%, we define it as an aged society[12], then aged population predominates in the region, indicating that population aging is deteriorating step by step in the demonstration area, and the intensification of aging means that the burden of social support will be increased.

In China, strict population control measures are adopted. In the mean time, different fertility policies between urban and rural areas are also adopted, leading to dramatic decline in fertility rate. In the period 2005 – 2009, the proportion of people aged 0 – 15 in the demonstration area declined on the whole. From the perspective of the demographic dividend[13], the labor in the demonstration area has increased from 64.59% in 2005 to 66.41%, and tends to further increase, which requires the demonstration area to create more employment opportunities to absorb surplus labor; if not handled properly, it will harm the ecological environment of the demonstration area.

Table 3 Age structure of population in Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area

Year	The total population (at the end of year)	0 – 15 years old		16 – 40years old		41 – 59 years old		60 years old and above	
		Population	Proportion//%	Population	Proportion//%	Population	Proportion//%	Population	Proportion//%
2005	15 811	4 334	27.41	7 056	44.63	3 156	19.96	1 265	8
2007	15 852	4 392	27.71	6 525	41.16	3 588	22.63	1 347	8.5
2009	17 051	4 186	24.55	7 568	44.38	3 757	22.03	1 540	9.03

2.2.2 Small-scale farmland irrigation and water conservancy facilities are weak. Small-scale farmland irrigation and water conservancy facilities generally refer to the water conservancy projects with 666.67 hm^2 of irrigation surface, 2000 hm^2 of waterlogging control area, 0.1 million m^3 of storage capacity, and channel flow below 1 m^3 per second[14]. But for special geological features of the karst areas, small-scale irrigation and water conservancy refers to the project system that takes water storage projects (water cellars, reservoirs, small ponds, grit chamber, grit channel) as the center; adopts surface water-groundwater comprehensive utilization measures to develop and utilize water resources for residents' water consumption and irrigation. The survey results of small water conservancy facilities in the demonstration area (Table 4) show that there were 239 pools (including wells) in 2005, with volume of 3 040 m^3; 297 pools in 2009, with volume of 5 705m^3. In a normal year, the growth of small-scale irrigation and water conservancy facilities can basically meet the basic social and economic growth needs, but when severe drought ravaged the southwest region in the period 2009 – 2010, the drinking water provided by water conservancy facilities for people and livestock can only meet 41.55% and 49.12% of the normal needs of residents' drinking water and large livestock's drinking water, respectively, posing extreme challenge to the residents' normal life and production activities.

Table 4 Water conservancy in Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area

Year	Pool or well		The number of residents and the proportion of drinking water that can be met		The number of livestock and the proportion of drinking water that can be met	
	Quantity	Capacity//m^3	Population	Percentage//%	The number of large livestock	Percentage//%
2005	239	3 040	15 811	100	4 705	100
2007	275	4 485	15 852	100	4 732	100
2009	297	5 705	7 085	41.55	2 981	49.12

2.2.3 Ecological reconstruction is difficult. The yield per unit area of land in the demonstration area is high, with high economic benefits, but in the development process, there are some problems as follows: some people only pay attention to

the immediate economic interests, but neglect ecological and environmental protection; excess reclamation destroys the original vegetation, making rock bare, resulting in reverse evolution of ecological environment; for urban development, people constantly cut into a mountain for quarrying, aggravating the rocky desertification, exerting adverse impact on regional socio-economic development and tourism resources development. The development and evolution of rocky desertification is a long process and a product of a historical period. The changes in rocky desertification lead to a follow-up response process under man-made disturbances.

There was no big change in land types of the demonstration area during the period 2005 – 2010 (Table 5). Over the five years, the basic spatial pattern of rocky desertification did not change much, but in the main influencing factors, there was slight change in the natural factors such as parent material basis, landscape types, vegetation cover, and slope; the major factor causing changes in the short term was human activities. Afforestation, forest conservation and other project measures reduced the bareness rate of bedrock in the rocky desertification areas. At the same time, the development of rural settlements had profound influence on the region; land use experienced great changes, for example, the planting area of orchard and tea garden was increased, and the number of transportation and residential areas was increased, reducing rocky desertification areas to some extent.

