Study on Relationship between Evolution of Karst Rocky Desertification and Human activities in karst canyon area

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ABSTRACT

Quantitative analysis and located monitoring of the evolution and trend of karst rocky desertification (KRD) based on GIS and RS, using remote sensing images in 2001 and 2014 as the data source. Using probability function to calculate the certainty factor (CF), discussed evolution driving mechanism of karst rocky desertification. The following conclusions are obtained: (1) The evolution of KRD includes three types: no change, better and deterioration, which is given priority to with good transformation, 47.22% of the total area of karst, followed by deterioration and no variant, the karst area of 28.05% and 24.71% respectively; (2) The KRD with a total area is overall improvement, but local aggravating, mild rocky desertification is the important direction, and is also a rallying point rocky desertification in the evolution of the forward and reverse; (3) Contribution rate of different land use types on rocky desertification evolution, forestland and grassland driver with good transformation of evolution is given priority to, grassland and the bare is given priority to with deterioration, driven by the dry land, garden land, open woodland and construction land under the influence of three kinds of rocky desertification evolution way go hand in hand; (4) 50 hu/km² is the populated density point of rocky desertification evolution. The significance of quantitative analysis of KRD is to put forward the decision-making and regulation mechanism.

1. INTRODUCTION

The karst region of Southwest China is one of main ecologically fragile zone in the world [1]. The problem of rocky desertification is one of the biggest ecological environmental problems in the southwest karst region. In the late 1980 s to the early 90 s, some researchers in soil and water conservation work, especially in sand shale and red rock series and limestone hills mountain steep slope soil erosion caused by reclamation study, put forward the "fossil", "rock desertification", "rocky desertification" concept, and discusses the scientific connotation [2-5]. Some scholars have suggested that the evolution of rocky desertification in the karst mountains is extremely complex. There are two kinds of changes in the direction of forward and backward. [6-9]. At present, the research on the evolution of rocky desertification is focused on four aspects: time-space evolution characteristics、the evolution process、the driving mechanism and the prediction of the evolution of rocky desertification. It is generally accepted that the factors of the formation of rocky desertification are mainly natural factors and human factors. and with the development of social economy and human social activities, some scholars have proposed that human factors become more and more important [10-12]. Li-fei Yu has quantitative evaluate the relationship between anthropogenic interference and the degradation of karst forest in guizhou province [13]. Qiu-yan huang has quantitative research the relationship between the incidence of karst rocky desertification and the intensity of human activities, such as population density, the density of the economy, land use degree, the distance from residential areas and roads [14]. however, these studies have been studied from the perspective of human interference, without taking into account the comprehensive treatment. This article using GIS and remote sensing technology analysis the relationship between computing key factors, and calculates the certainty factor (CF), diagnosis of driving mechanism, to better provide a theoretical basis for comprehensive control of rocky desertification.

2. Materials and Methods

2.1. Study Area

The Guanling Zhenfeng Huajiang rocky desertification comprehensive treatment demonstration area, referred to as "Huajiang demonstration area", as a representative of Karst Plateau gorge area, located in the southwest of Guanling County, the north of Zhenfeng County, Guizhou Province. Huajiang demonstration area contains Chaeryan village, Yindongwan village, Mugong village, Xiagu village, Bashan village and Falang, Ganerpan villagers groups. The total area of Huajiang demonstration area is 51.62 km², which Karst area is 45.38 km², accounting for 87.92% of the total area. In 2013, the area of rock desertification accounted for 71.81% of the total area, mainly in the medium - strength stony desertification. Demonstration area landform is broken, bedrock expose rate high, serious soil erosion, high development of KRD, the ecological environment is very fragile is typical karst dry hot valley ecological environment [15-16]. the average annual precipitation 1100mm, but uneven distribution of time and space, rainfall mainly concentrated in the 5-10 months, accounting for more than 80% of the total annual precipitation, which accounted for more than 50% of the total annual precipitation 6-8 months of precipitation, precipitation from the bottom to the top of the mountain increased by about 30%. Lack of water storage project, human and livestock drinking water and production, ecological water is extremely short [17]. In 2001, the total population is 7102 people, the average population density is 138 people / km². But, in 2013, the total population is 9030 people, the average population density is 175 people / km².

