Benefit Evaluation on the Control Mode for Typical Karst Rocky Desertification in Guizhou Province, China

ZUO Xing-jun[1]*, ZUO Tai-an[2], XU Shu-jian[3]

1. Linyi Vocational College, Linyi 276000, China; 2. Department of Environmental and Life Sciences, Bijie University, Bijie 551700, China; 3. College of Chemistry and Resources Environment, Linyi Normal University, Linyi 276000, China

Abstract Control mode for typical karst rocky desertification in Guizhou Province, China is selected as the research object. The ecological benefit, the social and economic benefit and the popularization prospect of mode are selected as evaluation indices. Evaluation index system of control mode benefits for karst rocky desertification is established. The Dingtan mode and the Wangjiazhai-Yangchangdong small watershed control mode are selected as evaluation objects. Preliminary assessment on the two modes are carried out by Analytic Hierarchy Process, grading evaluation, and comprehensive evaluation method. Result shows that comprehensive score of Dingtan mode is 3.81, which is higher than the score of Wangjiazhai-Yangchangdong small watershed control mode (3.11). In the aspects of ecological benefit and social and economic benefit, Dingtan mode (4.83 and 3.258) is superior than the Wangjiazhai-Yangchangdong small watershed control mode (3.38 and 2.531). In the aspect of popularization prospect of mode, score of Dingtan mode (3) is lower than that of Wangjiazhai-Yangchangdong small watershed control mode (3.333). Therefore, the evaluation index system has certain science and offers reference and guidance for the karst rocky desertification control in southwest China.

Key words Desertification, Control mode, The Dingtan mode, The Wangjiazhai-Yangchangdong small watershed control mode, Guizhou Province, China

Guizhou is a province with the largest area and most serious damage of rocky desertification. The party and government, as well as relevant professional scientific and technical personnel, have paid high attention to it, have started a series of control pilot project of Karst rocky desertification, and have summarized some good experiences and models, such as the biological control mode for rocky desertification in Southwest Guizhou Province, the Dingtan mode for pepper plant in lower altitudes[1-4], the " Pingshang" mode for honeysuckle and plum in mid-altitude areas, the " Qinglong" mode for grassland animal husbandry in high altitude areas[5], the intercropping control mode in Bijie Experimental Area[6-7], the basic farmland improvement mode, the courtyard economy mode[8], and the rural energy construction mode with methane as the link. According to the benefits of different control modes for Karst rocky desertification, He Yuejun and Liu Jiming conduct ecological economic research on 4 patterns of returning cropland to forest in Huajiang low heat valley area[9]. Su Weici discusses the ecological rehabilitation model for Karst Huajiang valley rocky desertification areas, compares the benefits of society, economy and ecology, points out their advantages and disadvantages, and puts forward countermeasures[10]. Su Weici also establishes a benefit evaluation index system for typical karst rocky desertification control mode according to the control mode for typical karst rocky desertification in Guizhou Province, analyzes the Dingtan mode and the Wangjiazhai-Yangchangdong small watershed control mode, so as to select a suitable rocky desertification control mode for decision makers and to provide a scientific basis for the reconstruction of degraded land.

Received: May 24, 2010 Accepted: June 18, 2010
Supported by the Special Project for High-level Talents of Guizhou Province (TZJF-2008. No.22).
* Corresponding author. E-mail: sdlyzuo@126.com

1 Construction of benefit evaluation system for karst rocky desertification control mode

Based on the related data, benefit evaluation index system for karst rocky desertification control mode is established by a method integrating qualitative analysis with quantitative analysis. And each evaluated index has 5 grades with their scores of 1, 2, 3, 4 and 5, respectively.

1.1 Ecological benefit After the control of ecological environment, many scholars discussed on the evaluation methods for returning farmland into forest, water and soil conservation, small watershed control, and other ecological control project. However, since it is difficult to measure the ecological benefits and its quantitative method is immature, data are enumerated during evaluation to conduct qualitative description and word description. Few use quantitative measurement. In this research, we select biodiversity, vegetation coverage, soil and water conservation ability (soil erosion area and soil erosion modulus), change rate of rocky desertification (before and after the control mode) as quantitative indices for ecological benefit.

1.1.1 Forest coverage rate. Forest coverage rate is an important index to evaluate ecological environment. Undergrowth

vegetation can reduce the intensity of rainfall, promote water infiltration, increase the contents of soil nutrient and organic matter, improve available nutrient contents in soil, especially in the karst mountainous areas[11].