Table 5 Land type in Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in 2005 and 2009 hm^2

Year	Total	Karst	No rocky desertification	Potential rocky desertification	Mild rocky desertification	Moderate rocky desertification	Intense rocky desertification	Non-karst
2005	6 043.8	5 744.7	3 236	991.1	923.6	553.1	25.1	299.1
2010	6 043.8	5 744.7	3 305.9	1 130	876.8	407	15.5	299.1

2.3 Opportunity analysis

2.3.1 Opportunities brought by Development of the West Regions. The central government's policies for the western development include the infrastructure construction policy, ecological environment construction policy, industrial restructuring policy, internal and external opening-up policy, science and education policy, and social development policy[15]. The overall plan of developing the western region can be divided into three stages. (i) The first stage (2001 – 2010). It is the stage for laying foundation. The focus is to adjust structure, strengthen the building of infrastructure, ecological environment, science and technology education, establish and perfect the market system, and cultivate the growth point of characteristic industries, so that the western region's investment environment is initially improved, the ecological and environmental degradation is basically arrested, the economy steps into a virtuous cycle, and the growth rate reaches the national average. (ii) The second stage (2010 – 2030). It is the stage of accelerated development. On the basis of improvement in the infrastructure, strategic restructuring and institutional building achievements at the previous stage, it steps into the sprint stage of western development. The focus is to consolidate and improve the basis, cultivate the characteristic industries, implement comprehensive upgrade of economic industrialization and marketization, and professional regional distribution, to achieve economic growth leap. (iii) The third stage (2031 – 2050). It is the stage of comprehensively advancing modernization. On the basis of some developed regions enhancing the strength and blending into the domestic and international modern economic system, the focus is to speed up the development of remote mountainous areas and backward agricultural and pastoral areas, to universally promote the western people's standard of living and comprehensively narrow the gap. For the demonstration area, at the first stage of the past 10 years, rocky desertification control achieved preliminary results, the worsening trend of rocky desertification was basically arrested, and at the same time, corresponding pattern was fished out for rocky desertification control in the central Guizhou Plateau; at the second, third stage, constant policy and economic support is provided for rocky desertification comprehensive control.

2.3.2 Opportunities brought by the division of main functional areas in Central Guizhou. In the 12th National Five-Year Plan, the Guiyang-centered central Guizhou Province is the key national development area. In the 12th Guizhou's Five-Year Plan, the main functional areas are divided into four types: optimized development, key development, restricted development and prohibited development. For Qingzhen City, based on the division of the main functional areas at the provincial level, it should further subdivide the main functional areas according to its actual situation, implement the fiscal and taxation system conducive to scientific development, establish and improve the resource paid use system and ecological environment compensation mechanism, focus on increasing the financial transfer payment used for public services and the ecological environment compensation, in the areas whose development is restricted and prohibited; support the infrastructure construction in Qingzhen's key development areas, promote the development of the built-up areas in Qingzhen City, provide more space for the absorption of labor in the demonstration area. In addition, the building of city circle in the central Guizhou Province and the Guiyang metropolitan development, also bring opportunities for transferring the surplus labor in the demonstration area, and reducing the population pressure in the process of rocky desertification control.

2.3.3 Opportunities brought by new socialist rural construction. With the development of industrialization and urbanization, in order to solve the issues concerning agriculture, farmers and countryside, the Chinese government has strengthened "the city feeding on rural areas" and "industry nurturing agriculture"; through the construction of new socialist rural areas, has effectively improved farmers' lives and narrowed the urban-rural wealth gap, to achieve common prosperity[16], so that agriculture gets the basis for sustainable development, and the rural community achieves harmony. The specific measures are

as follows: strengthening the construction of rural roads, housing, energy, water conservancy, and communications; resolving farmers' difficulty in hospitalization; ensuring that people drink clean water; cracking the difficulty in schooling of farmers' children. From the point of view of rocky desertification comprehensive control, the construction of a new socialist countryside will bring opportunities for economic, social and ecological construction in the demonstration area.

2.4 Threat analysis

2.4.1 Climate and weather disadvantage. The climate and weather disasters faced by the demonstration area include spring drought, summer drought, hail, and the spring and autumn cold damage, occurring each year in varying degrees. First, the demonstration area is located in the hail belt of the central Guizhou Province, thus hail damage sometimes occurs. In April – May, the demonstration area is prone to hail damage, but this period is just the season suitable for Kate apricot (introduced from the United States) to flower, fruit and come into the market. Through the survey of typical farmers in the Yangchangdong small watershed in the demonstration area early in 2010, farmers benefit little from planting Kate apricot. Therefore, most of the farmers have cancelled or intended to cancel the planting of Kate apricot. Spring and autumn freezing is also the disaster that should not be underestimated, because it will exert grave impact on transportation, electricity and other facilities in the demonstration area, mainly causing serious obstacles to the material, energy and information exchange of the demonstration area with the outside in winter or early spring. In addition, spring drought and summer drought, cause great loss to the production and living in the rocky desertification areas. Severe hail, drought and other natural disasters, pose serious challenges to the ecological restoration in the rocky desertification areas.