2.2. Data and method

2.2.1 Spatial distribution of KRD

Rocky desertification grade using Xiong' s grading index system [1]. The remote sensing interpretation of rocky desertification is using the 2001 ETM + (International scientific data service platform) and the 2014 spot6 (Beijing Spot Image co., Ltd.). On the ENVI platform, Spatial distribution of rocky desertification in 2001 and 2014 (Figure 1) have been obtained using the human-computer interaction interpretation [7-8, 18-22]. The spatial overlay analysis of the 2 phase rocky desertification data was carried out on GIS platform to obtain the evolution of rocky desertification

in the study area from 2001 to 2014, to determine the metastatic direction of rocky desertification, Based on the transfer matrix model [23-24].

Figure 1. Spatial distribution maps of KRD (left: 2001,; right: 2014)

2.2.2 Calculation on Human intervention driving factor

land use: According to the present situation of land use classification (GB T21010-2007), the study area can be divided into rice paddies, dry land, garden plot, forest land, bush forest land, open forest land, grassland, construction land, wild grass ground, Bare rock.

Populated density: According to the number of residential per square kilometer, the population density is divided into six levels according to the actual situation of the study area.

hemeroby index: The index is used to describe the intensity of human disturbance in a certain area[24,25], this article uses landscape pattern method to make quantitative evaluation. The interference degree was the area of the human disturbance index 0.1-0.59. Moderate interference is the area with an artificial disturbance index of 0.6-0.79, and intensive index is 0.8-1.

Engineering of Karst Desertification Control: Rocky desertification comprehensive control is the key ecological construction project, by restoring vegetation, and animal husbandry development facilities, terrance and supporting the field production facilities, management measures, water and soil conservation facilities, in order to gradually restore the damaged natural ecological system. The paper evaluates five key projects, such as the mountain forest, the characteristic meridian forest, the slope change ladder and the small water conservancy, the grassland construction, and the soil and water conservation.

Figure 2. Spatial distribution maps of human intervention factors

2.2.3 Certainty factor

Certainty factor(CF)[27] is a probability function which was proposed by Shortlife and Buchanan in 1975, and is improved by Heckerman in 1986. It is used to analyze the sensitivity of the factors that affect the occurrence of a certain event[19]. CF function is specifically expressed as:

$$CF = \begin{cases} \frac{P_{pa} - P_{ps}}{P_{pa}(1 - P_{ps})}, & P_{pa} \geq P_{ps} \\ \frac{P_{pa} - P_{ps}}{P_{ps}(1 - P_{pa})}, & P_{pa} < P_{ps} \end{cases} \quad (1)$$

In the formula: P_{pa} represents the probability of event occurrence in data class A (The deterioration of KRD in different category factor units); P_{ps} represents The occurrence of the event in the entire study area A a priori probability (That is, the deterioration of rocky desertification in the study area).

By the formula (1) we can know the change of the CF is [-1,1], The positive representative the event of a deterministic has growth, The negative representative the value of the event has a lower certainty. The 0 value represents the prior probability of the event is very close to the probability of the condition (This element can't judge the certainty of the event.)

3. Results

3.1. Temporal and spatial evolution of KRD

In 2001 and 2014 rocky desertification spatial distribution characteristics

were obtained by using the ArcGIS and ERDAS software, and then spatial overlay this result obtained the typical evolution map (Figure 3) and the evolution trajectory of KRD (Table 1). We found: (1) no change mode. During the study period, the type of rocky desertification did not change. (2) better transition, this means the type of reverse evolution of rocky desertification grade. During the evolution of KRD, the degree of rocky desertification is decreased, and the ecological restoration is reflected, and the ecological environment of KRD is recoverable; (3) serious transition, this represents the evolution of the grade of KRD. During the course of evolution, the degree of rocky desertification is increasing, the ecological degradation, and the necessity of comprehensive prevention, recovery and protection of rocky desertification ecological environment is reflected. The evolution of KRD is the main way of good transformation in huajiang demonstration zone in 2001 to 2014. It accounts for 47.22% of the area of the Karst demonstration area. The ecological environment of the demonstration area is improving continuously. The second is the deterioration type and the variant, accounts for 28.05% and 24.71% of the Karst area. The transition matrix of KRD were built (Table 1), and it can judge the evolution trend of KRD, and can also judge the evolution law of each grade of the rocky desertification.