1.1.2 Biodiversity. Biodiversity refers to the various biotypes, emphasizing on the variability of species. Biodiversity represents the spatial scope of species evolution and the ecological adaptability of a particular environment, which is the main product of evolutionary mechanism.

1.1.3 Soil erosion modulus. Soil erosion modulus is the erosion amount of soil and parent soil material per unit area in a given time, which typifies the index of soil erosion intensity, reflects the erosion intensity per unit time in a certain area, and is one of the exhibition forms of ecological degeneration in karst mountainous areas.

1.2 Social and economic benefits Social and economic development is extremely backward in karst mountainous areas of Guizhou Province. And there are a total of 48 poverty-stricken counties given priority in aid. In the year 2005, absolutely poverty-stricken population is more than 2 660 thousand in Guizhou Province; more than 4 650 thousand population are below the poverty line with an annual per capita income of 625 -865 yuan, accounting for 1/5 of the total rural population in the whole province. These poverty-stricken counties and people are mainly distributed in karst mountainous areas with fragile economy with prominent "Three Agricultural Problems". One of the principal objectives for rocky desertification control is to improve the social and economic level in karst rocky desertification area and the people's living standard. Therefore, we select the per capita net income of farmers, the labor attraction ability of control mode, the proportion of cultivated area, the proportion of income from planting industry, the energy structure (use status of gas, electricity, coal, firewood and other energy), the enrollment ratio for children of school age as the quantitative indices of social and economic benefits. Among them, per capita net income of farmers refers to the income of farmers in the Statistical Report on Rural Economic Income Distribution, which is made by the Ministry of Agriculture, approved by the State Statistics Bureau, and can better reflect the economic income level of local farmers.

1.3 Popularization prospect The maturity of mode, the adaptation range of mode, the quality of farmers, and the participation degree of farmers are selected as indices.

1.4 Result of valuation Analytic hierarchy process method is used to determine the weight of evaluation index parameters. Judgment matrix is established and index weights at all levels are obtained, according to the hierarchical structure determined by evaluation index system, the requirements of AHP, and the suggestions of relevant expert. Table 1 reports the result of valuation.

Table 1 Evaluation index grading, weight and relative score of the control mode for karst rocky desertification

Criterion layer	Index layer	Weight	1	2	3	4	5
Ecological benefit 0.461	Vegetation coverage rate//%	0.538	[0,15]	[15,30]	[30,45]	[45,60]	[60,100]
	Biodiversity	0.045	<0.5	[0.5,1.5]	[1.5,2.5]	[2.5,3]	>3
	Soil erosion modulus//t · km^2/a	0.158	≥1 000	[500,1 000)	[200,500)	[100,200)	<100
	Reduction rate of moderate and strong rocky desertification area//%	0.259	≤0	(0,15]	(15,30]	(30,45]	>45
Social and economic benefit 0.308	Increase rate of farmers' net income//%	0.359	<20	[20,40]	[40,60]	[60,100]	>100
	Labor attraction ability	0.106	Few	Relatively few	General	Relatively more	More
	Proportion of cultivated land//%	0.158	>45	[35,45]	[25,35]	[15,25]	<15
	Proportion of income from planting industry//%	0.218	>45	[35,45]	[25,35]	[15,25]	<15
	Energy structure (Proportion of firewood)	0.218	All	Mostly used	General	Rarely used	Completely not used
	Enrollment ratio for children of school age//%	0.065	<80	[80,85]	[85,90]	[90,95]	>95
Popularization prospect 0.231	Maturity of mode	0.333	Experimental stage	Immature	Relatively mature	Mature	Very mature
	Adaptation range of mode	0.333	Narrow	Relatively narrow	Medium	Relatively wide	Wide
	Quality and participation degree of farmers	0.333	Low	Extremely low	Medium	Relatively high	High