2.4.2 Pressure arising from industrial transfer. The demonstration area is in the central Guizhou Province, located in the junction of horizontal axis of the Yangtze River passage and longitudinal axis of Baotou-kunming passage. Guizhou – Chongqing Railway, Guiyang-kunming Railway, Hunan-guizhou Railway, Guizhou-guangxi Railway; the high-speed railway from Guiyang to Guangdong, Guiyang to Chongqing, and Guiyang to Chengdu; passenger dedicated line from Changsha to Kunming via Guiyang, cross in Guiyang. Hangzhou-ruili Highway, and southwest passage to the sea, run through its territory, which are important land transportation hub connecting the southwest and the south, the southwest and the east in China. At the same time, with the construction of the Pan-Pearl River Delta and Guiyang-guangzhou High-speed Railway, it will cause the industries in the Pearl River Delta region to divert to the central Guizhou Province. From the perspective of space, it will inevitably bring about large-scale urban construction and urbanization movement, which will pose unpredictable challenges to the water conservation, soil conservation, and other rocky desertification control projects in the upper reaches of Hongfeng Lake.

3 Conclusions and discussions

(i) The ecological restoration in the Qingzhen Hongfeng Lake Demonstration Area has either strength or weakness, either opportunity or challenge. How to use these factors to promote the success of ecological restoration in the area, has become a pressing ecological problem facing this area at present.

(ii) On the basis of analysis of ecosystem in the demonstration area, we use SWOT analysis method to conduct comprehensive analysis of the favorable and limiting factors influencing ecological restoration in the demonstration area, from internal strength, internal weakness, external opportunity and external threat of Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in Qingzhen City. We believe that based on the goal of social, economic and ecological sustainable development, as for rocky desertification control, we should grasp the strength and opportunity facing rocky desertification control, circumvent the existing weakness and challenge, and select the appropriate ecological restoration strategy.

(iii) Based on the actual situation of Hongfeng Lake Rocky Desertification Comprehensive Control Demonstration Area in Qingzhen City, we put forth the following four ecological restoration strategies.

First, the SO strategy, namely the expansion-based strategy. It is to rely on internal strengths, seize external opportunities, to promote the integration of form and connotation of demonstration area as far as possible. The region has geographical advantages, social environment strengths and resources strengths and other advantages. The internal and external environment of the region provides a good opportunity for its ecological restoration, such as developing the western region, the construction of a new socialist countryside, and the construction of city circle in Central Guizhou. Therefore, the SO strategy should be a key strategy for ecological reconstruction in the area. This strategy requires us to integrate the elements of the ecological reconstruction in the demonstration area, enhance the overall strength of the region; cultivate new agricultural structure in the demonstration area using the opportunities of the western development strategy, planning strategy of the main functional areas and a new socialist countryside construction; speed up the establishment of the industrial chain in the demonstration area, and promote the extension of industrial chain in the demonstration area.

Second, the WO strategy, namely the reversing-based strategy. It is to use the external opportunities to overcome the internal disadvantage, in order to tap new extended strength. In this demonstration area, it has the income structure strength, but at the same time, has the weakness of weak small-scale irrigation and water conservancy facilities, climate and weather disadvantages, hindering its effective ecological reconstruction. It can seize external opportunities and overcome its own weaknesses, make the demonstration area have the ability to effectively control rocky desertification, for example, it can protect and rebuild the fragile environment in the karst areas of Guizhou Province, using the ecological protection opportunities of " Pearl River Shelterbelt Construction Project" and " Yangtze River Shelterbelt Construction Project" ; the infrastructure set up using the western development strategy, complemented by emergency measures, can be adopted to confront the challenges of extreme weather and meteorological

disasters; the construction of a new socialist countryside and other opportunities can be used to improve the social, economic and ecological environment in the demonstration area, provide services for rocky desertification control.

Third, the ST strategy, namely a variety of strategies for rebuilding the ecological environment. It is the strategy of using one's own advantages, to avoid or mitigate the external threat. With the change in national policy, the ecological reconstruction in the demonstration area will face more and more challenges (such as over-dependency on the outside). In this case, we can use the ST strategy: using our own strength to avoid or mitigate the external threat; giving play to our own geographical location advantage, brand effect and other advantages, to develop suburban participatory tourism; improving the structure of income, in order to reduce pressure on the regional ecological restoration. On the basis of the ecological compensation mechanism, the governments' emergency measures in face of climate, meteorological disasters are discussed, in order to improve the ability of residents to respond to disasters.

Fourth, the WT strategy, namely the defense-based strategy. It is the strategy for overcoming the internal disadvantage, and avoiding the external threats as much as possible. In face of its own disadvantages and the challenges, the region can rely on its own resources, and draw on the national policy opportunities. In the first place, the industrial chain that takes its own resources as strength is extended; in the second place, in input of matter, energy, information from the outside, the industries that adapt to the characteristics of suburban agriculture, are cultivated, to get rid of the threat of traditional agricultural model to the ecological environment.

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