From the table 1, we can see that the evolution of KRD has the characteristics of the coexistence of forward and reverse evolution during the 14 years. On the whole, from the rocky desertification to rocky desertification area of 389.67 hm², The area of rocky desertification area turn to no rocky desertification area was 625.88hm², The comprehensive treatment of KRD has obvious effect, and the ecological environment has improved. no rocky desertification mainly to mild and potential rocky desertification evolution, potential rocky desertification mainly to mild and no rocky desertification, mild major to potential rocky desertification evolution, moderate mainly to mild evolution, strength mainly to mild evolution, strength mainly to mild, moderate, and intensity of desertification evolution (figure 3). and It can be seen that the transition of light to stony desertification is a key direction, which is a convergence point of forward evolution and reverse evolution.

Figure 3. Map of rocky desertification evolution tracks and types in Study area (2001-2014)

Table 1. Conversion matrix of different rocky desertification types in Study areas (2001-2014)

2014年 \ 2001年	no KRD	potential KRD	light KRD	moderate KRD	severe KRD	extremely severe KRD	severe KRD
no karst rocky desertification (No KRD)		127.4	173.57	47.68	41.02		
Potential karst rocky desertification (Potential KRD)	178.38		213.17	70.75	65.28		
Light karst rocky desertification (Light KRD)	196.2	266.77		186.2	181.28		
Moderate karst rocky desertification (Moderate KRD)	147.76	169.14	341.22		158.62		
Severe karst rocky desertification (Severe KRD)	88.96	119.87	287.87	122.31			
Extremely severe karst rocky desertification (Extremely severe KRD)	14.58	30.36	83.04	43.93	53.98		

3.2. Relationship between Rocky desertification evolution and human intervention

On ARCGIS platform, the map of rocky desertification from 2001 to 2014 and human intervention factors were superimposed to calculate the coupling relationship between different human intervention factors.

Table 2. Relationship between Rocky desertification evolution and human intervention

dominant factors	The Secondary factors	area (hm ²)	area of evolution (hm ²)		
			no change mode	better transition	serious transition
land use	rice paddies	1.30	1.30	0.00	0.00
	dry land	670.39	167.61	294.10	208.68
	garden plot	838.29	191.39	436.55	210.35
	forest land	477.10	73.6	399.74	3.76
	bush forest land	499.17	149.27	247.19	102.71
	open forest land	734.90	194.27	301.09	239.54
	grassland	300.04	50.09	197.52	52.43
	construction land	90.81	26.77	54.41	9.63
	wild ground	364.38	90.15	75.14	199.09
	Bare rock	410.60	109.39	117.26	183.95
Populated density (amilies/km ²)	(0, 30]	826.94	204.45	380.18	242.31
	(30, 40]	656.61	154.69	332.56	169.36
	(40, 50]	630.82	195.82	272.81	162.19
	(50, 60]	288.12	70.99	144.04	73.09
	(60, 70]	1555.89	354.89	809.85	391.15
	>70	545.84	140.41	204.98	200.45
human disturbance intensity	light	1495.63	374.7	772.64	348.29
	moderate	2499.17	600.67	1204.71	693.79
	intensive	509.28	145.83	166.99	196.46
comprehensive management engineering (KDCE)	forest reservation	310.06	16.79	187.76	105.51
	economical forest-fruit	485.97	22.31	298.9	164.76
	terrace	27.67	8.24	10.74	8.69
	grassland construction	113.83	24.28	72.82	16.73
	soil and water conservative forest	365.87	82.84	179.43	103.6

3.3 The evolution rates and CF values of karst rocky desertification

According to calculation formula (1), better transition of rocky desertification in the study area is 0.4725, better transition probability is 0.2805, the rates and CF values of key influence factors can be seen in table 3.