2 Case analysis

2.1 General situation of research area

2.1.1 Dingtan District. Dingtan District is located along the right bank of Hua River, maim stream of the Beipanjiang River, in Beipanjiang Town, Zhenfeng County. Its area is 27.24 square kilometers and its population reaches 2 982 in the year 2001. Carbonate rock is widely distributed in Dingtan District (more than 90%), belong to typical karst valley landform. Beipanjiang river valley has the highest altitude of 1 373 meters and the lowest altitude of 445 meters, a relative height difference of 928 meters. It has a climate of dry hot valley with sig-

nificant vertical differentiation of climate element, low vegetation coverage rate (only 13.29% before treatment), serious water and soil loss, and 2 340 t/km^{2}a annual average soil erosion modulus. In some areas, there is no soil to loss with a large area of bare bedrock, prominent rocky desertification, and lack of water and land. the per capita cultivated land is 0.32 hectares and the per capita net income of farmers is less than 200 yuan in the year 1990 in Dingtan District, which is one of the poverty areas with extremely difficult living conditions in Guizhou Province. Thus, Dingtan District is under the Dual pressure of ecological reconstruction and economic development[12-15].

2.1.2 Wangjiazhai demonstration area and Yangchangdong demonstration area. Wangjiazhai demonstration area and Yangchangdong demonstration area are located in Boluo Village and Luojiaqiao Village in Hongfenghu Town, respectively, about 10 kilometers from Qingzhen County, belonging to kast peak-forest basin landforms. Topography and geomorphology of test area are relatively complex. Since the mountains and hills tilt towards central valley, a large number of gullies are formed. Area of central depression accounts for a large proportion; and the mountains and peak clusters around it show a broken terrain with steep slop and strong karstification. Mean temperature of this area is 14 degrees centigrade and the total annual accumulated temperature is 4 700 degrees centigrade. Wangjiazhai demonstration area and Yangchangdong demonstration area belong to subtropical monsoon humid climate with abundant rainfall, enough heat, rainy season and hot season at the same time, which is suitable for the growth of many plants and animals. However, precipitation has an uneven seasonal distribution due to the impact of monsoon. The general precipitation is 900 millimetres mostly from May to October, accounting for 80% of the total precipitation. And the rainfall erosion is relatively great.

2.2 Comparative analysis of the Dingtan mode (mode Ⅰ) and the Wangjiazhai-Yangchangdong small watershed control mode (mode Ⅱ)

2.2.1 Ecological benefit. Dingtan District and Wangjiazhai-Yangchangdong small watershed area has 4.583 and 3.38 total scores of ecological benefits, respectively, which are both relatively high, indicating that the two control modes have both achieved the desired results of ecological control. Since the ecological control in the year 1996, Dingtan District has accumulated a large amount of invaluable experiences and has greatly improved its ecological benefit. However, Wangjiazhai-Yangchangdong small watershed area has a relatively short period of ecological control and its ecosystem is still at the process of restoration. Thus, ecological benefit of Wangjiazhai-Yangchangdong small watershed area is not as significant as that of Dingtan District.

2.2.1.1 Forest coverage rate. Table 2 reports the forest coverage rates of Dingtan District and Wangjiazhai-Yangchangdong small watershed area.

Table 2 Comparison of karst forest coverage rates in two mode areas %

Mode type	Intensity of rocky desertification	2000	2001	2002	2003	2004	2005	2006	2007	Increasing rate
Mode Ⅰ	Potential rocky desertification	20	25	31	38	60	77	86	91	355
	Slight rocky desertification	16	22	28	35	50	75	80	87	444
	Moderate rocky desertification	14	17	22	28	35	50	59	61	436
	Strong rocky desertification	8	10	15	20	23	35	38	40	400
Mode Ⅱ		–	–	–	–	–	–	23.10	48.80	111.3

Table 2 reports that mode Ⅰ has the greatest increasing rates of vegetation coverage rates in both potential and slight rocky desertification areas, which have increased from 20% and 16% to 91% and 87%, respectively. And the vegetation coverage rate in the whole rocky desertification area has increased from 14.2% to 76.6%. Especially after the year 2004, pepper, honeysuckle, paper mulberry tree and other plants grow well in rocky desertification area, indicating that more local farmers have participated in the control mode due to the economic benefits. Thus, the score of mode Ⅰ is 5. According to the mode Ⅱ, vegetation coverage rate of Wangjiazhai-Yangchangdong small watershed area has greatly improved from 23.10% in the year 2006 to 48.80% in the year 2007, an increase of more than one time. This is because highland areas are greatly affected by human activity. After the ecological control, the restoration of vegetation is achieved in this area by turning farmland into forest and other supporting measures. Thus, the score of mode Ⅱ is 4.