Table 3. The rates and CF values of key influence factors of karst rocky desertification

dominant factors	The Secondary factors	The incidence of evolution (Ppa)		Prior probability (Pps)		Certainty factor (CF)	
		better transition	serious transition	better transition	serious transition	better transition	serious transition
land use (LUCC)	rice paddies	0.0000	0.0000	0.4725	0.2805	1.0000	1.0000
	dry land	0.4387	0.3113	0.4725	0.2805	0.1274	0.1376
	garden plot	0.5208	0.2509	0.4725	0.2805	0.1757	0.1405
	forest land	0.8379	0.0079	0.4725	0.2805	0.8267	0.9796
	bush forest land	0.4952	0.2058	0.4725	0.2805	0.0869	0.3353
	open forest land	0.4097	0.3259	0.4725	0.2805	0.2251	0.1940
	grassland	0.6583	0.1747	0.4725	0.2805	0.5351	0.4567
	construction land	0.5992	0.1060	0.4725	0.2805	0.4008	0.6956
	wild ground	0.2062	0.5464	0.4725	0.2805	0.7100	0.6764
	grass ground	0.2856	0.4480	0.4725	0.2805	0.5537	0.5198
Populated density (amilies/km ²)	(0, 30]	0.4597	0.2930	0.4725	0.2805	0.0500	0.0596
	(30, 40]	0.5065	0.2579	0.4725	0.2805	0.1272	0.1082
	(40, 50]	0.4325	0.2571	0.4725	0.2805	0.1493	0.1120

human disturbance intensity(HI)	(50 , 60]	0.4999	0.2537	0.4725	0.2805	0.1040	-	0.1279
	(60 , 70]	0.5205	0.2514	0.4725	0.2805	0.1749	-	0.1384
	>70	0.3755	0.3672	0.4725	0.2805	-	0.3286	0.3284
	light	0.5166	0.2329	0.4725	0.2805	0.1618	-	0.2212
	moderate	0.4820	0.2776	0.4725	0.2805	0.0376	-	0.0140
	intensive	0.3279	0.3858	0.4725	0.2805	-	0.4553	0.3794
	forest reservation	0.6056	0.3403	0.4725	0.2805	0.4166	-	0.2444
	Economical forest- fruit	0.6151	0.3390	0.4725	0.2805	0.4394	-	0.2401
	terrace	0.3881	0.3141	0.4725	0.2805	-	0.2918	0.1487
	grassland construction	0.6397	0.1470	0.4725	0.2805	0.4956	-	0.5579
comprehensive management engineering (KDCE)	soil and water conservative forest	0.4904	0.2832	0.4725	0.2805	0.0693	-	0.0133

Table 3 shows: Rocky desertification can be easy to change better in 6 kinds land use areas: garden plot, forest land, bush forest land, grassland and construction, on the contrary, in dry land, sparse woodland, grassland and bare rock gravel driven easily deteriorated, evolved The maximum peak appears in the grassland. 40-50 households per square kilometer is the critical region of rocky desertification. The evolution of rocky desertification is positively correlated with the intensity of human disturbance. However, only the grassland construction's CF is negative, which is not easy to deteriorate, and the other regions are prone to deterioration. Therefore, we should be strengthened the management of the treatment of rocky desertification.

4. Discussion

(1) In 14 years, the total area of the rocky desertification is not obvious, but the rocky desertification evolution between internal types is significant, good transformation is given priority to, and reverse type is greater than the positive succession. It indicates that the treatment of rocky desertification has been effectively controlled. But through the transfer matrix of rocky desertification evolution, we found that local area has a tendency to increase, no rocky desertification evolved to mild and potential mainly, potential rocky desertification evolved to mild.

(2) Forest reservation and grassland construction are the effective intervention measures to control the rocky desertification. The land use type driven by dry land, garden plot, open forest land and construction land are prone to evolution. but the wild grass ground and barren land are difficult to recover

(3) The population density is 175 people /50 households per square kilometer is a tipping point for the evolution of rocky desertification.

5. Conclusions

Based on RS, GIS and statistical methods, we can capture the dynamic of rocky desertification evolution path and way, and estimate the evolution of the probability. To some extent, the desertification control project has curbed the development trend of the rocky desertification of guizhou, slowed the rate of the development of rocky desertification and reduced the level of stony desertification[25]. However, the prevention and protection of rocky desertification should be strengthened. In this kind of karst area, it is especially important to strengthen the protection of the forest and soil conservation.

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