2.2.1.2 Biodiversity. Table 3 reports the biodiversities of Dingtan District and Wangjiazhai-Yangchangdong small watershed area.

Table 3 Comparison of the biodiversities of the two mode areas

Mode type Type of rocky desertification	Mode Ⅰ				Mode Ⅱ		
	Potential	Slight	Moderate	Strong	Potential	Slight	Moderate
Index of biodiversity	2.62	2.7	3.26	4.43	1.60	1.98	2.44

Table 3 reports that based on the comparison of rocky desertification at the same intensity, biodiversity index of mode Ⅰ is greater than that of mode Ⅱ, indicating that Wangjiazhai-Yangchangdong small watershed area has a relatively short control period; the impact of people on the study area is too great; and the economic structure is single. Under the artificial control, long period control of Dingtan mode has improved the community structure and composition, which reduces the differences among rocky desertification at different intensities. At the same time, in both mode Ⅰ and Ⅱ, biodiversity indices of moderate and strong rocky desertification are greater than those of slight and potential rocky desertification, indicating that even-

ness degree of moderate rocky desertification community fluctuates greatly due to the interference of artificial seed selection, original site condition, and the pursue of economic interest. Biodiversity adopts Shannon-Wiener index; and higher index indicates greater amount of information[15-16]. Scores of biodiversity indices are 5 and 3 in Dingtan District and Wangjiazhai-Yangchangdong small watershed area, respectively.

2.2.1.3 Soil erosion modulus. Table 4 reports the soil erosion situation of Dingtan District and Wangjiazhai-Yangchangdong small watershed area.

Table 4 Comparison of soil erosion situations in the two mode areas t/km² a

Mode type	The year of 2006	The year of 2007
Mode Ⅰ	175.4	157.8
Mode Ⅱ	604.5	774.6

In the years 2006 – 2007, soil erosion modulus of mode Ⅰ are 175.4 and 57.8 t/k ㎡ a, respectively, which are far lower than those of mode Ⅱ, which are 604.5 and 774.6 t/km²a, respectively. This is mainly due to the landforms of the two modes and also shows the control effectiveness of mode Ⅰ. Based on the data in the two years, soil erosion modulus of mode Ⅰ in research area has declined, while that of mode Ⅱ has increased, indicating that the control mode is relatively mature and eco-system has been relatively stable for mode Ⅰ due to its long control period. Through the transformation of mode Ⅱ, vegetation coverage rate has improved greatly in research area. But ground vegetation has not shown the function of water and soil conservation and the soil erosion modulus has increased instead, due to the short control period and the impact of man-made change on land surface. Thus, the scores of mode Ⅰ and Ⅱ are 4 and 2, respectively.

2.2.1.4 Reduction rate of moderate and strong rocky desertification areas. Table 5 reports the rocky desertification situations in Dingtan District and Wangjiazhai-Yangchangdong small watershed area.

Table 5 Comparison of the karst rocky desertification situation in two mode areas

Mode type	Intensity of rocky desertification	The year of 2000		The year of 2005		The year of 2007		
		Area // km²	Percentage // %	Area // km²	Percentage // %	Area // km²	Percentage // %	Reduction rate // %
Mode Ⅰ	Moderate	9.96	19.29	6.40	12.40	–	–	34.59
	Strong	9.96	19.29	6.63	12.84	–	–	
Mode Ⅱ	Moderate	–	–	5.53	9.14	4.38	2.52	23.74
	Strong	–	–	0.41	0.68	0.15	0.25	

Table 5 shows that the reduction rate of moderate and strong rocky desertification area in Dingtan District is 34.59%, with its score of 4; while that in Wangjiazhai – Yangchangdong small watershed area is 23.74%, with the score of 3.

2.2.2 Social and economic benefit.

2.2.2.1 Increasing rate of per capita net income of farmers. Table 6 reports the per capita net income of farmers in Dingtan District and Wangjiazhai-Yangchangdong small watershed area.

Table 6 Per capita net income of farmers in two mode areas

Mode type	2000		2005		2008		Increasing rate of per capita net income in the years 2005 – 2008 // %
	Overall income Yuan	Per capita net income Yuan	Overall income Yuan	Per capita net income Yuan	Overall income Yuan	Per capita net income Yuan	
Mode Ⅰ	7 854 664	798	14 821 674	1 564	–	>3 000	91.82
Mode Ⅱ	–	–	–	1 600	–	>2 500	56.25

Table 6 shows that the overall income of Dingtan District has increased from 7 854 664 yuan in the year 2000 to 14 821 674 in 2005, an increase of about one time. Per capita net income has grown from 1 564 yuan in 2005 to more than 3000 in 2008, an increase rate of 91.82%[17]. Thus, the score of mode Ⅰ is 5. Meanwhile, per capita net income of Wangjiazhai-Yangchangdong small watershed area has increased from 1 600 yuan before mode control to more than 2 500 yuan, an increasing rate of 56.25%, which is lower than the increasing rate of Dingtan District. Thus, the score of mode Ⅱ is 3.

2.2.2.2 Labor attraction ability. Dingtan District adopts the ecological agricultural mode of "pepper – pig – biogas". Most young people have gone out to find jobs and Dingtan District shows a general ability of labor attraction. The score of mode Ⅰ is 3. Besides, Wangjiazhai small watershed demonstration area mainly adopts vegetable planting mode. And Yangchangdong small watershed demonstration area develops dairy production. Thus Wangjiazhai-Yangchangdong small watershed area has relatively good ability of labor attraction and its score is 4.

2.2.2.3 Proportion of cultivated land. Area of cultivated land is about 3 220.25 hectares in Qingzhen demonstration area in the year 2005, accounting for 58.25% of the total area of demonstration area. And its score is 1. At the same time, area of cultivated land is about 1 096.62 hectares in Huajiang demonstration area, accounting for 21.24%. and its score is 4.

2.2.2.4 Energy structure (Proportion of firewood). During the field investigation, energy structures of the two study areas have improved greatly. Most household use biogas and few use firewood. Thus, the score of the two modes are both 4.

2.2.3 Popularization prospect.

2.2.3.1 Maturity of mode. At the end of the year 1996, pepper was planted in a large area of land in Dingtan District. And pepper base has been built up. Through more than ten years' development, Dingtan mode has become mature and its score

is 4. In the year 2005, Institute of Geochemistry, Chinese Academy of Science has implemented the project of "Ecological comprehensive control techniques and ecological demonstration areas of Karst rocky desertification", and has set up two demonstration areas in Hongfeng Town, Qingzhen City, Guizhou Province. Wangjiazhai watershed ecological agricultural mode and Yangchangdong watershed ecological animal husbandry mode are relatively good in maturity. And its score is 3.

2.2.3.2 Adaptation range of mode. In Dingtan District, pepper should be planted in relatively dry and hot area. Thus, its adaptation range is relatively narrow and its score is 2. However, returning farmland to forest (grass) has a wide adaptation range in Wangjiazhai-Yangchangdong small watershed area. Thus, its score is 4.

2.2.3.3 Quality and participation degree of farmers. Farmers' qualities in Dingtan District and Wangjiazhai-Yangchangdong small watershed area are almost the same. And their scores are both 3.

2.2.4 Comprehensive evaluation. According to the scores of comprehensive ecological benefit, social and economic benefit, and popularization prospect of mode, Dingtan mode is superior than the Wangjiazhai-Yangchangdong small watershed control mode. Benefit score of Dingtan mode is 3.81, which is higher than that of the Wangjiazhai-Yangchangdong small watershed control mode (3.11). In the aspects of ecological benefit and social and economic benefit, Dingtan mode (4.83 and 3.258) is superior than the Wangjiazhai-Yangchangdong small watershed control mode (3.38 and 2.531). In the aspect of popularization prospect of mode, score of Dingtan mode (3) is lower than that of Wangjiazhai-Yangchangdong small watershed control mode (3.333).

3 Conclusion

Benefit evaluation system of the control mode for typical karst rocky desertification is established. And Dingtan mode and Wangjiazhai-Yangchangdong small watershed control mode are compared. Result shows that the benefit of Dingtan mode at present is superior than that of Wangjiazhai-Yangchangdong small watershed control mode, reflecting the actual situation and showing that evaluation system of the rocky desertification control mode has certain science. However, during the construction of evaluation system, few evaluation indices are selected and the process of selection is of certain subjective. Moreover, control of karst rocky desertification has a long history in Guizhou Province, but benefit of control mode usually needs several years to become visible. Therefore, we should pay attention to the long time span and insufficient initial data during the research on the control of karst rocky desertification. It can be sure that with the improvement of evaluation index system, knowledge of the control mode for karst rocky desertification in Guizhou will increase, and the benefit evaluation on control mode will be more accurate.

References

[1] SU WC. Stone desertification and eco-economics improving model in Guizhou Karst mountain[J]. Carsologica Sinica, 2002, 21(1): 19-25. (in Chinese).

[2] SU WC, ZHU WX, TENG JZ. Eco-controlling models of rocky desertification in Karst gorge region of Xingbei town in Guizhou province and its effects[J]. Ecology and Environment, 2004, 13(1): 57-60. (in Chinese).

[3] TENG JZ, SU WC, LIAO FL. Analysis of eco-economic control models and benefits of rocky desertification region in Huajiang Karst gorge in Guizhou[J]. Science of Soil and Water Conservation, 2004, 2(3):70-74. (in Chinese).

[4] LI YB, WANG SJ, XIONG KN. Ecological reconstruction of Karst rocky desertificafion and its significance in Huajian gorge[J]. China Population, Resources and Environment, 2005, 15(1):138-142. (in Chinese).

[5] WU JH, MOU Q, TANG CB, *et al*. Techniques for sheep raising through grass growing in rocky desertification mountain area[J]. Pratacultural Science, 2009, 26(1):126-128. (in Chinese).

[6] XU YJ, CHEN NH, LIU DW. Discussion on control of soil erosion and the model for rural sustainable development in stony desertification areas of southwestern China[J]. Water Resources Development Research, 2008(7):46-48, 60. (in Chinese).

[7] FANG XD, ZHU SL. Study on the forestry development and countermeasure of the ecological construction experimental area in Bijie prefecture[J]. Guizhou Forestry Science and Technology, 2008, 36(1):47, 53-56. (in Chinese).

[8] Environmental Protection Administration of Guizhou Province. Research on Karst environment in Guizhou[M]. Guiyang: Guizhou People's Publishing House, 1988. (in Chinese).

[9] HE YJ, LIU JM. Study on the vegetation recovery benefit from different conversions of farmland to forests models in Huajiang area of low-heat river valley[J]. Journal of Anhui Agricultural Sciences, 2008, 36(4):1439-1440, 1459. (in Chinese).

[10] SU WC, YANG H. A study on the models of eco-agricultural development in typical Karst gorge region——a case study from Dingtan District of Huajiang Gorge in Guizhou Province[J]. Chinese Journal of Eco-agriculture, 2005, 13(4):217-220. (in Chinese).

[11] ZHOU B, LI YN, CHEN Z. The significance of biodiversity in protection, restoration and reconstruction of Karst ecosystem[J]. Journal of Mountain Agriculture and Biology, 2003, 22(3):248-252. (in Chinese).

[12] DAN WH. The study on the sustainable agriculture development pattern in Karst gorge region—taking the Huajiang Gorge as an example[J]. Carsologica Sinica, 1999, 18(3):251-256. (in Chinese).

[13] WANG YR, TU YL. The study of classification of eco-economic type in Karst gorge areas[J]. Journal of Guizhou Normal University, 2001, 19(1):13-17. (in Chinese).

[14] YANG WL, XIONG KN. Investigation on population carrying capacity of the cultivated land in the Huajiang Karst Fengcong Gorge of Guizhou[J]. Journal of Guizhou Normal University: Natural Science, 2002, 20(1):32-39. (in Chinese).

[15] KREBS CJ. Eology: the experimental analysis of distribution and abundance[M]. 2nd ed. New York: Harper &Row, 1978: 449-487.

[16] MA KP. Measurement of biotic community diversity. Principles and methodologies of biodiversity studies[M]. Beijing: China Science and Technology Press, 1994: 141-165. (in Chinese).

[17] DANG Y, WA BL, WANG XH, *et al*. Zhenfeng country: success control model of Karst rocky desertification[J]. Theory and Contemporary, 2009(6):13-15. (in Chinese).

[18] LU ZX, GAO BT. Study on ecological compensation system and land desertification control[J]. Asian Agriculture Research, 2009, 1(7):33-36.

[19] LONG XM, ZHOU ZF, ZHANG H, *et al*. Study on Karst rock-desertification of extracting vegetation coverage inversion based on NDVI serial images and dimidiate pixel model[J]. Journal of Anhui Agricultural Sciences, 2010, 38(8):330-332. (in Chinese).